FM

FEBRUARY 1941

FIRST FM COMMERCIAL CONTRACT IS SIGNED

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

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BROWNING LABORATORIES, Inc.

755 MAIN STREET **WINCHESTER, MASSACHUSETTS**

WHAT THE FM BROADCASTERS HAVE TO SAY:

A Statement Concerning W55M, by Walter J. Damm, General Manager of Radio, The Journal Company

ALTHOUGH The Journal Company has been operating a standard broadcasting station in Milwaukee since 1925, we look upon FM as a new entity which will eventually dominate the radio scene. We feel that FM is not just a gadget to hang on the tail of standard broadcasting — not something to have around the shop in order to say, "Oh, yes, we're experimenting with FM." To us FM is a serious business proposition which must be handled as such.

In anticipation of the development of FM to a point equal to and eventually surpassing and replacing present-day AM broadcasting, we propose to program our new FM station in a way to build listeners — irrespective of the effect this policy may have on our established AM station. In this regard, we have had almost a year's experience in operating W9XAO, our experimental FM station, along these very lines and, I believe we can truthfully say, to an extent far beyond that attempted by any other licensee. Our convictions with regard to programming are, briefly, as follows:

1. If the public is going to buy FM sets, it needs an incentive — therefore, FM programs must be distinctly worth while and fill a genuine need.

2. It follows that FM program schedules must be entirely independent from AM schedules. FM's advantages of high fidelity reproduction and freedom from static are, alone, not enough in most cases to make people switch from AM to FM.

3. FM should be programmed to meet the radio desires of the discriminating listener who enjoys good music, and both sustaining and commercial programs should utilize the high fidelity reproductive advantage of FM to the utmost. In this respect, we believe that there is a place for electrical transcriptions, as well as live talent, on FM programs. Experience has shown that the new high fidelity electrical transcriptions now available to the broadcasting industry are remarkably well adapted to FM. They will provide the means of presenting famous artists and musical groups which could not otherwise be heard over an individual FM station until such time as an FM network becomes feasible.

4. While music should be the basis of FM schedules, we recognize that drama, news, special events and children's programs have their place. However, every effort will be made to place such programs where they best fit into the daily life of the listener.

5. We believe that daily luncheon and dinner concerts of uninterrupted music should be scheduled, as these two periods will make it possible for the listener to enjoy the benefits of FM to the utmost. The dinner concert, particularly, should fill the wishes of many set owners who have hungered for a program of music and not one made up of 15-minute units, ranging from children's programs to dramatics, sports and news.

6. We believe that by concentrating on music during the afternoon, FM will attract

(CONCLUDED ON PAGE 46)

STROMBERG-CARLSON BACKS UP ITS CONFIDENCE IN FM WITH...

. . . THE MOST COMPLETE FM LINE IN THE ENTIRE INDUSTRY

Only Stromberg-Carlson offers both radios and radio-phonographs with FM in a wide variety of models to suit all tastes . . . and in a price range that makes everyone a prospect! Here's your opportunity to cash-in *now* . . . to sell for the future as well as the present!

. . . OVER A YEAR'S FIELD-TESTING EXPERIENCE

No one can match Stromberg-Carlson's months of successful manufacture of FM receivers. It is a completely SEASONED line, backed by more than a year of field experience!

. . . TREMENDOUS NATIONAL MAGAZINE ADVERTISING

Right through the past year, Stromberg-Carlson has been telling and selling *your* prospects on FM . . . in *The Saturday Evening Post*, *Collier's*, *Life*, *Time*, and *The New Yorker*. No other FM line begins to offer such national advertising support!

No. 535-PG AUTOMATIC RADIO-PHONOGRAPH
NO NEEDLES TO CHANGE. "Feather-Light Permanent Point" multiplies record life. FM, Standard, Short Wave. "Preferred-Type" Tubes. Authentic Chippendale cabinet.

Licensed under Armstrong Wide-Swing Frequency Modulation patents.

Not only does Stromberg-Carlson offer you the most complete, most thoroughly tested, most heavily advertised FM line, but, in addition, has the exclusive Labyrinth and Carpinchoe Speaker Audio System that brings you, as nothing else can, the utmost of FM's increased tonal and dynamic range. All bands . . . FM, Standard, and Short Wave . . . efficiently and conveniently on *one* dial and controlled by *one* set of knobs. See your distributor for details, or write direct.

There is nothing finer than a
Stromberg-Carlson
Frequency Modulation
ARMSTRONG SYSTEM

STROMBERG-CARLSON TELEPHONE MANUFACTURING CO., ROCHESTER, N. Y.

FIRST FM CONTRACT

THE first contract for commercial time on an FM broadcasting station was signed by Fred Cartoun, vice president of Longines-Witenauer, Inc., on behalf of his company. Calling for Longines time announcements on W2XOR, the commercial rates will become effective as soon as the station qualifies under the FCC requirements. Meanwhile, W2XOR is operating on a regular program schedule under an experimental license.

In the cover picture, Fred Cartoun is seated, while Theodore C. Streibert, vice president and general manager of WOR, looks over his shoulder. J. R. Poppele stands at the extreme right, and beside him is Eugene S. Thomas, WOR sales manager.

W2XOR's audience has been increasing rapidly. In fact, it is surprising to see how the apathetic attitude toward FM which prevailed in the stores last fall changed to active enthusiasm and support as the dealers began to recognize the improved service afforded by FM programs.

By Christmas, the demand for receivers exceeded the manufacturers' shipments into New York, with the result that many orders taken with a promise of delivery before the 25th could not be filled on time.

Unquestionably, W2XOR's programs have done much toward building up the FM audience in the New York City area. Soon, when this station steps up its power, as required by the FCC, its service area will include a population of 12,000,000 people.

FM

THE COMPLETE AND AUTHORITATIVE SOURCE OF INFORMATION ON FREQUENCY MODULATION

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M. B. SLEEPER, *Editor*
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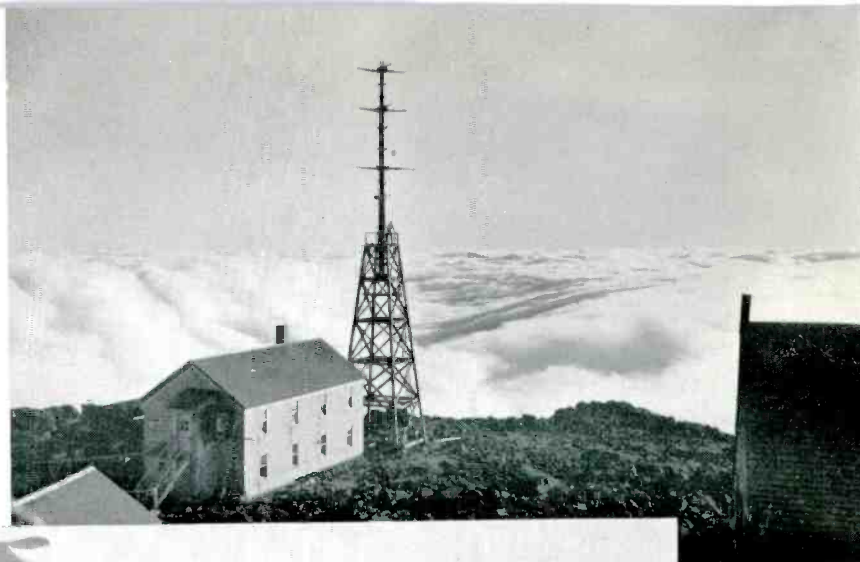
FM MAGAZINE IS SOLD BY SUBSCRIPTION ONLY

W1XER, YANKEE NETWORK STATION ON MT. WASHINGTON, IS ON FULL-TIME SCHEDULE WITH PAXTON PROGRAMS. EXCEEDING ITS ESTIMATED RANGE BY PUTTING A GOOD SIGNAL INTO BOSTON, 130 MILES DISTANT, THIS STATION SERVES AN ENORMOUS AREA IN MAINE, NEW HAMPSHIRE, AND VERMONT THAT HAS NEVER HAD ADEQUATE AM PROGRAM SERVICE



ABOVE, LEFT TO RIGHT, ROBERT BARTLEY, V.P. OF YANKEE NETWORK, PROF. G. W. PICKARD, AND PAUL DE MARS, YANKEE CHIEF ENGINEER, ATOP MT. WASHINGTON. BELOW, AIRPLANE VIEW OF THE TRANSMITTER WHERE, 6,288 FT. UP, OPERATORS ARE SNOWED IN 8 MONTHS OF THE YEAR, AND BATTLE 150-MILE GALES DURING STORMY WEATHER

FM MAKES PROGRESS

1941 Starts with Shortage of Advertised FM-AM Sets—Leaders Are Pleased, While Faint-hearted Display Usual Timidity

BY M. B. SLEEPER

MOST opinions concerning the immediate future of FM reflect, as is natural, the hopes and wishes of those who express them. The observations which follow, however, present a realistic view of the FM situation as it stands at the present time.

Manufacturers of broadcast receivers who looked upon FM as a technical improvement which, adequately promoted and aggressively merchandised, would win the recognition it merits were gratified to find themselves behind on deliveries at the start of the new year.

Dealers, notably in New York, Springfield, Worcester, and Milwaukee, report sales of substantial volume, running considerably ahead of their expectations. Boston, home of the Yankee Network, has been as slow to get FM-AM set sales started as it usually is to take up anything new. Talking to dealers there, one almost gets the impression someone has tipped them off that there is a time-bomb packed in each FM-AM set!

All the dealers with slow-thinking minds are not located in Boston, however. There are those who do not feel that they should do anything with FM until Philco starts to build sets. Recalling Philco advertising about metal tubes at the time they were first introduced, one would hardly expect them to undertake anything new until they were forced into it by the success of others. Their one piece of pioneering, the magic control box, was an engineering blunder. And from their running fight with RCA over the payment of royalties, it seems certain they they will not contract any agreement with Major Armstrong to the same end until such time as they are forced to do so by the pressure of competition.

RCA, on the other hand, taking a more progressive attitude, has been negotiating with the Major for an FM license in all fields of application. It appears that each is asking for more than the other is willing to give, so far. An agreement will undoubtedly be reached shortly, for FM is important to RCA in several respects other than the manufacture of broadcast receivers.

Those who examine the facts without prejudice are highly gratified by the prospects for FM in 1941. Progress on the part of the manufacturers and broadcasters must go hand in hand. There is no reason for any hen-or-the-egg controversy because, with the increasing rate of set sales, there will be a well-established audience in each area by the time the stations are ready with sufficient power to cover the areas assigned to them.

For example, the following stations are among those which have requested, and were granted, special temporary authority to continue operation on an experimental basis until March 1st, 1941, because they have not yet completed the installation of the more powerful transmitters necessary to cover their assigned areas for commercial operation.

W2XOR, New York, N. Y. — 43.5 mc.
Operated by Bamberger Broadcasting Co.
Still has 1-kw. transmitter. This station, now using vertical polarization may change to horizontal polarization, used by other New York stations.

W1XK, Hull, Mass. — 42.6 mc.
Operated by Westinghouse Electric & Mfg. Co.
Does not maintain full schedule of programs. Now using 1-kw. transmitter.

W1XSN, East Springfield, Mass. — 43.7 mc.
Operated by Westinghouse Electric & Mfg. Co.
Does not maintain full schedule of programs. Now using 1-kw. transmitter.

W1XSO, Hartford, Conn. — 43.7 mc.
Operated by The Travelers Broadcasting Service Corp.
Using experimental antenna and 1-kw. transmitter, pending erection of permanent antenna and new transmitter.

W8XVB, Rochester, N. Y. — 43.2 mc.
Operated by Stromberg-Carlson Telephone Mfg. Co.
Still using only 1-kw. transmitter.

W1XOJ, Paxton, Mass. — 44.8 mc.
Operated by Yankee Network, Inc.
50-kw. transmitter is installed, but only fractional power can be used until construction of new antenna is completed. Does not yet put an adequate signal into the business section of Boston where most of the radio stores are located.

W3XO, Washington, D. C. — 43.2 mc.
Operated by Jansky & Bailey.
Still using only 1-kw. transmitter.

W8XVH, Columbus, Ohio — 43. mc.
Operated by WBNS, Inc.
Has only 250-watt transmitter in operation.

W8XAD, Rochester, N. Y. — 42.6 mc.
Operated by WHEC, Inc.
Now using only 1-kw. transmitter.

W2XMN, Alpine, N. J. — 42.8 mc.
Operated by Major Edwin H. Armstrong.
Does not carry a full schedule of programs.

W2XQR, Long Island City, N. Y. — 43.2 mc.

Operated by John V. L. Hogan.
Station is not yet adequately programmed and has only an experimental antenna. Transmitter is only 1-kw.
W9XOA, Milwaukee, Wis. — 42.6 mc.
Operated by The Milwaukee Journal.
Now using only 1-kw. transmitter. Installation of 10-kw. output to meet FCC commercial requirements is already under way.
W2ZWG, New York, N. Y. — 43.9 mc.
Operated by the National Broadcasting Co.
Still using only 1-kw. transmitter.
W1XPW, Hartford, Conn. — 44.1 mc.
Operated by WDRC, Inc.
Still using only 1-kw. transmitter.
Columbus, Ohio — 44.5 mc.
Operated by WBNS, Inc.
New transmitting facilities now under construction, but not yet completed.
W9XZR, Chicago, Ill. — 42.8 mc.
Operated by Zenith Radio Corp.
Still using 5-kw. transmitter.

This list includes only the stations which have been on the air for some length of time. A considerable number of construction permits have been issued for stations now being built. These stations are designed to qualify for full commercial operation as soon as they are on the air, and will deliver the required signal in their assigned areas from the beginning. Sales will move much faster in such sections than where low-power stations of limited coverage have been operating.

Reviewing the FM situation on the basis of the facts, progress in set sales, within the limitations of the average dealer's merchandising ability, has been highly satisfactory. Broadcasting and set sales must necessarily move forward together, with the broadcasters taking the initiative, since they are organized to do promotion that is beyond the capacity of most retail stores.

Some dealers have expressed the opinion that it would be unfair to sell their customers FM-AM sets at this time. A little questioning invariably discloses the fact that these dealers are not familiar with FM reception, and in most cases, have never heard an FM program.

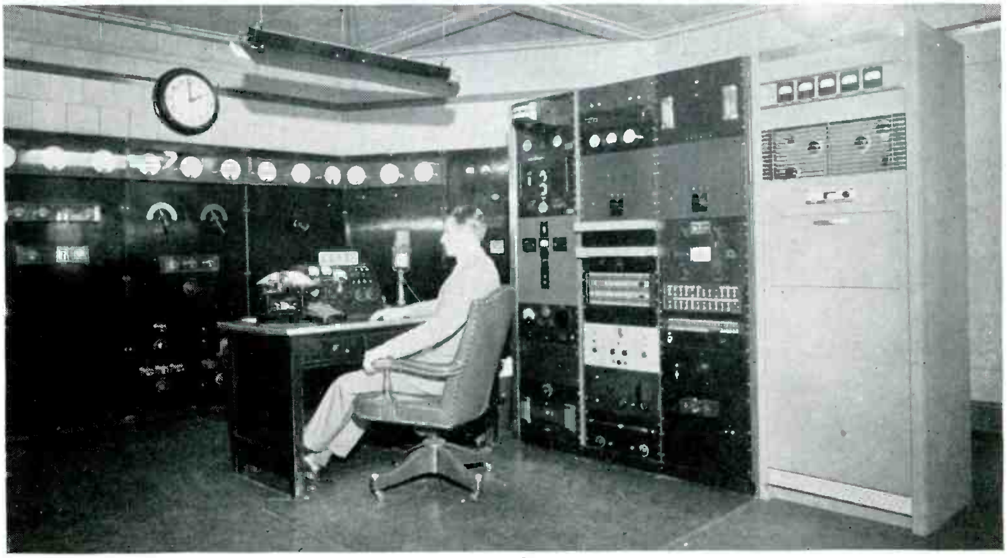
The fact is that the best AM reception that any dealer can sell is that provided by the AM band of an FM-AM receiver. This statement is not a matter of editorial opinion. It is because these sets have technical improvements, particularly in the audio amplifier and in the speaker system, which are not available in straight AM sets.

When it comes to the matter of giving the customer a square deal, the dealers must answer the question: "Is it fair to let the customer who wants a good radio buy a set that he will find inadequate as soon as he wants to hear FM programs?" How will the customer feel then, when he finds that the radio he expected to use for several years is virtually obsolete?

"But," some dealers say, "the FM band makes the set cost a lot more than a straight AM receiver." Well, let's see. Take the FM tuner out, and how much difference would it make? Actually, the difference is surprisingly small.

(CONTINUED ON PAGE 48)

WEBC, DULUTH, OPERATES FM IN CONJUNCTION WITH THEIR AM STATION, BUT FM OUTPUT HAS NOT BEEN UPPED TO MEET REQUIREMENTS OF FCC FOR COMMERCIAL OPERATION



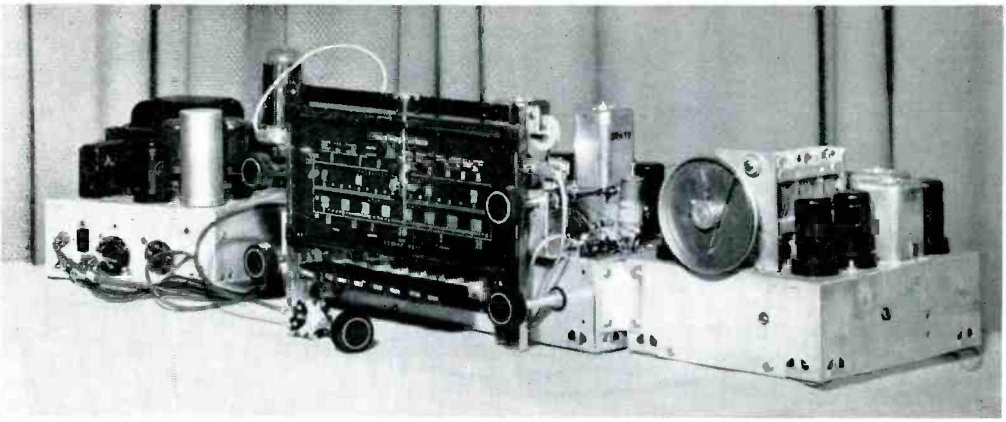


FIG. 1. THESE AM AND FM CHASSIS ARE MOUNTED SIDE-BY-SIDE. AMPLIFIER IS SEPARATE

FM-AM ENGINEERING DATA

Part 1. Explaining the Circuit Design Details and Performance of the Stromberg-Carlson Model 535 Three-unit FM-AM Receiver

BY M. L. LEVY*

FOR many years before the practical use of wide-band frequency modulation for broadcasting service, the laboratories of the Stromberg-Carlson Company were at work to perfect equipment for radio receivers capable of reproducing a range of frequencies from 50 to 10,000 cycles uniformly. These developments, made not only in the audio and radio systems, but also in the loudspeakers, were responsible for the number of amplitude modulation receivers produced by this company bearing the name "high fidelity" receivers.

The receivers were capable of reproducing frequencies from 50 to 7,500 cycles within 2 db. The cut-off point had to be at 10,000 cycles because of the 10,000-cycle beat note between adjacent channels. It was found that these receivers were useful only in a few places, viz., large centers where extremely powerful transmitters were available to produce strong signals. There were, up to a few years ago, few transmitters even in the large metropolitan centers capable of doing justice to receivers of such characteristics. The noise level on most amplitude transmitters is not nearly low enough for reception on a good high fidelity receiver. The exceptions to this are the more recent 50 kw. transmitters which give exceptionally strong signals in the metropolitan centers at reasonably low noise levels. Thus high fidelity in amplitude modulation is difficult to sell to the public because it is limited in its usefulness to one or two stations in any locality. The advent of frequency modulation is welcomed because of the inherent ability of the new system to produce not only high fidelity as we have known it in the past under ideal conditions, but a complete naturalness of reproduction, due to the even more extended frequency range with low noise levels. In amplitude modulation, the best conditions give only a top frequency of 7,500 cycles, and the desired signal has to be about 100 times the interfering signal to produce an adequate signal-noise ratio, whereas in frequency modulation the possible top frequency is 15,000 cycles, and the desired signal need only be two or three times the interfering signal to give the signal-noise ratio required to eliminate the interference.

Thus, we actually provide in FM receivers the advantages for which we strove in AM types, namely, the use of wider audio frequency range, better signal-noise ratio and dynamic range resulting from the better signal-to-noise ratio, usability of weaker signals, less interference on the same channel and adjacent channels by virtue of the extremely reduced ratio of desired to undesired signal necessary, and reduction of man-made and natural static effects to a negligible value under conditions of relatively weak signals.

The opportunity having presented itself to produce receivers for wide-band frequency

*Engineer-in-Charge, Radio Development Laboratory, Stromberg-Carlson Telo. Mfg. Co., Rochester, N. Y.

modulation broadcasting brought home the realization that this new system could do justice to the equipment available for not only extended high frequencies, but also our system of better low-frequency response using the Stromberg-Carlson "labyrinth", all of which had been developed and used for amplitude modulation receivers.

The Stromberg-Carlson Company has produced eight different models of frequency modulation receivers, three using the experimental range of 40 to 44 mc. and, subsequently, five using the final range of 42 to 50 mc. This number does not include cabinet variations using the same chassis.

chassis is the six-tube FM amplifier unit, with a 6AB7 RF amplifier, 6SA7 oscillator-converter, 6AB7 first IF amplifier, 6AC7 second IF amplifier, 6SJ7 limiter, and 6H6 frequency detector or discriminator. This unit is shown in Figs. 3 and 4.

The FM amplifier chassis and the main amplitude chassis are securely fastened together mechanically and connected electrically by a cable and plug. The power supply and audio amplifier chassis, mounted separately, are connected electrically by a cable and a plug, as shown in Fig. 2. The No. 535 receiver provides push button operation on FM as well as AM. The FM chassis has its own 3-gang

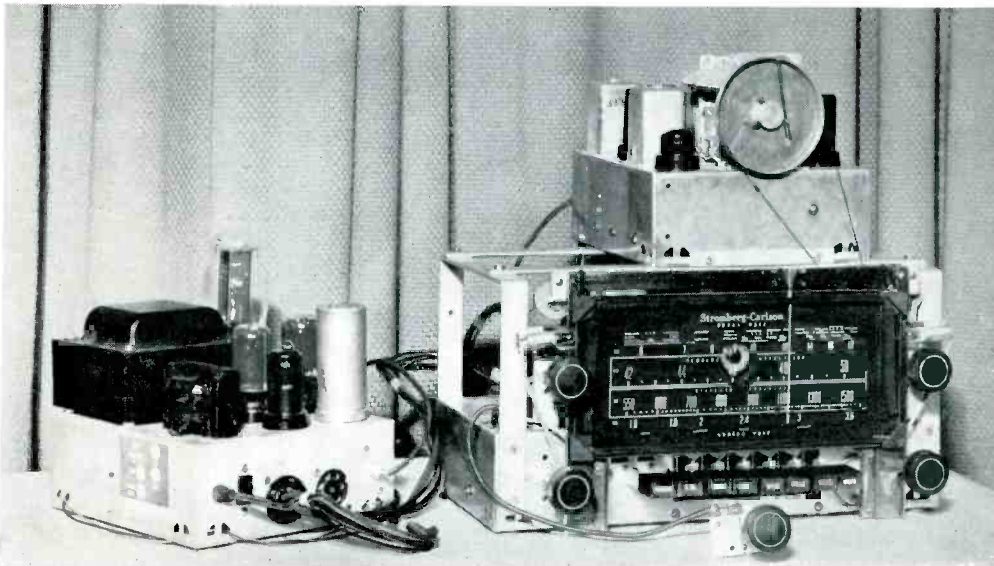


FIG. 2. HERE THE FM CHASSIS IS MOUNTED ABOVE THE AM UNIT. THIS TYPE OF MECHANICAL DESIGN OFFERS GREAT FLEXIBILITY, SUITING ALL KINDS OF CABINET STYLES

The model 535 chassis, chosen for detailed discussion in this article, has many interesting mechanical and electrical features. This is a 15-tube receiver, capable of delivering the extra performance expected by the public from FM-AM sets. The chassis is divided into three separate sections for reasons of simplicity in manufacture, as will be seen in Figs. 1 and 2. The main AM chassis carries five tubes, 6SK7 RF stage, 6SA7 oscillator-converter, 6SK7 IF amplifier, 6SR7 audio amplifier, and the 6U5 tuning indicator tube which is used for both FM and AM. The power supply and final audio amplifier are housed on a second, four-tube chassis, with a 6SC7 dual triode used as the second audio amplifier and push-pull inverter tube, two 6V6GT output tubes, and a 5U4G rectifier tube. The third separate

capacitor with about 29 mmfd. per section. The amplitude chassis contains a 3-gang capacitor for the antenna, RF stage, and oscillator, and has a mechanical unit for setting the push buttons. The AM and FM capacitors are corded together to operate from one control as shown in Figs. 1 and 2. This also allows the use of a common pointer and dial scale. Therefore, since 6 buttons are available for stations, any number desired can be used for FM. This direct method of pre-set stations has proved to be very successful since no extra circuit elements are added by the use of push buttons. The FM and AM operation for setting up the buttons is simplified and does not require a service man to adjust them.

The switching from AM to FM is a simple operation of pushing a button shown in Figs. 1

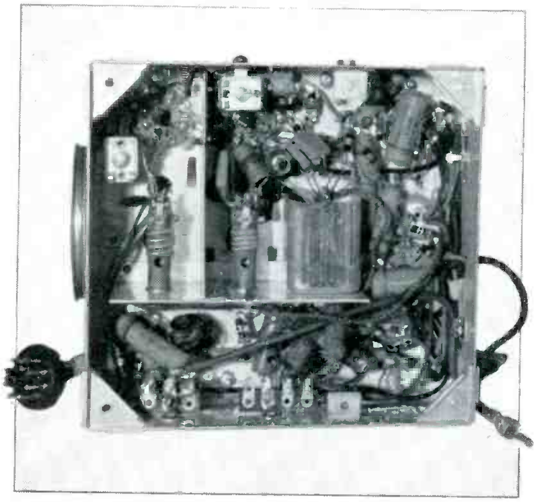


FIG. 3. BOTTOM VIEW OF THE SEPARATE FM CHASSIS

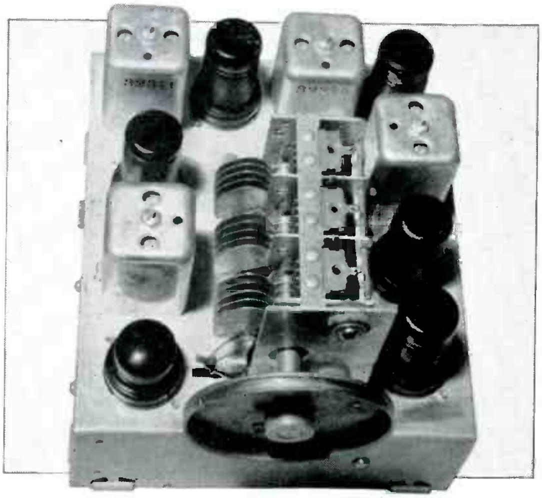
and 2. An examination of the circuit, Fig. 5, shows that the B supply is removed from the AM chassis and switched to the FM chassis. The result is instantaneous operation of FM because the heaters of all tubes, both FM and AM, operate with the on-off switch of the receiver. Switching from FM to AM reveals that some of the amplifier tubes of the FM take current even though not used. This is done to keep the B drain the same on AM and FM, since the FM operation of the receiver draws more current than the AM position. It will be noted that the tuning indicator circuit is operated on the limiter current for FM. The reliability of this method has been proven over a period of time, showing that the circuits are so designed that the center of the IF and the center of the discriminator always coincide. Previous designs of tuning indicators have operated from the discriminator, which indicates exact resonance with the discriminator. Such a circuit is used in the No. 585-M Stromberg-Carlson receiver. The limiter current method for tuning indication as used in the No. 535 receiver is successful because of the precautions taken to prevent the grid current of the limiter from failing to provide enough RF power to supply this grid current. This is accomplished by providing just enough AVC on the amplifier tubes to hold their characteristics to such a point of being free from the above mentioned effects. Tuning an FM receiver is aided greatly by the use of a tuning indicator tube, because of the loss of audio quality from off-resonance adjustment. It is felt that if such provision is not made, the receiver is lacking an essential feature.

The design of the amplitude section of the receiver is quite conventional, containing a rotatable loop, used for reception on the broadcast band and police ranges. A short-wave loop is provided on the back of the cabinet, along with a folded di-pole for FM operation. The conventional range switch is used to switch bands. The frequency characteristic at 1000 kc. on the broadcast band is shown, together with the selectivity and sensitivity, in Fig. 8, Part II, of this article.

In several respects, the design problems of the FM end of a receiver are different from those to be met in the AM end, not only because of the difference in the functions of the circuits, but because there are advantageous factors which make possible the achievement of improved FM performance.

The measure of sensitivity in an FM receiver is its ability to operate the limiter from relatively weak signals. The FM receiver, because of its inherent noise-reducing features, is designed for much greater over-all sensitivity than would be possible with AM circuits. The reason for this is that the tube noise of the receiver is of amplitude variety, and is not detected by the frequency detector. Therefore, the greater the sensitivity, the quicker the receiver is rendered quiet by weak incoming signals, due to its limiter and balanced detector action. It also follows that a much weaker signal is usable with an FM receiver than an AM receiver at the same carrier frequency. Sensitivity contributes to the over-all noise in an amplitude-modulation receiver and reduces noise in a frequency-modulation receiver. Therefore, frequency-modulation receivers must be designed to be as sensitive as is possible with good stability in order to

FIG. 4. THIS IS THE TOP VIEW OF THE FM CHASSIS



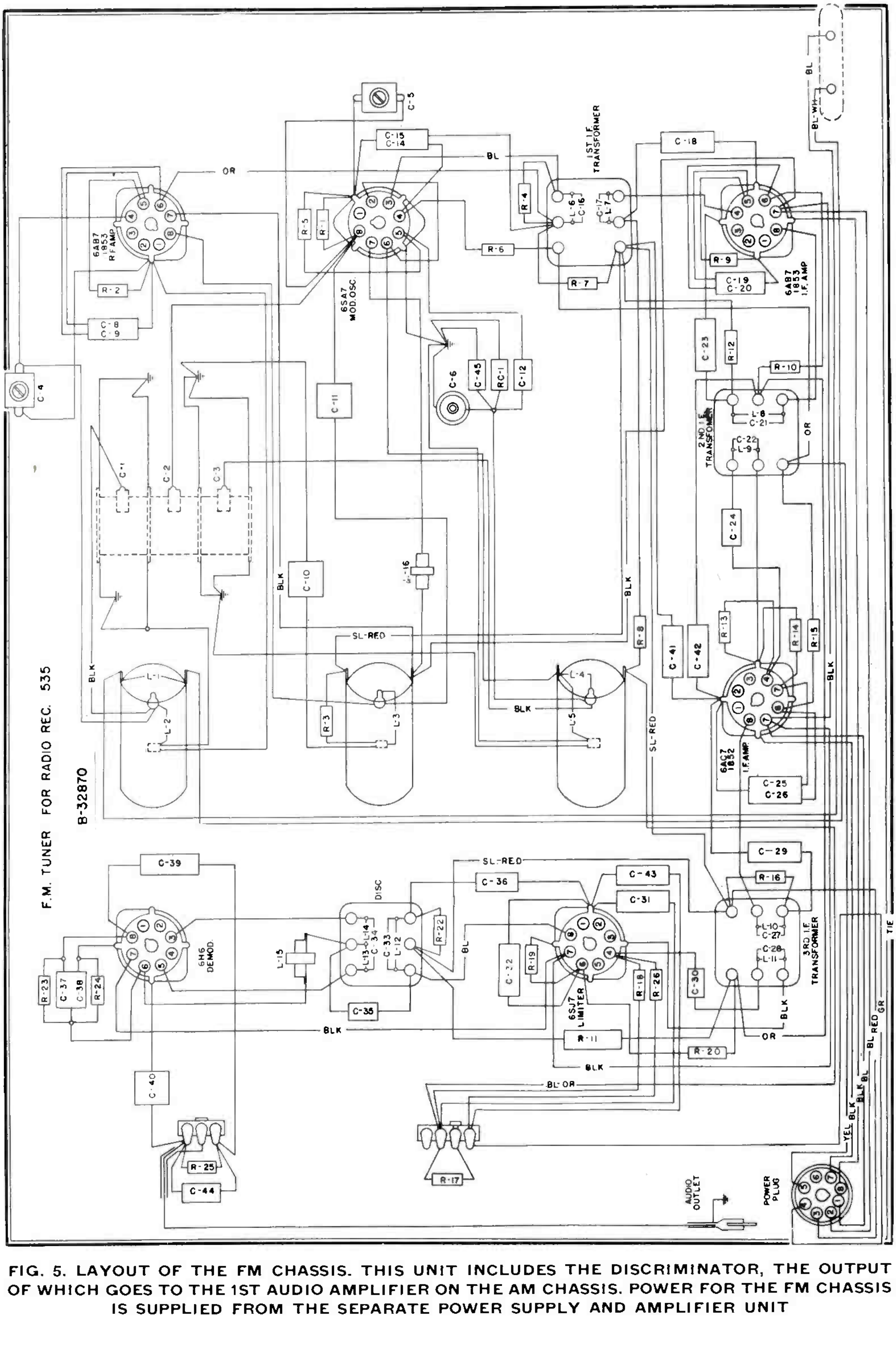


FIG. 5. LAYOUT OF THE FM CHASSIS. THIS UNIT INCLUDES THE DISCRIMINATOR, THE OUTPUT OF WHICH GOES TO THE 1ST AUDIO AMPLIFIER ON THE AM CHASSIS. POWER FOR THE FM CHASSIS IS SUPPLIED FROM THE SEPARATE POWER SUPPLY AND AMPLIFIER UNIT

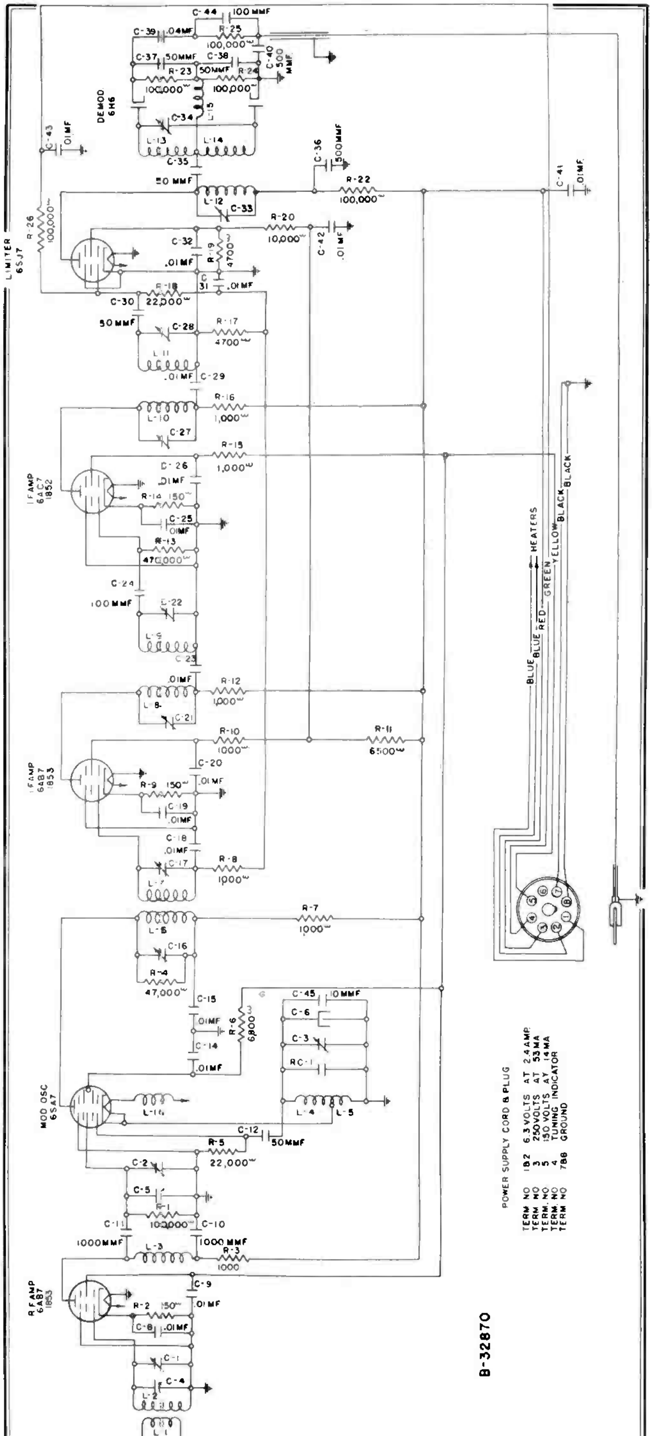


FIG. 6. SCHEMATIC EQUIVALENT OF CONNECTIONS IN FIG. 5

reduce circuit and external noises at low field strengths.

In the No. 535 receiver, this sensitivity is obtained by using two stages of IF with high mutual conductance pentodes, a 6AC7 in the second stage which produces a gain of about 60 times. The 6SA7 tube produces a conversion gain of about 6 times, allowing a total intermediate-frequency amplifier gain of about 15,000 times. It is to be noted here that such gains require very careful circuit design because slight regeneration becomes extremely detrimental to symmetrical circuits. Well designed and symmetrical circuits in an FM receiver are necessary to produce low harmonic distortion at low field strengths, whereas in an AM receiver, circuit design is secondary from the harmonic distortion standpoint, and linear characteristics of tubes must be maintained. Tube characteristics, except for amplification, are secondary in an FM amplifier.

The RF sensitivity at 42 to 50 mc. is obtained by the use of a tuned RF stage which is impedance coupled to the converter to obtain a gain of approximately 20 times. The antenna step-up from a 100-ohm line is also obtained by using a tuned stage, netting a gain of 4 times over the band. Thus, the RF gain is a total of 80 times, and the gain of the whole amplifier is about 1,200,000 times from antenna to the limiter grid.

The choice of the IF frequency of 4.3 mc. for the No. 535 was based on the first consideration that the lower the frequency in the IF amplifier, the better gains can be obtained not only per stage but over all. Also, this IF frequency was chosen so that no image frequency would occur in the band of 42–50 mc. Now, since the oscillator is below the carrier, and the IF frequency must be more than one-half the total band.

(TO BE CONCLUDED IN MARCH)

ARMSTRONG FM PATENT LICENSEES

List of the Manufacturers Licensed for the Various Applications of the Armstrong FM Patents, as of January 1, 1941

THE year just ended has witnessed phenomenal progress toward the establishment of FM broadcasting on a national basis, and the performance obtained by police and emergency equipment indicates that a general transition from AM to FM for this service can be expected. Following is the list of manufacturers, operating under Armstrong FM patent licenses, who have done the pioneering work in this field:

1. Manufacture of Broadcast Transmitters:

Radio Engineering Laboratories, Inc., 35-54 36th St., Long Island City, N. Y.

General Electric Company, River Road, Schenectady, N. Y.

Western Electric Company, 195 Broadway, New York, N. Y.

2. Broadcast Receivers:

General Electric Company, (address above)

Stromberg-Carlson Telephone Manufacturing Company, 100 Carlson Road, Rochester, N. Y.

Zenith Radio Corporation, 6001 Dickens Avenue, Chicago, Illinois

E. H. Scott Radio Laboratories, Inc., 4450 Ravenswood Avenue, Chicago, Illinois

Pilot Radio Corporation, 37-06 36th Street, Long Island City, N. Y.

Stewart-Warner Corporation, 1826 Diversey Parkway, Chicago, Illinois

Ansley Radio Corporation, 4377 Bronx Boulevard, New York, N. Y.

Freed Radio Corporation, 39 West 19th Street, New York, N. Y.

Philharmonic Radio Company, 12 West 45th Street, New York, N. Y.

Espey Manufacturing Company, 305 East 63rd Street, New York, N. Y.

3. Amateur and Experimental Receivers:

National Company, Inc., Malden, Mass.

Hallicrafters, Inc., 2611 So. Indiana Avenue, Chicago, Illinois

The Hammarlund Manufacturing Company, Inc., 438 West 33rd Street, New York, N. Y.

4. Special Receivers for Broadcasting Companies:

Radio Engineering Laboratories, Inc., (address above)

Western Electric Company, (address above)

5. Mobile Communication and Miscellaneous Apparatus:

Radio Engineering Laboratories, Inc., (address above)

General Electric Company, (address above)

F. M. Link, 125 West 17th St., New York, N. Y.

Finch Telecommunications, Inc., Passaic, N. J.

6. Aviation Apparatus:

Radio Engineering Laboratories, Inc., (address above)

General Electric Company, (address above)

This list will be augmented by the addition of several prominent radio manufacturers who are now preparing to manufacture FM-AM broadcast receivers and, in the meantime, are completing negotiations for licenses under the Armstrong FM patents. It is understood that FM equipment will play an important part in Signal Corps communication. This is probably due to the fact that mobile FM transmitters deliver a higher ratio of output to input power than AM transmitters, and that a greater range of communication[1] can be obtained, for the same output, with FM. Very likely the fact that there is no secondary area of transmission on FM is a point in its favor for military service, since that limits the opportunity for the enemy to listen in.

[1] See: Two-way Police FM Performance, by Sidney E. Warner, FM Magazine, January, 1941.

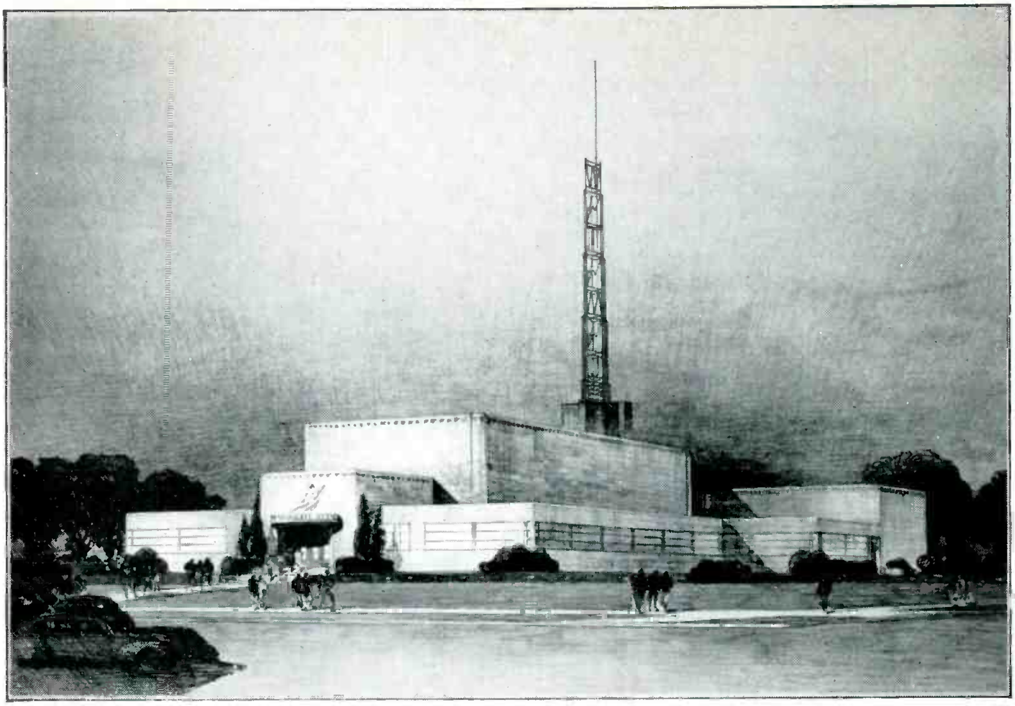


FIG. 1. NEW STUDIO AND OFFICE BUILDING WHICH WILL BE BUILT EARLY IN THE SPRING

FM FEATURED IN $500,000 PLANT

Milwaukee Journal's Own Radio City Will Provide Special Facilities for FM Program Production, to Serve 1,500,000 Population

ASSURED of a free hand in its plans to build an FM audience by the FCC's authorization of a transmitter to cover 8,500 square miles, the Milwaukee Journal is now going ahead with a half-million-dollar investment in studio plant and equipment, and transmitting facilities. Work on the FM transmitter building has been started already, and construction of the new studios will begin early in the spring.

This represents an expansion of The Journal's activities on both AM and FM. Station WTMJ, of 5,000 watts, was originally permitted only 1,000 watts after sundown. However, the FCC granted authority last year for the erection of two additional towers for a directional antenna to be used for full-power night transmission.

The original FM transmitter, using 1,000 watts at 42.6 mc., has been granted permission to continue on an experimental basis. The new station, with 10,000 watts on 45.5 mc., will have the call letters W55M. It is estimated that this power will cover the assigned area of 8,500 square miles, with a population of 1,500,000.

Work on the FM transmitter is proceeding rapidly. The site of the building, shown in Fig. 3, is 21 miles northwest of downtown Milwaukee, on US Highway 41. The elevation at the base of the tower is 450 ft. above the City of Milwaukee. The FM building will house the mechanical equipment and living quarters for the engineers. It is assumed that a wire line will be used to carry programs from the studio to the FM transmitter.

The plan of the new studio building, designed by Eschweiler & Eschweiler, architects, is an interesting study in modern facilities. Fig. 1 shows the drawing of the building, with the floor plan in Fig. 2.

The Journal's Radio City will contain seven studios, in addition to the giant three story sound stage, and will include an audience

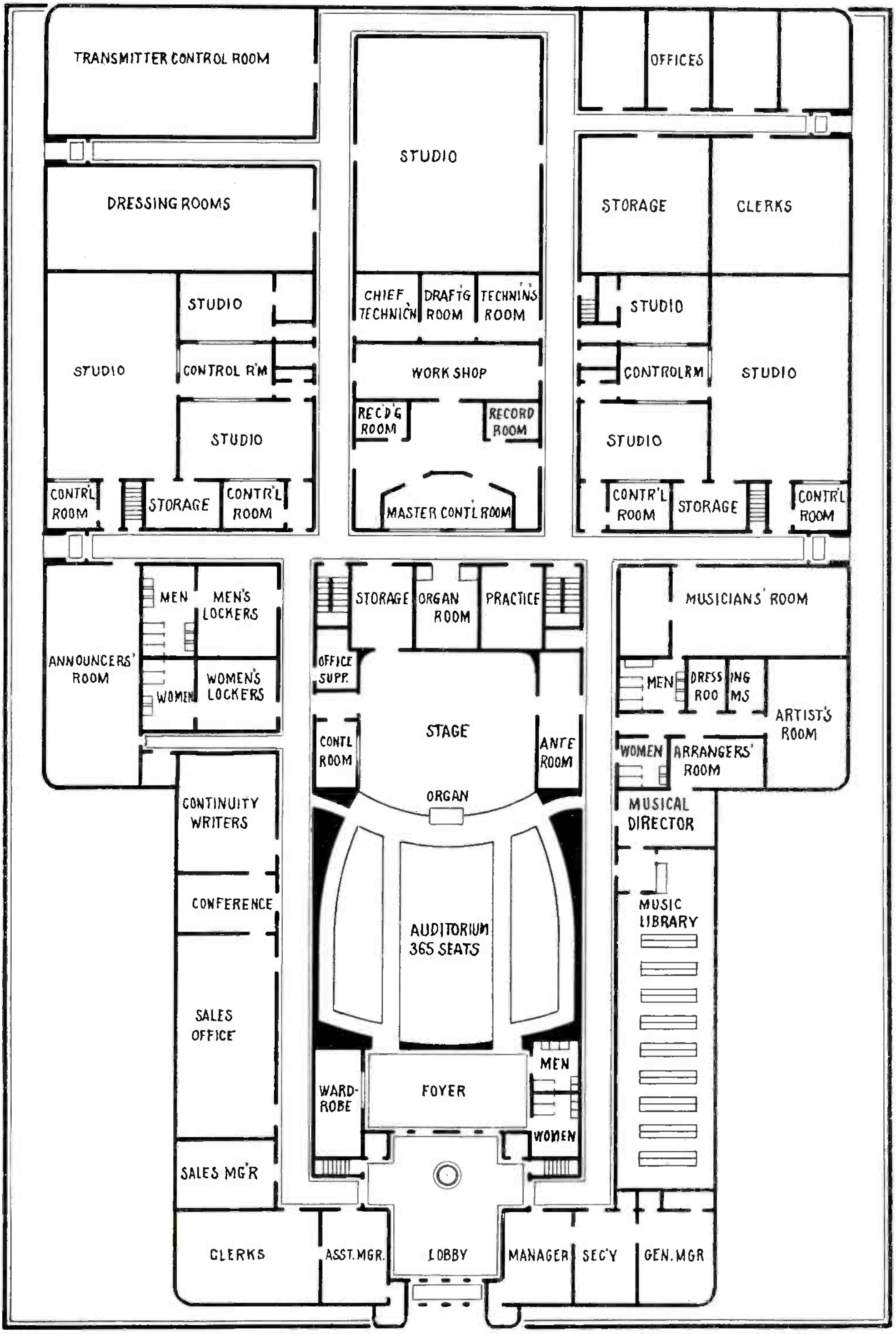


FIG. 2. THE LAST WORD IN COMPLETE AND MODERN BROADCASTING STUDIO CONSTRUCTION

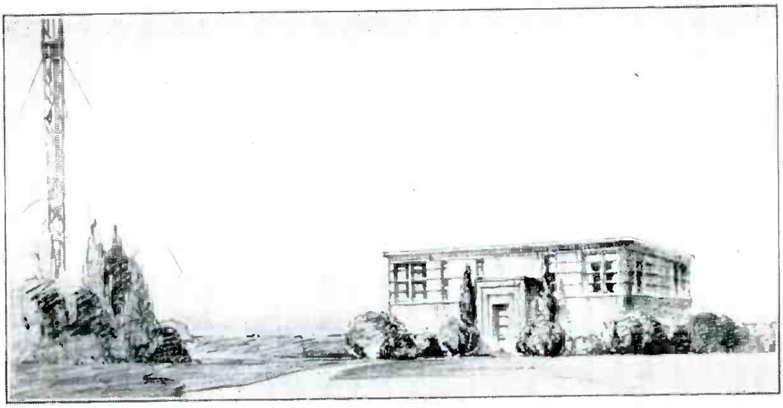


FIG. 3. CONSTRUCTION IS UNDER WAY ON THIS SEPARATE FM TRANSMITTER BUILDING

studio and six other studios of varying size — three for WTMJ and three for the FM station. The building also will house executive and program departments, musicians, announcers, music library, master control desk, short wave relay equipment and several storerooms and workshops.

The T-shaped building will have its narrow end facing the street and will be 114 feet wide at that point and 170 feet wide at the rear. Its depth will be 282 feet and height will range from one to three stories.

On entering the building, the visitor will find himself in a rectangular lobby. To right and left will be the front and sides of the building. All will have outside exposures and will be finished in the most modern manner, with the last word in lighting and air conditioning.

Directly ahead of the guest as he enters will be the double entrances to the audience studio. Just off the lobby will be the foyer, with check room at the left and rest rooms at the right. This studio will be patterned along the lines of the NBC audience studios in Hollywood — designed for a feeling of intimacy between the audience and performers, and still large enough to seat 365 people on the main floor alone. It also will have a glass enclosed balcony, but this will not have permanent seats, so that it can be used to serve several purposes, including receptions and meetings in addition to its probable use for additional audience space. In the center and front of the balcony will be a projection booth, fully equipped to show films.

The stage will have a curving apron and will be approximately 35 by 35 feet. A pipe organ will be installed at the rear of the stage, with the loft behind it, out of sight. The loft for the pipes will be three stories high — the height of the audience studio — insuring perfect tonal reproduction of organ music.

At left stage will be a glass enclosed control booth, where operators and production men will handle the technical details of broadcasts from the audience studio. On the other side, offstage, will be a lounge room for artists waiting to make their appearance, and above it will be a glass enclosed observation booth for clients and their guests. Back of the stage will be rehearsal rooms and storage space, while dressing rooms for artists will be across the corridor adjoining the artists' lounge.

Also flanking the stage across the corridor on the right will be the musicians' lounge, a room for arrangers, and storage space for musical instruments. All these rooms will be connected by a corridor with the office of the musical director and the music library toward the front of the building.

Flanking the stage at the left will be the announcers' offices, teletypes for news broadcasts and space for the news editors. These will be connected by a corridor with the continuity writers' office, sales and general offices toward the front.

A corridor cutting back of the stage from left to right divides the offices mentioned from the studios and control rooms placed near the back of the building. At the left will be three studios and control rooms for WTMJ, and at the extreme right the same number of studios and control rooms for the FM station. Between these two groupings will be the master control room built on the style of New York's Radio City. A huge plate glass window on the corridor will give visitors an opportunity to see how a radio "nerve center" works.

Back of the master controls will be the miles of wiring necessary to link studios and transmitters, amplifiers and switchboards. There also will be the workshop for the radio engineers. Offices for the chief technician and his assistants will be in this section, and also a storeroom for spare equipment.

PRACTICAL IDEAS FOR FM ANTENNAS

Highlights on Noise Elimination, from a Trouble-Shooter's Experiences

BY TORE LUNDAHL *

ONE of the reasons that FM has made such rapid progress in the New York City area is that, with a background of experience in television, the special problems of ultra-high frequency reception are fairly well understood. Naturally, perfect FM reception is easier to obtain than perfect television pictures, since many conditions which cause video troubles do not affect audio reception, and most of the interference on the AM television channel is eliminated by the change to FM.

Of course, when a television set is sold, the customer expects to use a special antenna, but many people think that because an FM-AM receiver is only for sound, it should give noise-free reception with any old piece of wire for an antenna, or even no antenna at all.

The fact that some people do get proper results with odd bits of wire just makes it harder for others to understand why they need to use outside antennas. Experience has shown that the outside antenna should be used in such a high percentage of installations that the smart dealer sells an antenna with every FM-AM receiver, so that the set will give perfect performance at the start. This avoids initial dissatisfaction, and the arguments that arise when a customer finds that he must spend more money in order to use what he has already bought.

The accompanying illustrations show three TACO FM-AM antennas which, with the matching transformers at the mast and at the set, deliver the maximum signal and minimum noise to the receivers. The horizontal di-pole, Fig. 1, is for use where all FM transmission is of horizontal polarity. The rods supplied are 69-ins. in total length, which is correct for the FM band. They are carried on a sturdy mast of two 4-ft. sections. All parts are mounted and the connections are made, so that the assembly and erection take only a few minutes.

In New York City, where WOR emits vertically polarized waves, and the other stations use horizontal polarization, the di-pole shown in Fig. 1 may still be all right, but if the antenna is to be at some distance from WOR, it may be necessary to use a special mounting bracket for the rods, so that they can be tipped, as in Fig. 2. This improves the pick-up of vertically polarized waves, without affecting reception of horizontal waves.

Where maximum efficiency is needed for both types of waves, two sets of di-pole rods are required, as in Fig. 3. One set is mounted horizontally, and the other vertically, with connections to the transmission line as in Fig. 4.

Connections from antenna transformer to the set are shown in Fig. 5. Leads to the set must be kept to minimum length, and twisted together. If the leads are long, they may pick up electrical interference. Several FM-AM sets can be connected to one antenna by using the special multiple transformers illustrated in Fig. 6. Connections to two different types of receiver antenna circuits are shown. This system was developed by TACO for use in radio stores, particularly.

In a recent bulletin from FM Broadcasters, the statement is made: "In many cases, a simple indoor antenna, consisting of a short bit of twisted wire fanned out above the molding at the top of the wall will be adequate to bring in strong FM reception." From my experience with FM receiving conditions as they exist today, I feel that such statements are liable to do much harm.

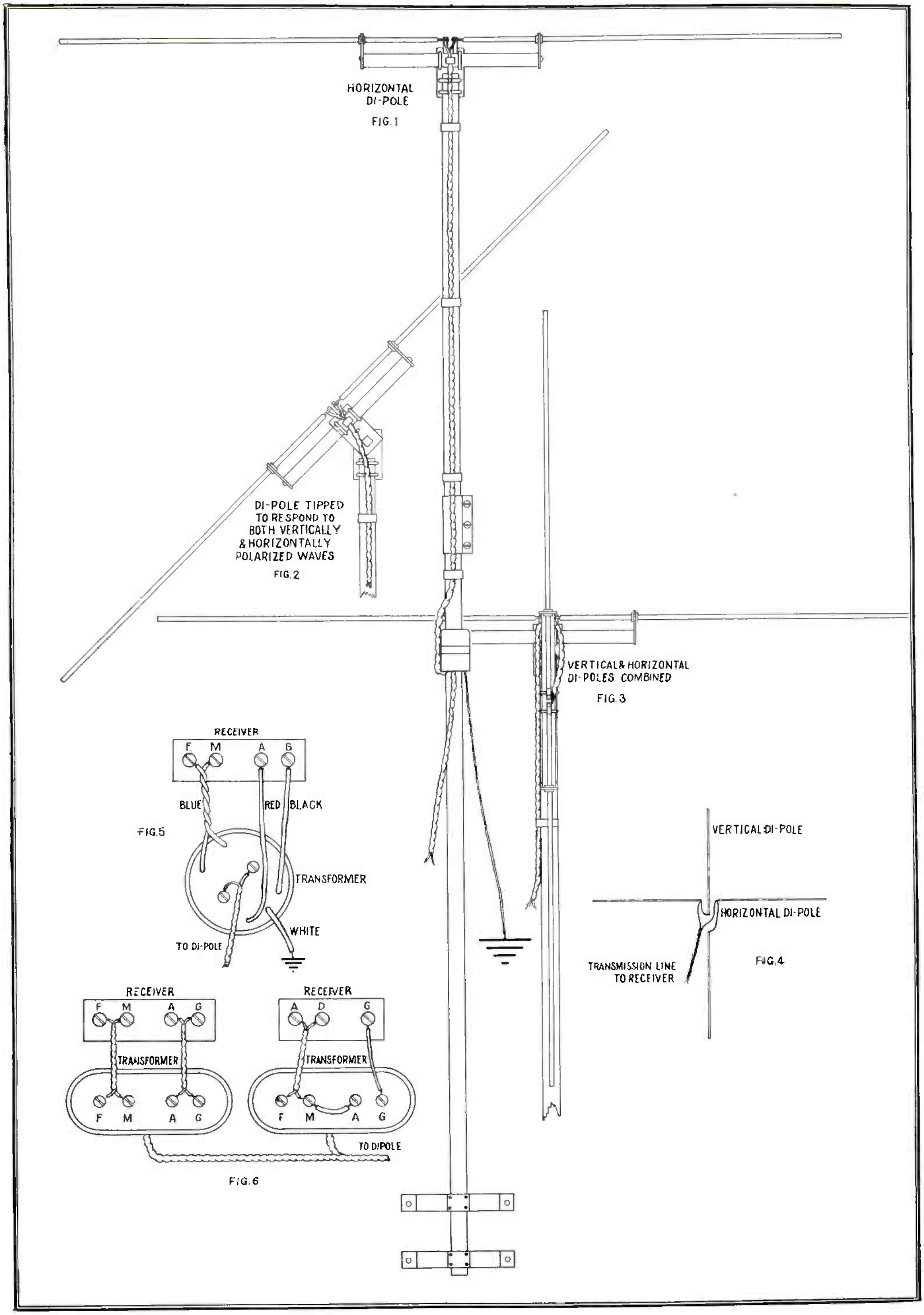
Reception with such an antenna may be good from a strong, nearby station. However, the owner will hear other stations but not satisfactorily. Then he will complain: "My set doesn't work right. I get good reception only from one station!" Right now, with a limited number of transmitters on less than the output required by the FCC for commercial operation, the best antenna possible is needed in order to give listeners the widest range of programs possible.

Conditions will change undoubtedly when more stations are on the air, and with full power. Meanwhile, sets are being bought, and their owners want satisfactory FM performance right now.

City apartment houses do present something of a problem to the serviceman who must erect a di-pole antenna. Usually, though, the superintendent or owner who objects is thinking of the hazards from wires strung across the roof. When he realizes how neat and tidy a di-pole really is, and that the only wire involved is the lead, dropping straight down to a window, he will probably relent. The objectionable and dangerous antennas are the AM types, which have wires running between

(CONCLUDED ON PAGE 32)

* Technical Appliance Corp., 17 E. 16th St., New York City.



FIGS. 1 to 6. DETAILS OF TACO FM-AM DI-POLE ANTENNAS, AND THE RECEIVER CONNECTIONS

WILLIAM A. READY

TYPICAL OF HIS PRODUCTS IS THE FAMOUS NATIONAL VELVET VERNIER DIAL, BROUGHT OUT IN 1922 AND STILL UNEQUALLED FOR SMOOTH ACTION AND LONG LIFE. EQUALLY SMOOTH AND DEPENDABLE ARE HIS NATIONAL COMMUNICATIONS RECEIVERS, MANY OF WHICH ARE NOW BEING SHIPPED OVERSEAS TO SERVE IN THE DEFENSE OF BRITAIN

THE MANUFACTURERS SAY:

A Statement by William A. Ready, President of the National Co., Inc., Malden, Mass.

THE particular interest of the National Company in FM equipment concerns its application to communication service, where great reliability of operation is required.

For many years, we have specialized in the development, engineering, and manufacture of communications receivers designed for commercial, government, and amateur use. This program, carried on continuously for nearly 20 years, has resulted in the production of AM receivers which, in all fields of communications service, have achieved a surprising certainty of operation.

Now, going into the manufacture of FM receivers, we have undertaken this project with the same care and deliberation. We have designed many special parts, and have tooled up for their production, since it has always been our policy to manufacture all components entering into the construction of our sets.

Since price is not a limiting factor in communications equipment, and performance is the primary consideration, we have gone to great lengths to obtain the last measure of efficiency, accomplished through the use of low-loss materials and ingenious mechanical designs.

Some of the first of our FM receivers were supplied for service in Alaska, where climatic conditions are most unfavorable, and where the northern atmospheric static is extremely troublesome at times, even with rather high signal levels. In this application, the noise-reducing characteristics of FM reception were used to full advantage, and were found to be far superior to AM. Moreover, a wide-range audio channel was specified, since audio tone signals had to be transmitted simultaneously with speech, and without mutual interference. I am glad to say that the equipment proved to be most successful.

We were particularly interested in this case, because it gave us a chance to compare the FM sets with our highly perfected AM receivers. The latter type has been found to deliver spectacular performance, but under the conditions of comparison, the FM sets proved more satisfactory!

This and subsequent experiences have convinced us that FM will become increasingly important for certain applications in the communications field.

We are equally certain, however, that FM is no royal road by which better results can be obtained from poor engineering and construction. Sloppily-designed and cheaply-built sets will be just what they have always been, whether AM or FM. Happily, in National's chosen field, our business is with customers who require the fullfillment of exacting performance specifications, so that we can build to high-quality standards without being at a price disadvantage.

Competition between FM and AM equipment will unquestionably result in great improvements in both types of equipment. As long as radio was limited to the AM system, there was a tendency in some instances to say: "This is the best we can do, and you'll have to be satisfied." Now, with an alternative method of communication available, there will be a new incentive to further research and development. Within our organization, we shall not slight one system and favor the other. Rather, we shall put forth every effort to provide the best equipment of both types, so as to meet any given set of conditions which may arise.

Most of the development work on FM has been in connection with high-fidelity broadcasting. This represents only a part of the possible applications, however. It seems likely that numerous developments which met with only partial success when used with AM transmission may prove to be of commercial value when they have the benefit of FM's special advantages.

It is too early to say whether national defense activities will accelerate or delay such projects. The superheterodyne was the result of communication needs during the last war. Similar conditions may do much toward bringing about important applications of frequency modulation.

In the meantime, we shall push ahead with the development of FM for communications work in the various fields where we have found that it offers special advantages. Our experience has convinced us that it will become increasingly important, and our FM equipment will be planned to take full advantage of its features of superiority over the AM system.

FIG. 1. FM STATION W57A IS IDEALLY LOCATED ON THE EDGE OF A STEEP CLIFF FACING THE AREA OF CONCENTRATED POPULATION. TRANSMITTING ANTENNA IS AT RIGHT

PLANNING AN FM STATION

An Outline of the Requirements and Cost of Installing and Operating an FM Broadcast Studio and 1-kw. Transmitter

BY W. R. DAVID*

FREQUENCY modulation is opening a new horizon for radio listeners, radio entertainers, radio broadcasters and radio manufacturers, and a wide field of activity and progress to the radio consulting engineers, radio distributors, radio dealers, radio advertisers, and the wire-line companies. Its possibilities challenge the ingenuity of men in all of these fields. The Federal Communications Commission has provided the FM broadcasting channels; the radio manufacturers are building transmitters and receivers; now we need FM broadcast stations, better programs, improved wire-line facilities, and FM audiences.

Inquiries and correspondence about the installation and operation of FM transmitters, from companies now operating AM stations and from those who look upon FM as an opportunity to enter the broadcasting field, indicate the need of supplying at least general information to the legal requirements, the plan of the studio and transmitter, the electrical and mechanical equipment involved, and the personnel needed to operate the station.

The purpose of this article is to outline and analyze these factors. Obviously, it is not possible to extend the scope to cover all the variations introduced by local conditions. Therefore, as a working basis, a 1 kw. installation is analyzed in detail. From this starting point, those interested can proceed to more detailed inquiry concerning their individual requirements.

Economics ★ The nature of transmission on the high frequencies (42 to 50 megacycles) used for FM broadcasting is such that the coverage can be predetermined with considerable accuracy. Therefore, a station is licensed by the FCC to cover a specific trading area, and such power is authorized, and must be used, as is needed to give satisfactory reception to listeners within that area.

The first step, then, toward establishing an FM station is a thorough study of economic conditions in the area to be served. In fact, such a study is practically essential in order to

* Radio & Television Department, General Electric Company, Schenectady, New York.

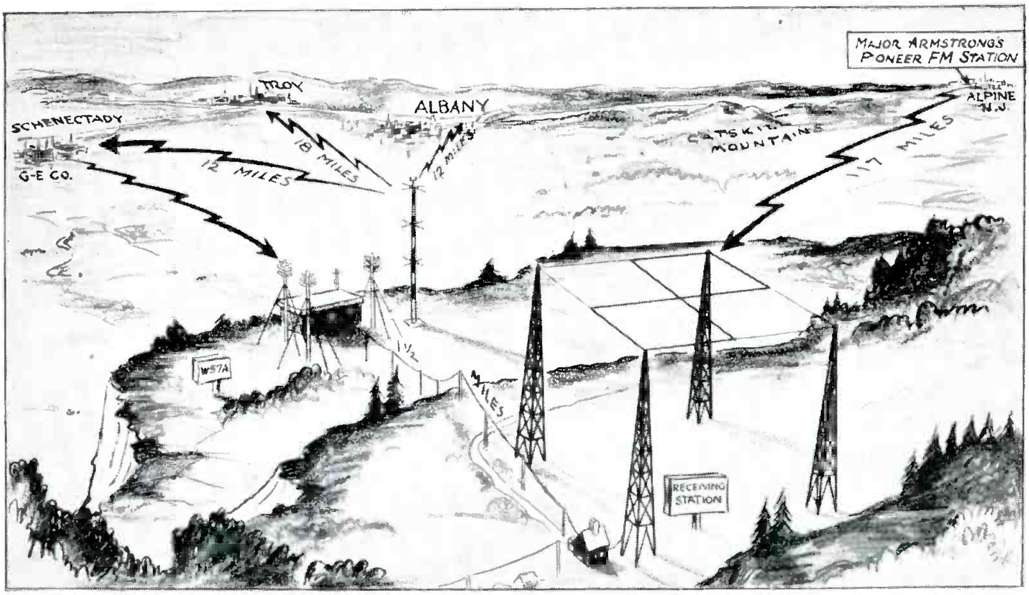


FIG. 2. HIGHER UP THE MOUNTAIN IS THE RELAY RECEIVING ANTENNA, USED TO PICK UP PROGRAMS FROM ALPINE. STUDIO-TO-TRANSMITTER LINK IS SHOWN BY ARROW

fill out an application to the FCC for a construction permit. The FCC has allocated 35 station channels to FM broadcasting. With their present policy of assigning every other channel in any one area, there could be as many as 17 stations[1] within a trading area. At present, this number seems to be more than most localities could support.

Therefore, practical economics are likely to limit the number of FM stations, whereas the number of AM stations is limited because no additional channels are available. With FM on an equal commercial footing with AM, this condition will tend to improve broadcasting through competitive ingenuity, aside from the technical advances provided by FM.

Although commercial operation is authorized by the FCC in the construction permits now being issued, it is unlikely that any appreciable revenue will be derived from an FM station during the current year. To avoid disappointment, it is recommended by many that an applicant for an FM station be prepared to operate it without appreciable revenue for at least two years. In this connection, it is interesting to note that some contracts have been signed with FM stations, to take effect when the stations qualify for commercial operation. Both sponsors and advertising agencies are following the progress of FM broadcasting with the closest interest.

On the bright side, it can be recalled that conventional broadcast frequencies were readily available in the early days of broadcasting. They could be had for the asking and today, even though the frequencies are not salable as such, stations holding those frequencies have appreciated greatly in value. FM is now in that beginning stage, and no crystal ball is needed to forecast that those will prosper who establish themselves now in FM broadcasting, and give the public the outstanding program service that the FM system makes possible.

A schedule of approximate costs has been drawn up for the general information of those who are unfamiliar with initial and operating costs of broadcast stations. Two sets of estimates are included, to show the approximate minimum and average costs of building and operating a 1-kilowatt FM station.

With a knowledge of the probable operating costs, the next step is to determine if the advertising possibilities in the proposed area are sufficient to justify the new station. This involves careful consideration of the following:

(a) Population in the proposed service area
(b) The wholesale trade in the area
(c) Volume of retail trade
(d) Purchasing power of the population
(e) Population and income levels
(f) Cultural status of the communities
(g) Number of AM receiving sets already in use
(h) Number of new sets purchased annually
(i) Advertising revenue realized by local newspapers and present radio stations

[1] Five additional FM station channels have been set aside exclusively for non-commercial educational broadcasting.

APPROXIMATE COST OF BUILDING AND OPERATING AN FM BROADCAST STATION

CAPITAL INVESTMENT

	Minimum	*Average*	*Minimum*	*Average*
A. Preparing & Filing Application with F.C.C.				
1. Legal services	$ 500	$ 1,000		
2. Engineerng services	500	1,200	$1,000	$2,200
B. Purchase & Installation of Equipment				
1. Transmitter, 1 kilowatt (a) Crystal (b) Spare tubes	$8,850	$9,300		
2. Antenna	100	1,500		
3. Transmission line	200	500		
4. Antenna support erected including lighting	500	1,200		
5. Studio, control room and transcription equipment	1,500	2,500		
6. Installation	400	1,100		
7. Field engineering	200	500		
8. Frequency monitor and modulation monitor	750	750	12,500	17,350
C. Special Expenses During First Year				
1. Engineering services and rental of equipment for: (a) Proof of signal coverage (b) Proof of overall audio performance Total Cost	$750	$1,500	750	1,500
D. Equipment for Picking Up Outside Programs				
i.e., sporting events, dance orchestras, etc.			300	600

E. Cost of Studio and Office Facilities

For the very minimum of facilities, space should be provided for two studios and a control room between them with the transmitter also located in the control room.

Some may prefer to have the transmitter in a separate room or a separate building, which arrangement would *necessitate the addition of three radio operators* to the personnel specified under B-3 of Maintenance. If the transmitter is in a separate building, another item must be added under C-1 of Program Production covering rental of a high-quality wire line between the control room and the transmitter. (Also, see text regarding installations requiring a studio-to-station radio relay circuit.)

In addition, there should be a reception room and two generous size offices — one office for the station manager and announcers and another for the engineer and operators.

When the station is first started, the station manager can act as the program director. His stenographer can act as the receptionist. Two announcers will be required. The engineer and two operators can look after both the control room and the transmitter. (Latter is possible only where transmitter is located in control room.) Subsequently, this personnel force may be expanded as warranted.

These facilities are for the smaller Class A and Class B FM stations.

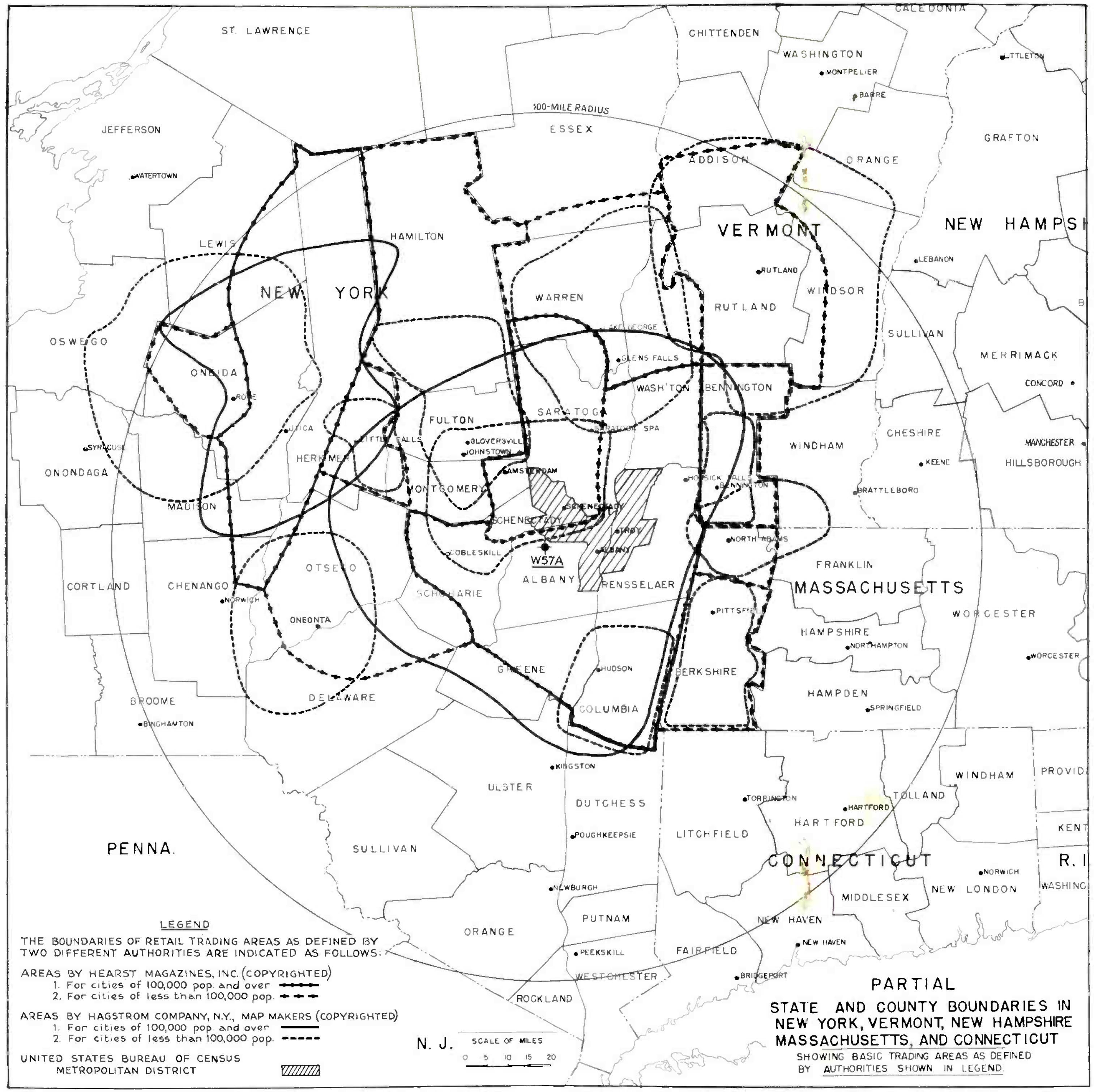
	Minimum	*Average*	*Minimum*	*Average*
1. Sound-proofing and structural alterations for studios and control room	$1,500	$3,000		
2. Studio and office furniture	1,000	2,000	$ 2,500	$ 5,000

Note: It is assumed that quarters may be rented for studios, control room, transmitter, and antenna. Rent is included for these under Maintenance.

	Minimum	*Average*	*Minimum*	*Average*
TOTAL INITIAL CAPITAL INVESTMENT			$17,050	$26,650
F. Additional Cost if Studio-to-Station Radio Link Is Required.				
1. Transmitter	$4,450	$5,500		
2. Transmitter antenna	100	1,000		
3. Receiver	400	550		
4. Receiver antenna	100	500		
5. Installation	200	500	$ 5,250	$ 8,050

Note: Ordinarily this involves a studio building in the city and a transmitter building at the main transmitter site.

	Minimum	*Average*	*Minimum*	*Average*
TOTAL INITIAL CAPITAL INVESTMENT INCLUDING STUDIO-TO-STATION RADIO RELAY			$22,300	$34,700



Location of Station ★ The inherent nature of FM combined with ultra-high frequency propagation offers signal coverage characteristics confined much more definitely to specific areas than conventional broadcasting. That is why FM stations are being authorized by the FCC to cover specific trading areas. The Commission recognizes four classifications of FM coverage, as follows:

(a) An area comprising a limited trade area and a "city". Usually composed of one small city and the immediately adjacent area.

(b) An area comprising a basic trade area and a "principal city". Usually composed of a principal city, one or more smaller cities, and the areas adjacent to these cities.

(c) An area of at least 15,000 square miles, comprising primarily a large rural area, and particularly that part of basic trade areas which cannot be served by stations assigned basic trade areas, due to economic and technical limitations.

(d) An area having substantially different characteristics (social, cultural, or economic) from those specified in Classifications (a), (b) and (c) where, by reason of special conditions, it is shown that a need (which cannot be supplied by a station-serving area under Classifications (a), (b) and (c)) for the proposed service, both program and technical, exists which makes the establishment of the service area in the public interest, convenience, and necessity.

A more complete statement of these classifications, including frequencies assigned to each, can be obtained by writing to the Secretary of the Federal Communications Commission in Washington, D. C.

In setting up these trading areas, reference is made to four maps, namely: Hagstrom Map Company "Four-Color Retail Trading Area Map", Hearst Magazines, Inc. "Consumer Trading Areas", Rand McNally Map Company "Trading Areas", and J. Walter Thompson "Retail Shopping Areas."

All stations in a given trading area must provide substantially the same signal coverage of that area. Therefore, anyone wishing to start an FM station should first determine the extent of the trading area in which the proposed station is to be located. Until all trading areas have been definitely established by the FCC, it is necessary to use the maps listed above in determining the class of trade area in a given locality. Usually, the classification can be determined readily from the information on the maps. However, it should be noted that because of various additional considerations which the FCC must keep in mind, the service area actually assigned by the FCC may not agree exactly with that of any of the four above-mentioned authorities. Of course, where FM station licenses have been granted, the area is already established by the FCC. Fig. 3 shows, for example, the trade areas in the vicinity of General Electric's FM station W57A, as set forth in the reference maps referred to above. This map covers an area 240 miles on a side, and the circle has a 100-mile radius, with W57A as the center.

The next step is to select a tentative location for the station, so that it will cover the trading area. A central location is usually best. The actual site for the transmitter and antenna should be some high point overlooking, if possible, the entire service area. Large trading areas require well-elevated transmitter sites and high antennas, whereas small trading areas can be ade-

FIG. 3. TYPICAL MAP OF TRADING AREAS, USED FOR PLANNING FM COVERAGE, AND THE STUDY OF MARKETS

MAINTENANCE (PER YEAR)

	Minimum	*Average*	*Minimum*	*Average*
A. Studios and Offices				
1. Rental The studio facilities and personnel mentioned above will require about 1,500 to 2,000 sq. ft. of floor space. Approx. rental cost $1.50 to $3.00 per sq. ft. per year	$2,250	$6,000		
2. Salaries Station manager, 2 announcers, and 1 stenographer	8,400	10,200		
3. Miscellaneous (Telephone, printing, etc.)	500	1,000		
			$11,150	$17,200
B. Plant				
1. Apparatus Depreciation and obsolescence	$4,500	$6,000		
Comprising: (a) Transmitter 25% (b) Other equipment 15% (c) Buildings (if involved) 5% (d) Furnishings 10%				
Insurance and taxes				
Note: Insurance involves fire, storms and public liability. Taxes involve income, personal property, payroll (state and federal social security) and franchise.				
2. Rental (included above in studio and offices)				
3. Salaries — Chief Engineer and two operators	7,200	8,400		
4. Power	1,000	1,200		
5. Maintenance of apparatus including antenna	500	750		
6. Tubes	500	600		
			$13,700	$16,950
C. Program Production				
1. Program production and wire line costs	$6,000	$18,000		
Note: This item may vary over a wide range depending on choice of programs, network affiliations, and general conditions surrounding the station. The minimum and average figures specified here are believed to be representative for the first and second years, based on twelve hours' program per day.				
2. High-fidelity transcription record service	600	3,000		
3. Membership in FM Broadcasters, Inc.	300	300		
Note: This is the national organization for the promotion and development of FM broadcasting				
4. Items which eventually must be considered: News service Teletype service Music library Artist Bureau Dramatic scripts				
5. Royalties to musical organizations (A.S.C.A.P., B.M.I., S.E.S.A.C., etc.)				
Note: This item is very indefinite at present since the royalties are usually based on income.			$ 6,900	$21,300
TOTAL APPROXIMATE MAINTENANCE AND PROGRAM EXPENSE PER YEAR			**$31,750**	**$55,450**
TOTAL OUTLAY FOR FIRST YEAR (See Note A)			**$48,800**	**$82,100**
Note A: If studio-to-transmitter radio link is not required. These figures include Capital Investment, and Maintenance and Program Expense for first year.				
TOTAL OUTLAY FOR FIRST YEAR (See Note B)			**$54,050**	**$90,150**
Note B: Use these figures if studio-to-transmitter radio link is needed. Figures include Capital Investment, and Maintenance and Program Expense for first year.				

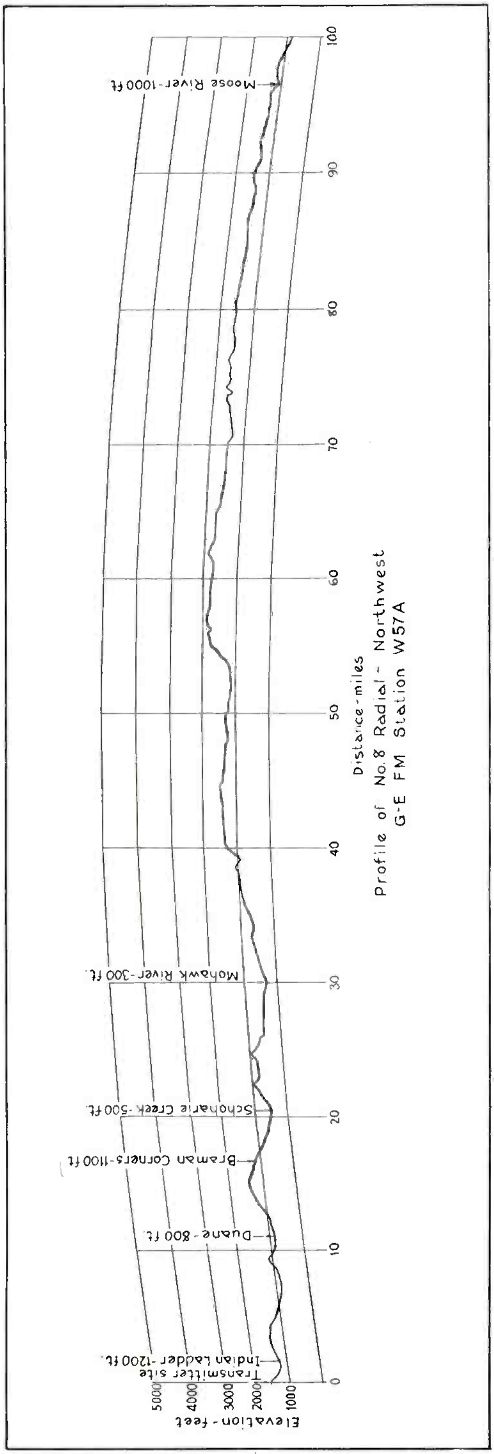


FIG. 4. EXAMPLE OF TOPOGRAPHICAL RADIAL

quately covered from less height. If the area is predominately urban, a high building may offer possibilities. For combined urban and rural areas, or where two or three cities are grouped into one "principal city" within a basic trading area, a tall building or a high hill or mountain, if available, should be selected. Considerations in selecting sites such as the latter are: Accessibility to roads, wire-lines, water and power supply, and the possible effective height of an antenna on the hill or mountain. A sharp peak is ideal as the effective height of the antenna will then approach the entire height of the hill above the surrounding terrain, while extra antenna height is required on a hill or mountain with a large flat top.

If the location is some distance from a suitable studio location, wire-line facilities having the proper characteristics for FM broadcasting may be quite expensive. In such a case, the economics may warrant the use of a radio relay circuit, or radio link, between the studio and the main transmitting station.

At this point, it may be enlightening to describe the General Electric FM station, Fig. 1, in the Helderberg Mountains about twelve miles south of Schenectady. It is located on the edge of a mountain range about 1,500 ft. high, overlooking the New York State Capitol District Trading Area comprising Schenectady, Albany, and Troy grouped as the "principal city". The station is about equi-distant from all three cities. In addition, it overlooks a large rural area bordered roughly by the Catskill Mountains to the south, Berkshire Mountains to the east, the Adirondack Mountains to the north, and the increasingly narrow Mohawk Valley to the west. This is shown pictorially in Fig. 2.

With studios in Schenectady (12 miles airline to the transmitting station or 22½ miles by road), getting high-fidelity programs to the transmitting station becomes a problem. Since a suitable wire-line was not available when the station was constructed, the problem was solved by using a low power, ultra-high-frequency radio relay circuit, with directive antennas at the transmitter and receiver. In order not to detract from the overall performance of the station, an FM transmitter and receiver were utilized for the radio relay circuit, each having characteristics better than the overall characteristics required by the FCC for an FM station. This FM station, including the studio-to-station radio relay circuit, has now provided regular program service for several months.

Technical Consideration ★ Once the location has been determined tentatively, the type of antenna, its height, and the transmitter power output must be considered. For this study, it is best to employ a competent radio engineer, who, among other things, must make a careful study of the general topography within the proposed service area, including the contours along eight radials from the proposed location to the outer limit of the service area. The topography of each radial must be plotted and the field strength calculated in accordance with the Rules and Regulations issued by the FCC. A typical radial drawing, such as must be filed with the FCC, is shown in Fig. 4.

This study is to determine the height and type of antenna, and the power output required for the transmitter. Other factors involved are the length of transmission line to the antenna support, and the loss in lines feeding the antenna if a multiple-bay antenna is employed.

According to the FCC, the station must provide a signal coverage of 1,000 microvolts in urban areas and 50 microvolts in rural areas. When the application for a construction permit is filed, these values of signal coverage are based on calculated field strength. Subsequently, the station must show proof of signal coverage throughout the area and may be obliged to increase the power output of the transmitter. Also the station must show proof of audio performance in accordance with the overall requirements of the FCC.

Construction permits for FM stations are authorized in terms of square miles of service area. Within certain limits, the applicant can determine the necessary antenna height, antenna power gain, and the power output of the transmitter. Usually some economic balance or compromise can be obtained from a careful study of the three variables just mentioned. The antenna height is usually determined from practical and economic limitations, subject to Civil Aeronautic Authority regulations. Antennas range from simple structures having a power gain of 1 to more complicated structures having power gains up to 6. At the informal hearing before the FCC Engineering Department in Washington December 9th, the following transmitter standard power-output ratings were proposed and tentatively accepted by the companies licensed to manufacture FM transmitters:

250 Watts	25 Kilowatts
1 Kilowatt	50 Kilowatts
3 Kilowatts	100 Kilowatts
10 Kilowatts	

The 25-kilowatt transmitter is not in production or available now, and the 100-kilowatt transmitter is not yet developed. These ratings proposed for standardization are maximum output, which means that the next higher output rating should be considered in case the service area requirements exceed a particular standard rating.

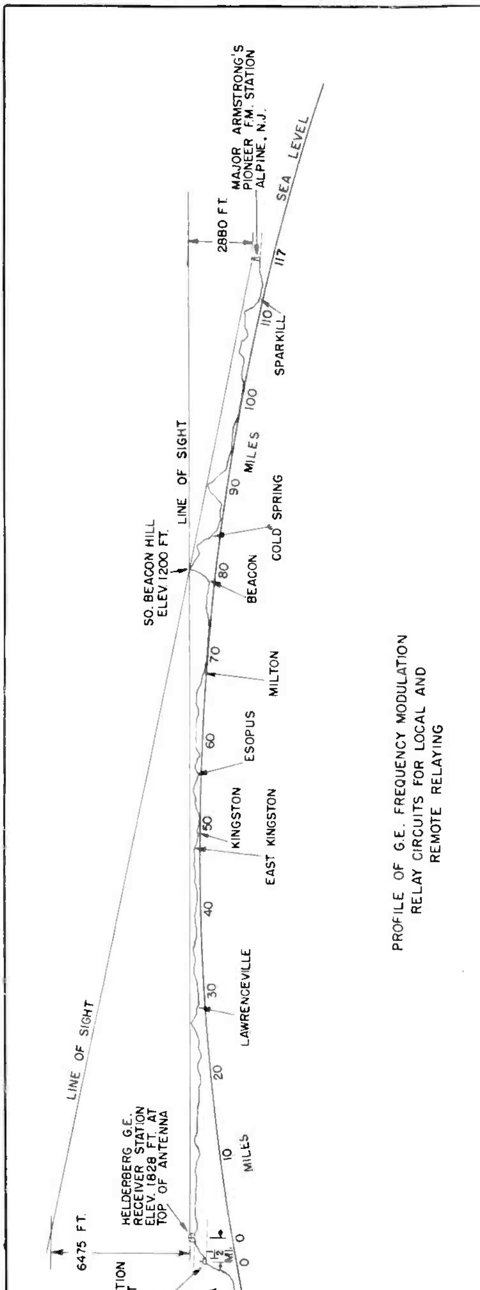


FIG. 5. CONTOUR BETWEEN W57A AND W2XMN

FCC Application Form No. 319 ★ A copy of construction permit application form No. 319, revised December 1940, should be obtained from the Secretary of the FCC in Washington, D. C., or from the local Radio Inspector. Filling in this form requires the services of a lawyer in addition to the radio engineer mentioned above. Detailed information is required regarding the applicant's financial qualifications, the corporate structure if the applicant is a corporation, other business interests, etc. Other items required are: statement of citizenship, signal coverage calculations, a topographical map showing the 1,000-microvolt and 50-microvolt contours, topographical profiles along each of the eight radials, drawing of the antenna, statement of its proximity to airports, location of the transmitter and studio, and technical descriptions of the antenna, transmitter, and studio equipment. Most manufacturers of FM broadcast transmitters have filed with the FCC the necessary technical information on the various sizes of transmitters. Therefore, it is only necessary to mention the manufacturer's model or type number with the statement that the information is on file in the FCC Offices.

Studio and Control Room ★ Some present-day studios are adequately equipped for FM broadcasting, but many are not. The important items to consider are audio fidelity, harmonic distortion, and noise level. In constructing an entire new FM station, care must be exercised to select studio and control room equipment which will deliver the overall level of audio fidelity as required by the FCC. The installation of the equipment, too, must be planned with this in mind.

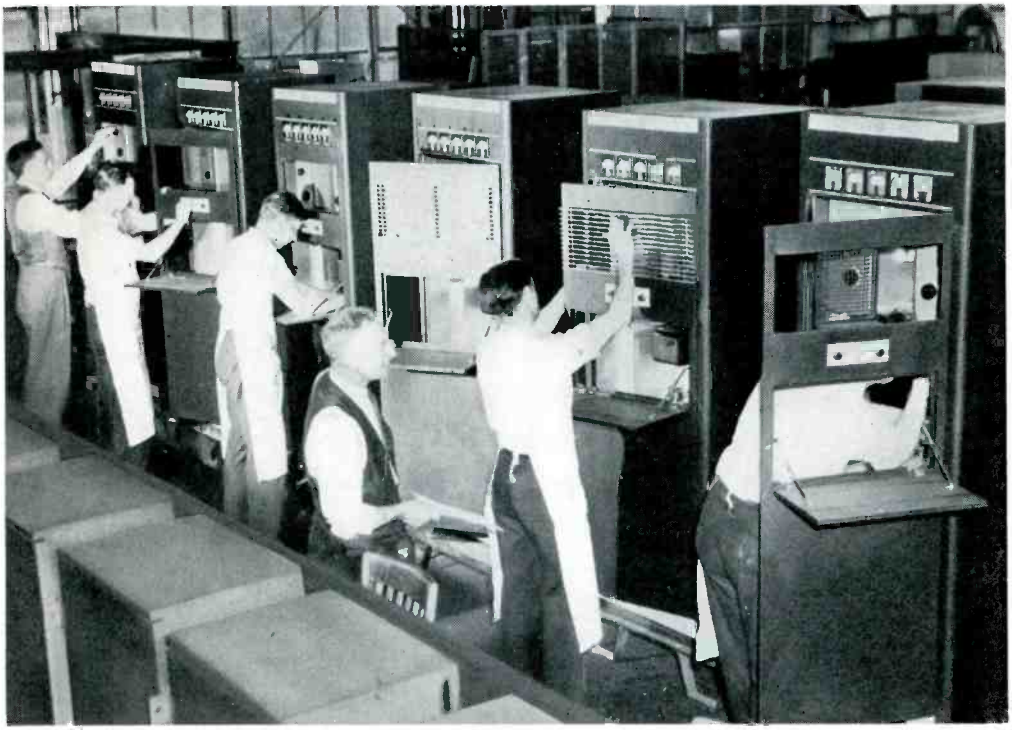


FIG. 6. ASSEMBLY LINE OF 1 KW. FM TRANSMITTERS AT GENERAL ELECTRIC'S SCHENECTADY PLANT. AMPLIFIER UNITS CAN BE ADDED TO INCREASE THE OUTPUT TO THE ANTENNA, IF NECESSARY

Unusual precautions are necessary to insure that the studios will be quiet. They must be well insulated from all outside noises. Any air conditioning must receive special treatment to avoid the introduction of noise into the studios through the ducts; also to avoid the passage of sound from one studio to the other through the ducts. Moving panels employed for changing the acoustical properties of the studio should be noiseless if it is intended that they be operated during programs. The studio noise level must be as low as possible.

For an entire new station, usually two studios and equipment are sufficient. Where network programs are used, wire line connections are required. Where arrangements have been made, and the location is such as to make it possible, programs from other FM stations may be rebroadcast. Permission from the originating station is necessary as well as from the FCC. The permission in writing from the originating station must be filed with the FCC. It may be necessary to locate such special relay receiving stations at some distance from the transmitter building to avoid interference [2] from the strong field of the main transmitter.

This type of relay broadcasting just mentioned has been successfully carried on by General Electric for several months. On a hill 200 feet higher, and about 1½ miles south of its Helderberg transmitting station, General Electric has constructed an FM and television receiving station with a highly directive antenna system. Fig. 2 shows the complete layout. This receiving station is connected with the main transmitting station by a high-fidelity wire-line for FM broadcasting and television sound. This receiving site, with its 4-mast antenna, is about 129 miles from New York City and about 7000 feet below the tangent line-of-sight, as shown in Fig. 5. Yet programs have been successfully relayed from Major Armstrong's FM station at Alpine, New Jersey.

Major Armstrong's station can be picked up direct in some sections of Schenectady at all times, but it is noise-free only a part of the time. This poor direct reception is due to Schenectady's location in the deep shadow of the Helderberg Mountain range with respect to signals coming from New York City. The Paxton FM station of the Yankee Network can be received direct in Schenectady with about the same signal level as the Alpine station.

Speech input equipment for the FM station under consideration can be of the consolette, console, or regular cabinet rack-mounted type, installed in the control room adjacent to the studio. The amount of speech input equipment and the number of microphones will depend upon the number of studios and the studio layout.

FM Station Accessories ★ Two indispensable accessories are a frequency monitor (or center-frequency monitor as it is called for FM) and a modulation monitor. These are necessary for every station.

In order to show proof of signal coverage performance over the entire service area, the station must purchase or rent equipment to record the field strength or, preferably, the signal-to-noise ratio along each of the radials described in the construction permit application. Also it is necessary to purchase or rent equipment to measure the overall audio performance characteristics, the audio distortion, and the noise level of the station. These measurements can be made by the station engineer or a competent consulting radio engineer.

A high-fidelity monitoring loudspeaker, capable of reproducing the entire audio range, should be provided for the control room and possibly the reception room at the studio.

FIG. 7. COMPLETE G.E. 1-KW. TRANSMITTER REQUIRES LESS THAN 10 SQ. FT. FLOOR SPACE

Programming the Station ★ Experience thus far has indicated that new methods must be devised and new technique employed to obtain best results in FM broadcasting. Microphone placing is important. Undesired sounds which are not transmitted on AM show up in the FM programs because of the increased audio range and the low noise level of the system. Changes may be necessary in arranging the instruments of orchestras, and placing the artists and, in general, fewer microphones are used for FM than for AM pick-up.

The FCC requires one hour of transmission during the day and one hour in the evening

[2] Reception of studio-to-station relay transmissions can be successfully accomplished at the transmitter building, since the frequency employed for this purpose is much higher than that of the main transmitter.

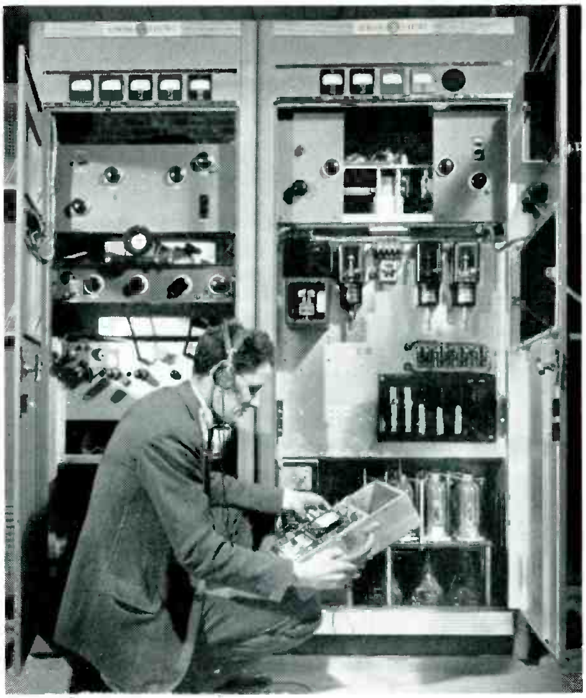


FIG. 8. G.E. 3-KW. FM TRANSMITTER UNDERGOING FINAL TEST RUN BEFORE SHIPMENT

during which must be employed the full audio quality provided by the FM system of broadcasting. Specifications of such performance have been established by the FCC. These two periods will probably require the use of original talent at the studio, although it is believed that the FCC will authorize the use of high-fidelity transcriptions for at least a part of this program time.

Special programs designed to demonstrate the superiority of FM broadcasting are very useful in helping to build an audience. Cooperative plans with schools, news services, musical societies, churches, state and national museums, charitable organizations, Chambers of Commerce, State Departments of Commerce, Finance, Agriculture, Education, etc., are suggested as sources of local program material.

Building an Audience ★ Building an audience is a very important phase of FM broadcasting. Real ingenuity is essential on this score and requires the cooperation of all those interested including the receiver manufacturers, the distributors, the dealers, and the FM broadcast stations. A promotional drive in which all of these groups play a part should be planned and carried out aggressively.

FM Receivers ★ FM receivers are now being produced by several manufacturers at prices ranging from approximately $50 to $200. In addition, a few custom-built FM receivers are being offered at prices ranging from $500 to $600.

The General Electric line of sets includes an FM Translator and a combination AM-FM console receiver as shown in the Figs. 10 and 11. The Translator is an ideal unit for the transition period during which many listeners want FM reception but are unwilling to dispose of their present AM receivers. It is a complete FM receiver except for the audio amplifier and loudspeaker. The output may be connected to the phonograph, FM, or television jack of any modern AM receiver.

The combination AM-FM receiver consists of the Translator and an AM receiver conveniently arranged in one cabinet. Three antennas are built into the cabinet. There is a Beamascope for conventional broadcast reception, another for shortwaves, and a folded dipole for FM programs.

Summary ★ Obviously, a matter as comprehensive as the subject of FM broadcasting cannot be treated exhaustively in this article. However, it is hoped that the outline presented will give a general picture of the problems and possibilities of this new system, and that the material presented will serve as a basis for further investigation by those who are interested in the opportunity afforded by FM to enter the broadcasting field, or by those who want to add FM to their present AM program facilities. Transmitters and receivers are fully developed and perfected, and are in regular production. Their successful performance has been demonstrated conclusively in various sections of the Country. It is reasonable to expect that 1941 will see rapid and widespread extension[1] of commercial FM broadcasting service.

FIG. 11. G.E. FM TUNER USES SEPARATE AUDIO AMPLIFIER AND LOUDSPEAKER

Without venturing to make predictions, it appears that there are two underlying reasons why this is so:

First, the interference conditions on the AM band are such that further improvement in service to the public may call for a reduction in the number of stations. Much has been accomplished in this direction through the erection of new transmitting antennas, so designed as to reduce the radiation towards each other of two stations using the same frequency. Serious congestion, however, exists on the higher frequencies in the AM band, and this is not subject to correction by alterations in the transmitting antennas. With the establishment of FM broadcasting, it may develop that a considerable number of the AM broadcasting stations will find that they can serve their listeners to better advantage by shifting to FM transmission.

This will relieve the congestion now responsible for the squeals and howls, particularly troublesome during evening hours, which result from interference between stations operating on the same frequency. Fortunately, the nature of FM transmission is such that this type of inter-station interference is non-existent on the FM band.

Second, FM makes possible the expansion of broadcasting service, and opens new oppor-

[1] See map of U. S. A. with locations of FM stations in operation and under construction, FM Magazine, January, 1941.

FIG. 9. SOME OF THE SOUND-EFFECTS EQUIPMENT USED AT THE W57A STUDIO, SCHENECTADY

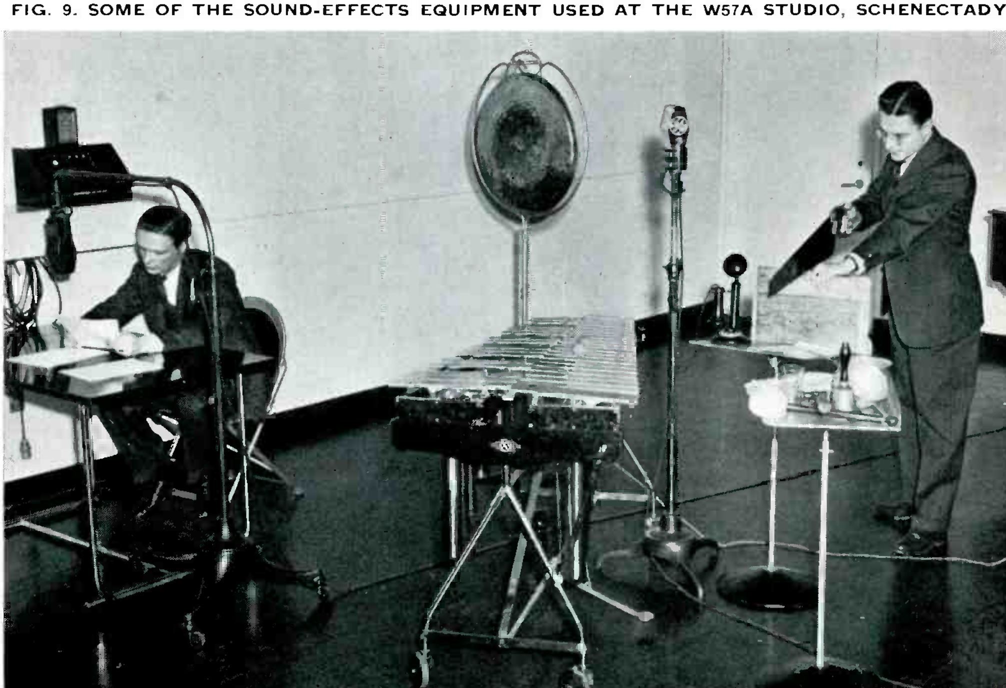


FIG. 10. G.E. RECEIVER FOR BOTH FM AND AM

tunities to those who have not been able to enter the AM field. Now, FM channels are available for several hundred new stations to operate in the U.S.A. without any inter-station interference.

Competitive conditions are favorable to this development since, at very moderate cost, it is possible to furnish programs by FM which cannot be equalled on AM because of the inherent limitations of audio fidelity in AM transmission.

The degree of realism achieved with FM reception, due to its unlimited tone fidelity and volume range, has the effect of conveying to the listeners the actual personality of the artist or speaker. Moreover, the background and action can be made real to the FM audience in a way that is impossible to accomplish on AM broadcasting. These characteristics may be found to augment the effectiveness of FM as an advertising medium.

Much study is being given to this subject, and much is still to be learned. Advertising agencies are greatly interested in this phase, for it has been already found possible to increase the degree of audience-impression by innovations in studio technique and programming which can be employed only for FM broadcasting.

PRACTICAL IDEAS FOR FM ANTENNAS

(CONTINUED FROM PAGE 16)

chimneys and such supports on the roof.

I hear the question frequently: "Will an FM-AM di-pole give good AM reception?" My experience has been that reception is much better than from loops or the makeshift arrangements that are found on most AM sets. In other words, the listener who replaces his old set with an FM-AM receiver operating with a di-pole can expect much better AM programs than he has ever heard before.

It is fortunate that the advent of FM broadcasting has brought the subject of receiving antennas to the public attention. No less an authority than Paul A. de Mars, chief engineer of the Yankee Network, is responsible for the statement that nothing ever done by the radio set manufacturers has so affected the quality of home radio entertainment as the introduction of the built-in antenna.

That is, the convenience-factor of the no-antenna set has been more than offset by poor and noisy reception in most homes. That is one reason why an FM-AM set, operating with a good FM-AM antenna, seems to give so much better performance on AM programs!

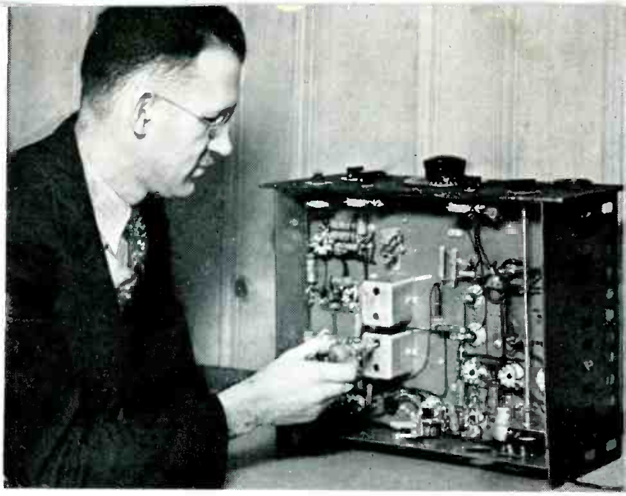
Furthermore, in the majority of cases where there are complaints about noise on the FM band, it will be found that an inadequate antenna is being used, with the result that the signal pick-up is insufficient to operate the limiter tube in the FM circuit, or else the arrangement of the makeshift antenna is such that it is particularly responsive to some source of interference, and not effective in picking up the radio signals. Thus a change to a correctly designed antenna promptly remedies the trouble by increasing the signal-to-noise ratio. The difference is particularly noticeable on sets which do not have a stage of tuned RF amplification.

Editor's Note: *Information on overcoming specific cases of interference will be given by Mr. Lundahl in a forthcoming issue of FM Magazine.*

SPECIAL PARTS FOR FM CIRCUITS

National Company Now Produces Newly Designed FM Receiver Parts

BY CALVIN F. HADLOCK*



THE AUTHOR CHECKS A NATIONAL FM SET

SINCE the description of the National Company's frequency-modulation receiver [1] for communications service appeared in *FM* Magazine, numerous requests have been received for more detailed information regarding it. Accordingly, this article will describe in some detail the component parts which are particularly adapted to the reception of frequency-modulated signals.

The three component groups which are most important in this respect are the tuning condenser assembly, the radio-frequency coil units, and the intermediate-frequency transformers. They will be described in this order.

The Tuning Condenser Assembly ★ The tuning condenser assembly shown in Fig. 1 consists of a three-section variable condenser with a reduction-gear drive box. The partitions of the condenser sections are extended to serve as mountings for the three acorn-tube sockets.

The condenser is tuned by a National PW precision dial, which reads directly to one part in 500. Division lines are spaced approximately one quarter of an inch apart. The scale is read directly in the usual way, but revolves ten times in covering the tuning range. Dial numbers are visible through small windows and change every revolution to give consecutive indexing by tens, from 0 to 500. The effective dial length is about 12 ft., allowing accurate logging and easy tuning. The dial uses an epicyclic gear which is spring-loaded, the movement being very smooth in operation.

The gear box contains two sets of gears. One set produces a twenty to one reduction so that the dial can make ten complete revolutions while the tuning condenser shaft is rotating through 180 degrees. The other set consists of two spring-loaded rider gears which eliminate any lost motion or play.

The condenser plates are a special shape which is the straight-line-frequency variety. The spacing between plates is much greater than that of the usual lower-frequency condenser, in order to provide good ganging and to avoid microphonic howling. In the receiver previously described, only five plates per section were used to cover the range from 38 to 42 megacycles. In the assembly shown in Fig. 1, there are nine plates per section. This is due to the fact that the particular assembly shown is taken from a receiver which has been designed to cover the frequency-modulation broadcast band and tunes from 42 to 50 megacycles.

The three rotor sections of this condenser are insulated from the shaft by Bakelite sleeves. Aside from the fact that this is convenient on the RF section for the purpose of AVC voltage isolation, it is very important at these high frequencies for eliminating inter-stage coupling which produces unstable performance, poor signal-to-noise ratio, or dead spots at various parts of the tuning range. We have found that best operation over the entire range can only be procured by careful grounding of each rotor at the proper point.

Often the most bothersome interaction in a high-frequency receiver is leakage from the HF oscillator into the input of the RF stage. For example, in one experimental receiver having the HF oscillator rotor grounded by a wire from the coil terminal to the chassis, RF gain near the low-frequency end of the tuning range was poor. No definite indication of resonance was obtained when the RF input circuit was tuned to the signal frequency, while considerable interaction was apparent when it was tuned to the oscillator frequency. When this grounding wire, which was a piece of No. 14 wire about a half inch long, was replaced by a heavy lug, the troubles were completely cured. A sharp peak was evident when the input circuit was tuned to the signal frequency, and interaction with the oscillator circuit was eliminated.

However, at the high-frequency end of the range, the back-ground noise was abnormally high, producing a poor signal-to-noise ratio.

*Engineer, National Company, Inc., Malden, Mass.

[1] FM in Communications Service, by Dana Bacon, *FM* Magazine, Dec. 1940.

This fault was eliminated by adding a heavy ground wire from this same rotor to a point of zero RF potential on the chassis. It so happened that such a point was found on the back of the gear box.

Acorn Tube Mountings ★ As mentioned above, the partitions of the condenser assembly have been extended so that the three acorn tube sockets can be conveniently mounted. They also have angles at the lower corners providing eight feet by which the assembly can be fastened to the chassis. The HF oscillator tube socket mounted on the front partition is a standard National polystyrene socket. On the next partition is mounted the socket assembly for the first detector tube, a pentode type 954. The grid of this tube is toward the back of the set. The screen and cathode by-pass condensers are mounted with the tube socket. The screen by-pass condenser consists of a copper plate, two inches square, separated from the grounded partition by a thin sheet of mica. This type of by-pass condenser is non-inductive and is much more satisfactory than the usual mica or tubular condenser at the frequencies involved.

The cathode condenser which is on the opposite side of the partition is constructed in a similar manner, except that several brass plates are added to get extra capacity. These plates are also insulated from one another by sheets of mica.

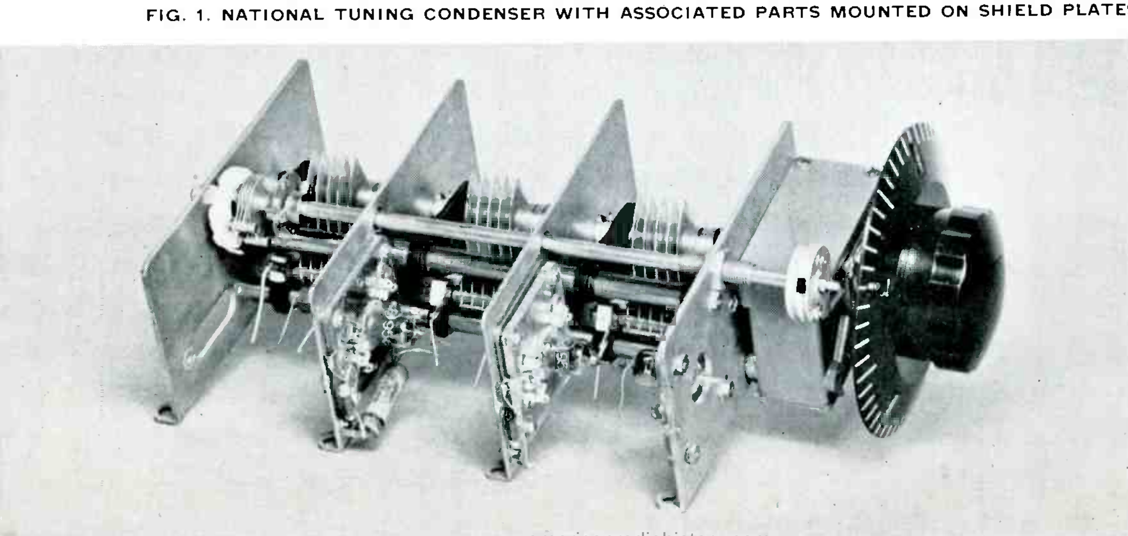
The RF tube, a pentode type 956, is mounted on the next partition toward the back. The screen and cathode by-pass condensers are built into the socket assembly as before, except that the tube clips are mounted directly on the outside cathode condenser plate instead of in a separate socket. This mounting places the tube in the position with respect to the grounded partition which gives the most complete inter-element shielding. The tube clips are riveted to the copper plate, all except the cathode clip being insulated from it by small pieces of mica.

Antenna Compensator ★ Mounted on the back partition is a small variable trimmer condenser. This is the antenna compensator. The rotor is grounded directly to the partition by the mounting nut, while the stator is connected to the stator of the RF tuning condenser by a long lug. The rotor is turned by a long shaft which is, in turn, driven by a front panel knob. This can be seen in Fig. 1. The usual trimmer condenser has been omitted from the RF coil unit as it is replaced by the antenna compensator. This compensator is intended to take care of variations in antenna loading, and is adjusted to give maximum limiter grid current. As may be seen in the photograph, several small resistors and fixed condensers are mounted directly on the assembly when it is built. These are later soldered into place when the unit is mounted on the chassis.

RF Coil Assemblies ★ Next, we come to the radio frequency coil units. As can be seen in Fig. 2, these consist of a coil and variable or fixed capacitors mounted on a base made of R-39 low-loss Bakelite. There are five prongs to which the external connections are made. The units are mounted on the bottom of the chassis so that the prongs protrude above the chassis in a line between the tuning condenser sections and the acorn tube sockets, thus facilitating the use of very short leads. Each coil unit is individually shielded by a rectangular aluminum box which is large compared with the size of the coils, and has no detrimental effect on the efficiency of the tuned circuits. There are two holes in the bottom of each can through which the trimmer condensers or the coil inductances can be adjusted.

The coil forms, of polystyrene, are machine-grooved to hold the windings firmly in place. These forms have extremely low loss at high radio frequencies. In addition, they almost completely eliminate frequency drift in the HF oscillator circuit. When the receiver is first turned on, the coils are at room temperature.

FIG. 1. NATIONAL TUNING CONDENSER WITH ASSOCIATED PARTS MOUNTED ON SHIELD PLATES



As the HF oscillator coil warms up, the diameter increases slightly due to the expansion of the winding. This, of course, increases the inductance of the coils, tending to change the frequency of the oscillator to a lower value. At the same time, however, the coil form will also expand. The expansion in a lengthwise direction tends to stretch out the coil, producing a decrease in inductance and a corresponding increase in the frequency of the oscillator. If the axial expansion of the form is sufficiently great, the increase in frequency, due to the lengthening of the coil, can compensate for the decrease in frequency caused by the radial expansion of the wire, so that coil heating does not affect the frequency appreciably.

When the secondaries are wound, the end of the winding is threaded through holes in the form in such a manner that a half-turn is produced at the end of the coil, forming a loop inside the form. By adjusting the position of this loop, the inductance of the secondary can be varied over a limited range. In this manner, the inductance of the coils can be adjusted to obtain proper tracking of the tuned circuits.

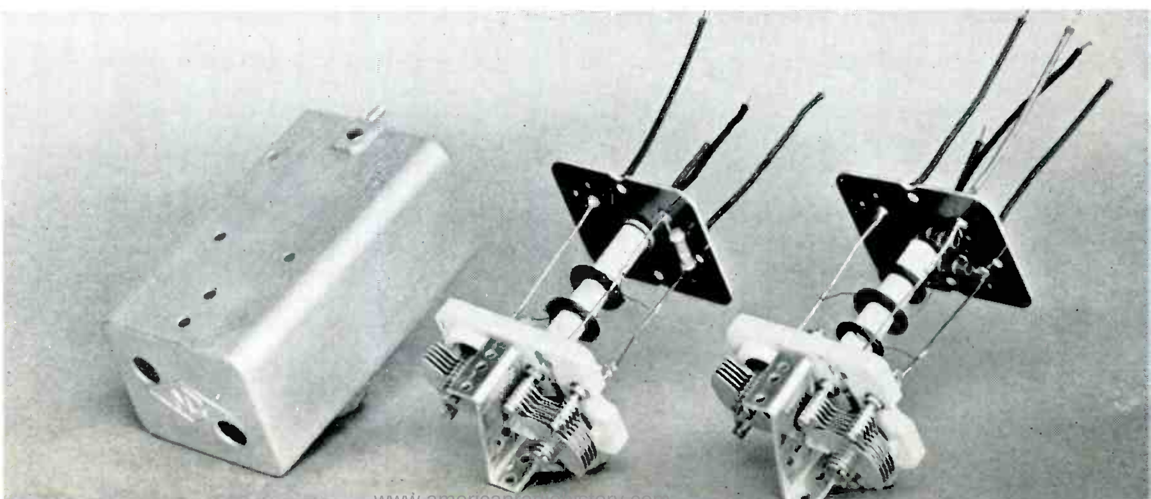
All fixed capacitors on the coil units are of the ceramic type having zero temperature coefficients. It was not found necessary to use capacitors having negative temperature coefficients in the HF oscillator circuit to effect temperature compensation, as the use of a polystyrene coil form and the type 955 acorn tube in the tuned-plate grid-tickler oscillator circuit reduces the frequency drift to a negligible amount. The variable trimmer condensers are of the air-dielectric type. Mica trimmers of the book-leaf type are not suitable for use in circuits which must be highly stable.

The RF input coil has a relatively low impedance antenna winding so that either a doublet or a single-wire antenna can be used. A certain amount of series padding is required in the secondary circuit to make it gang properly with the first detector circuit. This padding is provided by two fixed ceramic capacitors. Padding is necessary because the unusual primary arrangement of the first detector coil affects the tracking of that circuit.

The first detector coil is somewhat unusual. A very interesting primary circuit is employed to couple the plate of the RF tube to the secondary of the first detector. Two primary windings can be seen in the photograph. One winding consists of only two or three turns, and is wound rather close to the grounded end of the secondary winding. This low-turn primary is self-resonant above the high-frequency end of the tuning range, and insures plenty of gain at the higher frequencies. The other primary is wound in the opposite direction from the first, near the other end of the secondary, and is spaced somewhat farther from it. This winding has a comparatively large number of turns and is resonated by the output capacity of the RF tube to a frequency outside the low-frequency end of the tuning range. This primary helps to provide satisfactory gain toward the low-frequency end of the range. In addition, further coupling is provided by means of a 16-mmfd. coupling condenser connected between the plate side of the total primary and the grid of the first detector. By choosing the proper value of the coupling condenser and the number of turns for each primary, and adjusting the positions of the primaries, exceptionally high and uniform gain can be obtained over the entire tuning range of the receiver. The position and value of the high-turn primary is quite critical, as is also the value of coupling capacity, and variation of these affect the tracking of the detector circuit. Considerable care must be exercised in the design and adjustment of this coil.

The high-frequency oscillator coil has a small winding wound close to the secondary. This winding is the grid tickler. In addition to a variable trimmer, there can be seen in the photograph two ceramic capacitors which are connected in parallel. These provide the necessary

FIG. 3. IF TRANSFORMER, CENTER, AND DISCRIMINATOR TRANSFORMER, RIGHT, FOR FM SETS



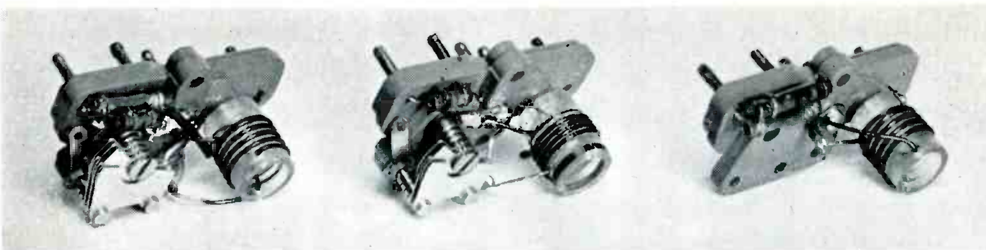


FIG. 2. RADIO FREQUENCY UNITS DESIGNED BY NATIONAL FOR FM RECEIVER CIRCUITS

series padding, this circuit being tuned to the high-frequency side of the signal.

IF Transformers ★ We are now ready to describe the intermediate-frequency transformers. The intermediate frequency of the national FM receiver is 3 mc. This frequency was selected after considerable experiment to determine the best compromise between selectivity, gain and image ratio requirements. The selectivity requirement was such that the overall IF gain should be flat to within 1 db over a band-width of 150 kc. At the same time, the skirts of the selectivity curve should rise sharply at the band limits, so that the gain will be down at least 40 db at a band-width of 400 kc.

This rigid selectivity requirement was met by using three stages of intermediate frequency amplification tuned to 3 mc. The primaries and secondaries of the transformer are slightly over-coupled. A lower intermediate frequency would have caused difficulty in obtaining the required flat portion of the curve, while a higher frequency would have caused the skirts to flare excessively. A higher frequency would also have resulted in lower gain per stage. The use of a 3-mc. IF also provides a satisfactory signal-to-image ratio, the value of which is about 60 db.

Since there are three stages of intermediate frequency amplification, four interstage transformers are used. These are identical except for lead arrangement. The transformers are quite conventional and are of the familiar double-tuned variety. Primary and secondary coils are identical and are Universal wound with No. 30 D.S. wire, thoroughly impregnated with polystyrene varnish. They are wound on isolantite forms and are tuned by air-dielectric trimmer condensers having a maximum capacity of about 50 mmfd. The secondaries are resistance-loaded with .1-megohm resistors. These resistors improve the shape of the selectivity curve to a certain extent, and also make the amplifier more stable. Capacity coupling between windings is reduced to a practical minimum by proper arrangement of leads, placing a grounded shield between the trimmer condensers, and connecting the leads so that the outsides of the coils are at ground potential.

Discriminator Transformer ★ The discriminator transformer consists of three pie-wound coils. The middle coil, the primary, is identical with the coils of the interstage IF transformers, but the secondary is split into two windings which are connected in series and have a total inductance of about 60 microhenries. Both the primary and secondary windings are tuned by air-dielectric trimmer condensers. A .0001-mfd. fixed mica condenser is connected between the plate side of the primary and the mid-point of the secondary, as is done on the usual discriminator transformer. A 50-mmfd. ceramic fixed capacitor is connected across each half of the secondary. Before these were added, complete cancellation of amplitude modulation was not obtained when the receiver was tuned exactly to the center-frequency of the signal. This was due to a small difference in capacity across the two halves of the discriminator secondary which exists in spite of the use of a split winding. The two ceramic condensers swamp out this difference in inherent capacity and give complete amplitude cancellation at the center frequency, reducing noise and signal distortion.

Alignment Procedure ★ It would be well to describe the procedure to be followed in lining up this intermediate-frequency amplifier. Since the inter-stage transformers are slightly over-coupled, the alignment technique described below must be followed carefully if proper alignment is to be assured when using an ordinary signal generator. If apparatus especially suited to the alignment of over-coupled IF amplifiers is available, the following procedure will be unnecessary. However, if the receiver is to be aligned in the more common manner, the process to be described must be followed:

The General Radio Type 605-B Signal Generator is very satisfactory for the purpose. No dummy antenna should be used. The discriminator circuit must be aligned first. The two trimmers are first set near their correct capacities. The output cable of the signal gen-

SPECIAL PARTS FOR FM CIRCUITS

(CONTINUED FROM PAGE 34)

erator should then be plugged into the 1-volt outlet and connected between the grid of the limiter tube and the chassis. Modulation should be applied to the carrier, about 30% being a good level. The generator frequency dial is tuned until a null point is found near 3 mc. on each side of which the output, as indicated on an output meter, will increase. The secondary trimmer condenser is adjusted until this null point occurs at 3 mc. Next, the generator should be detuned 50 kc. on both sides of 3 mc., and the output at these points noted. If the two values are unequal, the primary trimmer condenser should be reset until they are identical.

The next step is to line up the intermediate frequency amplifier proper. This must be done one stage at a time. The modulation should be removed from the carrier, and the AVC action of the receiver disabled. The signal generator cable should be clipped between the grid of the third IF tube and the chassis.

The trimmers are set approximately at the start. Then the primary trimmer condenser is adjusted for maximum gain at exactly 3 mc. Next, the generator is detuned 75 kc. on both sides of 3 mc., and the meter readings compared. If they are equal, alignment of this stage is correct. If they are unequal, the secondary trimmer is reset by trial, after which it is absolutely necessary that the primary trimmer be reset for maximum meter reading at 3 mc. Then, the generator is again detuned 75 kc. on both sides of 3 mc., and the meter readings compared. If these readings are still unequal, the above procedure must be repeated until they are exactly the same.

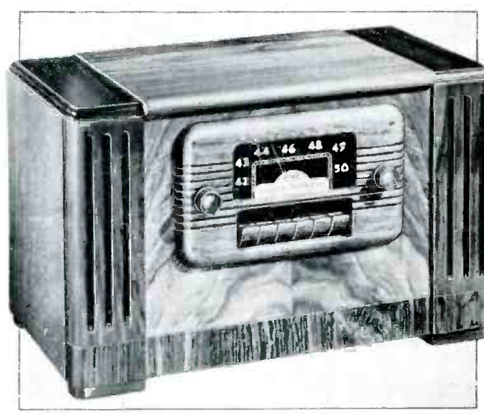
After this has been accomplished, the generator is connected to the grid of the second IF tube, and the same procedure is followed again, reducing the input from the generator as may be necessary. After this stage has been carefully aligned, the generator is connected to the grid of the first IF tube, and this stage is aligned in the same manner. Finally, the generator is connected to the grid of the first detector and the first IF transformer is aligned. IF alignment is now complete.

By this time, the reader may have formed the impression that the design and adjustment of a really good frequency-modulation receiver is very difficult. It is true that great care must be exercised in the design and adjustment of a receiver of this type, but any difficulty experienced in the alignment of a frequency-modulation receiver springs mainly from a lack of experience with this new type of circuit, and will disappear as greater familiarity with this equipment is attained.

MEISSNER SET HAS TUNING EYE

MEISSNER AND STEWART-WARNER ANNOUNCE FM TUNERS

Meissner Manufacturing Company, Mt. Carmel, Ill., has added to their extensive line of receivers an 8-tube FM Receptor, for use with the audio end of a conventional AM receiver, or with a separate power amplifier and speaker. A stage of tuned RF amplification is used to provide effective noise rejection. A feature of great importance is the tuning eye, as assurance against off-tune distortion. This tuner is also sold as a chassis, less tubes.



STEWART-WARNER HAS TUNING BUTTONS

Stewart-Warner Corporation, Chicago, Ill., one of the first companies to be granted an FM license, is now preparing to enter the FM set field. The first model is a 9-tube "Interpreter", or FM tuner, for use with an external audio amplifier and speaker. In addition to dial tuning, there are six automatic buttons. The popularity of FM tuners is growing rapidly, particularly among people who already own new, expensive AM sets.

SPEECH INPUT EQUIPMENT FOR FM

Western Electric 23-C Speech Input Equipment for FM Studios Is Also Being Installed by AM Stations Which Plan to Add FM Transmitters

BY H. F. SCARR*

A NEW single unit speech input console, designed to still further improve transmission performance, has been put into production by the Western Electric Company. The new equipment, known as the 23-C, has been developed by Bell Telephone Laboratories to serve those studios where the highest quality of transmission is required. The equipment will be welcomed by the studio engineer whose concern is to secure the additional band of audio tones afforded by FM.

With a frequency response flat from 50 to 15,000 cycles from microphone to output terminals, this most recent offspring of the famous line of "23 type" speech input equipment is recommended by the excellent records of performance of its predecessors throughout this and other countries.

The new 23-C provides the operating engineer with a centralized system of controls, economically and compactly designed, and extremely easy to install as can be seen from Fig. 1. Its operation is made clear from the block diagram, Fig. 2.

A frequency response flat from 50 to 15,000 cycles enables the 23-C to deliver with clarity and integrity both the deep resonant tones of the lower register and the rich tonal harmonics at high frequencies which give distinctive flavor to the various instruments and sound sources.

Being a single self-contained unit, many variables are eliminated and the wiring and apparatus locations can be factory-controlled for optimum protection against external disturbances. This unit can be depended upon to maintain these high standards throughout its life, since leads are short and permanently placed.

High quality broadcasting demands an improved signal-to-noise ratio and a very low distortion. The 23-C speech input equipment, in actual measurements under normal operating conditions using 70 db net gain, has an output noise level of 64 db below the single-frequency signal level which produces full modulation. It is only through long experience with the design of compact, unit-constructed speech input equipments, that this exceptional performance was achieved.

Both the factor of design and that of the stabilized feedback circuit are important in assuring a maximum signal to noise ratio and in keeping distortion at a minimum. Measurement of the distortion of the main amplifier at normal output shows this to be less than 1.1% over the whole band. The new wide-range equipment provides a total gain of 96 db which is ample for modern broadcast microphones.

Experience shows that four pre-mixing amplifiers satisfy the usual operating requirements. The 23-C was designed to conform with this requirement. It is a completely self-

* Western Electric Company, Inc., 195 Broadway, New York City, N. Y.

FIG. 1. ENTIRELY NEW EQUIPMENT, DESIGNED TO MEET THE FIDELITY REQUIREMENTS OF FM

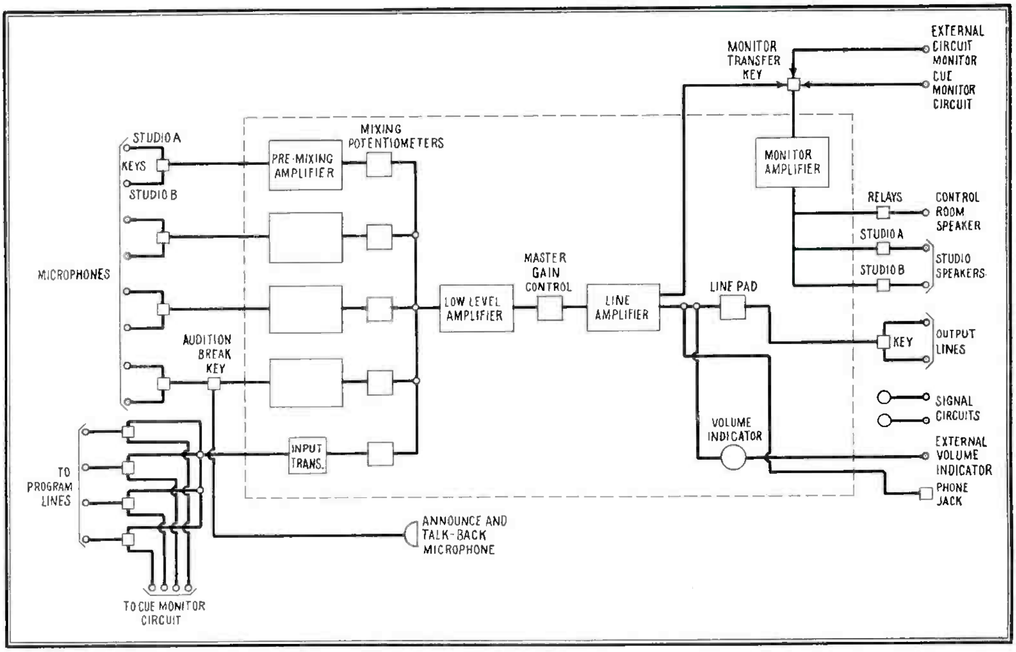
contained unit except for a 12-volt DC power supply needed to operate the loudspeaker cut-off relays. The equipment matches lines of 600 ohms impedance.

Microphone switching keys are arranged to accommodate eight studio microphones and, of these eight, any four may be operated simultaneously. There are separate input circuits for both remote and chain program lines and keys for terminating four incoming program line trunks. These keys permit rapid selection and switching of any one of four predetermined lines to the main amplifier system and also allow for monitoring of any one prior to switching, whether or not the main channel is being used for other program transmission.

In conjunction with these various input circuits is a five-channel mixer with a master gain control. The mixer can carry simultaneously four 30- or 250-ohm microphones, or their equivalent in any other program source. The announce and talk-back microphone circuit for making announcements from the control room and for audition breaks during rehearsals is controlled by a talk-back key which automatically silences the loudspeaker in the control room and connects the studio speaker. The microphone keys which switch the microphones to operating position can be cross-connected to silence the associated studio speakers, thus preventing speaker operation in the same location with "alive" microphones.

Monitoring is carried through a separate monitoring amplifier which has a level control and a three-position input switch for monitoring the output of the main amplifier for preliminary checking of line programs and for connection to some external source as, for example, a radio monitor or a master cue line.

In external appearance the new 23-C is much the same as the standard "23-type" line of speech input equipment. However, the mixer knobs are a mushroom-type knob, designed to fit the hand. They have a wide skirt for greater ease in reading and raised pointers and knurling to facilitate finger-tip control.



BLOCK DIAGRAM OF THE WESTERN ELECTRIC 23-C SPEECH INPUT EQUIPMENT FOR FM STUDIOS

Another notable innovation is seen in the output and monitoring keys. These are finished in red plastic to differentiate them from the other keys finished in black. These keys have flat-type handles with concave finger surfaces, making them both easier to handle and more attractive. An illuminated volume indicator meter gives readings in vu, and provision has been made for a duplicate volume indicator meter for readings to be taken at a remote point. A jack and a rotary switch are provided for measuring the plate current of the vacuum tubes, and a jack for headphone monitoring of the main channel when the loudspeaker cannot be used.

The compact mechanical design of the new equipment and the dark aluminum gray

(CONCLUDED ON PAGE 46)

FM HANDBOOK

Chapter 4: The FM Limiter—The Detection System—De-Emphasis and Pre-Emphasis Network

BY GLENN H. BROWNING

THE limiter and detection systems used in FM reception bring several new concepts to the study of radio circuits. As has been previously explained, the fundamental function of the limiter is to minimize any amplitude variations in the received signal due to static or other forms of interference, and to pass on to the detection transformer a substantially constant IF signal voltage.

Operation of Limiter Circuit ★ Theoretically, the performance of a limiter should be as shown in Fig. 1, curve A. This curve shows that if the frequency modulation signal is of not less than a certain minimum value, the IF voltage fed to the detection transformer is constant for all signal levels above this minimum value. Practically, this curve can not be achieved, but curves similar to those shown in Fig. 1, *B* and *C*, can be obtained. The method of obtaining these results is by employing a sharp cut-off tube such as the 6SJ7 and operating the plate and screen voltages at reduced values. From numerous data accumulated, it would appear that the plate voltage on the limiter tube should be in the order of about 30 volts and that the screen voltage should be between 50 and 75 volts.

With low voltages on the plate screen, the sharp cut-off tube saturates with a comparatively small input signal. If the resistor *R* (Fig. 2) is not used in the grid return of the limiter tube, it will be found that saturation occurs with less signal voltage but that if the signal increases, the IF voltage fed to the detector tube actually falls off as shown in Fig. 1, curve *C*. By placing a suitable resistor in the grid return of the limiter, the saturation point occurs at slightly larger signal levels, but the IF voltage fed to the detector remains constant until much larger signal voltages have been reached. (See curve *B*.) If too large a value of resistor is used, more signal voltage is required to saturate the limiter and consequently less noise reduction is obtained with weak signals.

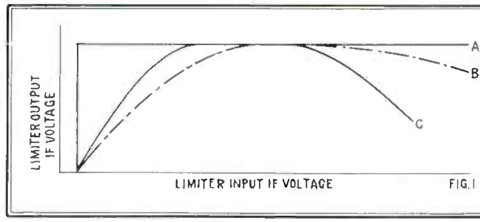
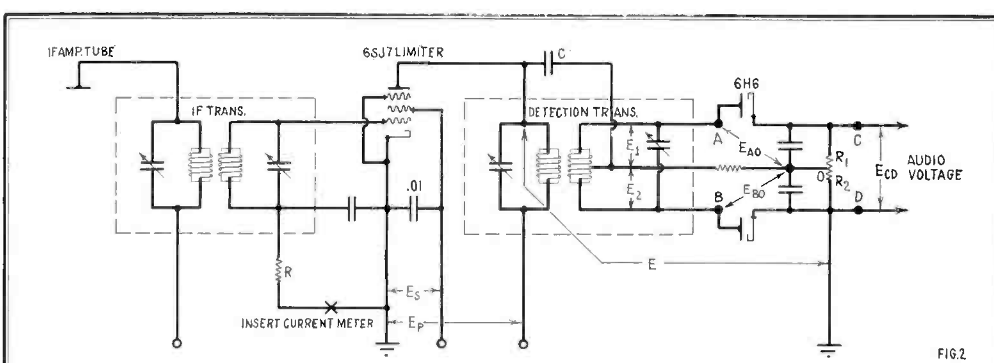


FIG. 1. CURVES SHOWING LIMITER ACTION

It will be noted from the curve shown in Fig. 1 that the limiter, besides performing the function of materially reducing noise, also acts as an automatic volume control, as the IF output voltage fed to the detector is substantially constant throughout a wide range of signal levels.

The limiter tube and associated circuit act as an amplifier when the signal strength is low, but in this case it is not assisting materi-

FIG. 2. FM LIMITER AND DETECTION CIRCUITS ARE NEW ELEMENTS IN RADIO RECEIVERS



ally in suppressing noise, for then most of noise reduction in the receiver is due to the detection system.

As the IF voltage developed in the plate circuit of the limiter is constant when the signal strength is sufficient for noiseless reception, the signal strength obtained must be measured before the limiter tube. A most convenient method of obtaining an indication of signal strength is by inserting a milliammeter or microammeter in series with the resistor R at a point marked X in Fig. 2. The current indicated by this meter is almost proportional to signal strength as will be noted from the curve shown in Fig. 3 which was taken by impressing on the

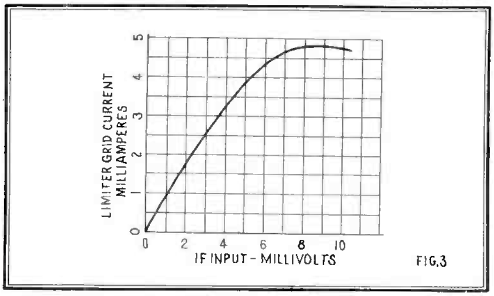


FIG. 3. CURVE OF LIMITER GRID CURRENT

grid of the mixer tube signals at the intermediate frequenty from 100 microvolts to 10 millivolts and noting the limiter grid current obtained when the grid resistor R was 10,000 ohms. In receivers where the resistor R is of high value, proportionally less grid current will be obtained with the same signal input. The gain of the IF amplifier will also directly affect the limiter grid current, but in any case this current is a reliable indication of relative signal strengths.

It will be apparent from the foregoing description that the gain in the RF and IF amplifier systems should be made as high as possible in order that weak signals will develop sufficient voltage in the grid circuit of the limiter to properly operate it. In amplitude modulated receivers, tube hiss is one of the limiting factors affecting the gain of the receiver. In the case of an FM receiver, however, it will be found that noise due to tube hiss is substantially eliminated in the limiter and detection systems. Practically, the limiting factors in usable gain with FM receivers is the problem of regeneration in the RF or IF systems. Other than this problem, IF stages might be added almost indefinitely and the result would be a receiver which had better limiting action on low signal strengths.

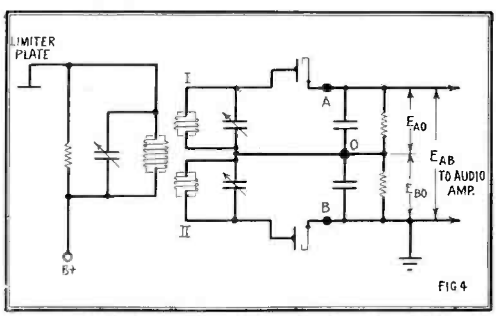
It will be noted that the resistor R, Fig. 2, in the grid circuit of the limiter is by-passed by a condenser. The function of this condenser is two-fold. First it allows the intermediate frequency signal a low impedance path to the cathode of the limiter tube.

Second, this condenser in combination with the resistor R forms a resistor-condenser circuit with a time constant depending upon the capacity of the condenser and the value of the resistor. If either condenser or resistor is large, the time constant of this circuit is low. The reader is probably familiar with time constants as combinations of condensers and resistors for giving the required time constants used in AVC systems. The theory of a circuit of this type is that the time in seconds taken for a condenser to discharge through a resistor to one-third of its original charge is equal to the product of the capacity of the condenser in farads and the value of the resistance in ohms.

In this case, the condenser is charged during what might be termed the positive half of the IF cycle. That is, when the grid of the limiter tube is positive the voltage charging the condenser is the voltage developed by the signal across the resistor R. For instance, if a current meter inserted in series with R reads 1 ma. and R is 10,000 ohms, the voltage charging the condenser would be 10 volts. For proper operation, the time constant of this RC circuit should be high so that sudden amplitude changes in the signal due to noise will not bias the limiter for any appreciable length of time, thereby allowing the limiting operation to be altered. Employing a 100-mmfd. condenser for the value of C and 10,000 ohms for R, the resultant time constant is 1.0 microseconds.

Dual Limiters ★ As has already been pointed out, the value of the resistance R determines to some degree where the limiter starts functioning, but if too small a value of resistor is used, large signal strengths actually reduce the IF voltage developed in the plate circuit of the limiter tube. Therefore, if two limiters were used, somewhat better action could be obtained, for the first limiter would have a com-

FIG. 4. FREQUENCY DEVIATION PRODUCES VARYING VOLTAGE IN DETECTION CIRCUIT



paratively large value of R and would only function as such on strong signals while the second limiter would employ a smaller value of R and would be the prime limiter with weak signals. The second limiter could not be overloaded because of the action of the first limiter in reducing the signal fed to it.

In some receivers, it will be found that the function of the first limiter is performed by the last IF amplifier tube, while in others two separate sharp cut-off tubes are employed. In this latter case, the IF system usually consists of two IF stages plus two limiters.

The operations described above cause waveform distortion. However, this does not affect the quality of the received signal as it would in amplitude modulated receivers for, as has been pointed out, the amplitude of the recovered audio signal depends upon the frequency swing of the FM transmitter and the frequency of the recovered audio depends upon the rate of frequency change of the carrier.

The Detection System ★ The function of the detector in an FM receiver is to recover, from the frequency-modulated signal, the audio voltage which originally modulated the transmitter. As the frequency-modulated voltage is entirely different from an amplitude-modulated voltage, it is logical to expect the detection system employed with frequency modulation to differ widely from those employed for amplitude modulation.

The type of circuit required is one which will perform just the opposite function of a frequency modulator. That is, a circuit is used which produces a voltage whose amplitude depends upon the frequency deviation of the transmitter from its center frequency.

Several types of circuits are capable of performing this function. Fig. 4 illustrates one of these. In this illustration, a primary circuit is tuned to resonance at the center of the intermediate frequency, while two secondary circuits are tuned to frequencies below and above the center frequency. The outputs of the two secondaries are rectified in two diodes arranged so that their outputs are in series, the audio voltage being developed across this series output network. The theory of operation of such a circuit is briefly as follows:

Fig. 5A illustrates the DC voltage which will appear across the diode load of each of the tuned secondary circuits. The upper secondary circuit No. I is assumed to be tuned to a frequency f_A while the lower (No. II circuit) is tuned to a frequency f_B. The center frequency lies halfway between f_A and f_B and is marked fc on the diagram. It will be noted that the resonance curves for the upper and lower circuits cross at a point which occurs at the center frequency. It has already been stated that the audio voltage appears across the two diode loads connected in series. In other words, the audio voltage appears between points A and B, point B being connected to ground. Referring to Fig. 4, it may be seen that the voltage between point A and B is the algebraic sum of the voltage between A and O and between O and B. We have already plotted in Fig. 5A the voltage which appears between points A and O, this voltage being labelled E_{AO}. We have not plotted the voltage between O and B, but we have plotted the negative of this voltage labelled E_{BO} in the diagram. To obtain the voltage between point A and B, we must subtract the voltage E_{BO} from the voltage E_{AO}. This can be done graphically by drawing E_{OB} below rather than above the axis, as shown in Fig. 5B. The resultant voltage E_{AB} is shown in this illustration, and it will be noted that this voltage varies linearly with frequency despite the non-linear curves which go to make it up. This is in some ways analogous to the distortionless amplification which can be obtained with push-pull tubes, despite the fact that either tube working alone would produce considerable distortion.

It can be seen from the above explanation that as the carrier frequency departs from

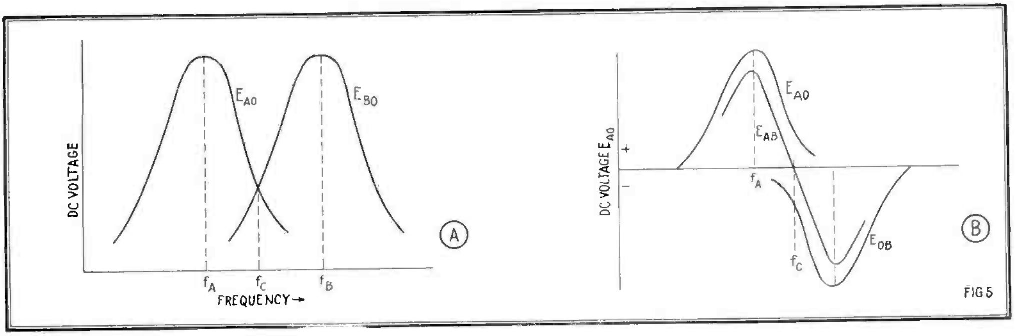


FIG. 5. DC VOLTAGES APPEARING ACROSS THE DIODE LOADS OF CIRCUITS SHOWN IN FIG. 4

the chosen center frequency, a voltage between point A and ground will be developed which is positive or negative depending upon the direction which the frequency departs (above or below center frequency), with a magnitude proportional to the frequency departure over the range of frequencies between f_A and f_B. If the carrier frequency is varying at an audio rate, an audio voltage will be developed between A and ground and that this voltage will be a faithful reproduction of the original audio modulating voltage.

The Q of the tuned circuits used in this type of detector circuit depends upon the width of frequency deviation which it is desired to accommodate. Obviously, if the curves of Fig. 5 were displaced by twice the distance shown in the diagram, the resultant rectified voltage E_{AB} would no longer approach linearity. It has been found empirically[1] that the Q of the primary circuit should be given by $Q_p = \frac{f_R}{3D}$. Q_p is the Q of the primary of the detection transformer. f_R is the resonant frequency (the intermediate frequency), and D is the frequency deviation to be employed (frequency deviation of the transmitter from its center frequency).

The Q of each of the secondary circuits can be twice that of the primary circuit. To obtain a Q lower than that of the primary tuned circuit itself, a resistance may be connected in parallel with it as shown in Fig. 4. It is unnecessary to load the secondary circuits except by means of the diode load resistors which are chosen to give the required Q. This circuit gives a linear response, but has the disadvantage that it requires the adjustment of three circuits for alignment, and all of these must be tuned to different frequencies, which is difficult.

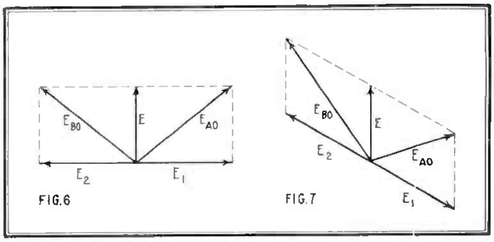
Another circuit which may be used to detect a frequency modulated signal is shown in Fig. 2. This circuit is the one most widely used in practice and has only two tuned circuits to adjust, both of which are tuned to the same frequency. The operation of this circuit is as follows:

It will be noted from the diagram that point O is by-passed to ground and, therefore, has substantially zero radio frequency potential to ground. The analysis will first be worked out for the case where the frequency of the voltage fed from the limiter is the same as that to which the primary and secondary circuits of the detection transformer are tuned. Under these conditions the DC voltage developed between C and O in the diagram is the rectified IF voltage appearing between A and O.

[1] "Reactance Tube Frequency Modulators," by M. G. Crosby, *QST*, June, 1940.

This IF voltage E_{AO} is in turn composed of two components, one due to the capacity coupling between the plate of the limiter and the center tap of the detection transformer secondary, and the other due to an induced voltage produced by magnetic coupling between the primary and secondary. The DC voltage between D and O is also produced by a rectified IF voltage appearing between B and O, which voltage is in turn composed of two IF components. It will be shown that when the frequency fed from the limiter is that to which both primary and secondary are tuned, the voltage between C and O will be equal and opposite to that between D and O, thus resulting in zero voltage being developed between C and ground.

Fig. 6 shows the vectors for the voltages in the secondary circuit. The voltage E is due to



FIGS. 6 AND 7. VECTOR DIAGRAMS OF VOLTAGE IN CIRCUITS SHOWN BY FIG. 4

the capacity coupling between the plate terminal of the primary and point O. If the Q of the primary is sufficiently low, this voltage is relatively constant over a range of frequencies about the center frequency. The voltages E_1 and E_2 shown on both Figs. 2 and 6 are the IF voltage developed across the two halves of the secondary of the detection transformer, and are always equal in magnitude and opposite in direction (180° out of phase with each other). As explained before, the vector sum of $E+E_1$ is the voltage which produces the DC voltage (rectified AC voltage) across the resistor R_1 between points C and O. This vector sum is voltage E_{AO} shown in Fig. 6.

In a similar manner, the vector sum of $E+E_2$ produces E_{BO}, which in turn produces the DC voltage across the resistor R_2 between points O and D. As E_{AO} and E_{BO} are equal in magnitude, the DC voltages developed across resistor R_1 and R_2 are equal in magnitude but opposite in polarity. Consequently, the DC voltage between C and D is zero. This is the condition which exists when the transmitter is sending out a frequency which is its center frequency. (The frequency deviation is zero). This also assumes the FM receiver is aligned properly.

(CONTINUED IN MARCH ISSUE)

MEISSNER MODELS 9-1023, 9-1037

Service Data on Meissner FM Sets, with 9-1041A Chassis

SPECIFICATIONS

Type of Circuit: FM-Superheterodyne
Tuning Range: 42–50 mc.
Input Power Rating: (117-volt line) 110 watts
Intermediate Frequency: 4.3 mc.
Image Ratio at 42 mc.: 172
Selectivity: 170 kc. broad at 2 times signal
Sensitivity: 10 microvolts, average
Speaker: 8-in. PM
Power Output: 6 watts undistorted
Types of Tubes:
Fig. 1, showing the chassis as viewed from the rear, illustrates the types and purposes of the various tubes.

Power Supply ★ Unless otherwise marked, this receiver must be operated on a 117-volt, 50 to 60 cycle AC supply only. Do not insert the plug of the power cord into the receptacle unless *all* tubes *and* the speaker plug are in their proper sockets. The power rating of this receiver is shown on the tube arrangement label. Receivers of this model which are to be used on 25-cycle, 230-volt or other special service are so marked on this label. If there is any doubt regarding the voltage and frequency of the power supply, consult the local power company before inserting the plug.

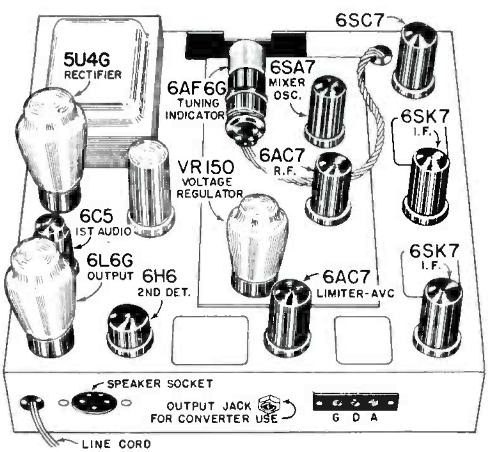


FIG. 1. REAR VIEW OF MEISSNER FM CHASSIS

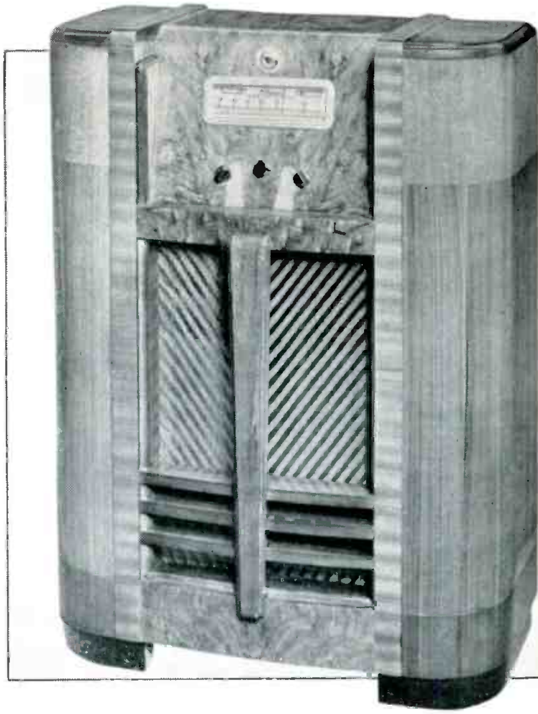


FIG. 2. MEISSNER CONSOLE MODEL, FM ONLY

Tubes ★ The type and position of each tube are shown in the illustration. The type 6AC7, used as an RF amplifier and limiter, may also be known as a type 1852. These two type numbers are directly interchangeable.

The Tuning Indicator tube is a type 6AF6G and has two shadows instead of the more familiar one. The tube socket should be rotated in its supporting clamp so that the two shadow portions are horizontal.

Dial Lamps ★ The dial lamps are of the bayonet base type, 6 to 8 volts, .15 to .25 amperes. To replace either lamp, first turn the receiver off, remove the defective lamp by twisting slightly to the left and insert the new lamp, twisting it to the right until it is properly seated in its socket.

Voltages at Sockets ★ The voltages that should be considered normal at each tube socket terminal are indicated in the table at the bottom of the schematic circuit diagram. All voltages indicated are measured between the socket terminal and ground (chassis). Readings shown are positive on the socket terminal with the chassis as the negative terminal except where a negative voltage reading is given in which case the chassis is positive. Readings marked "AC" indicate normal AC heater voltage and should not be read with a DC meter.

These voltages are read under the following conditions:

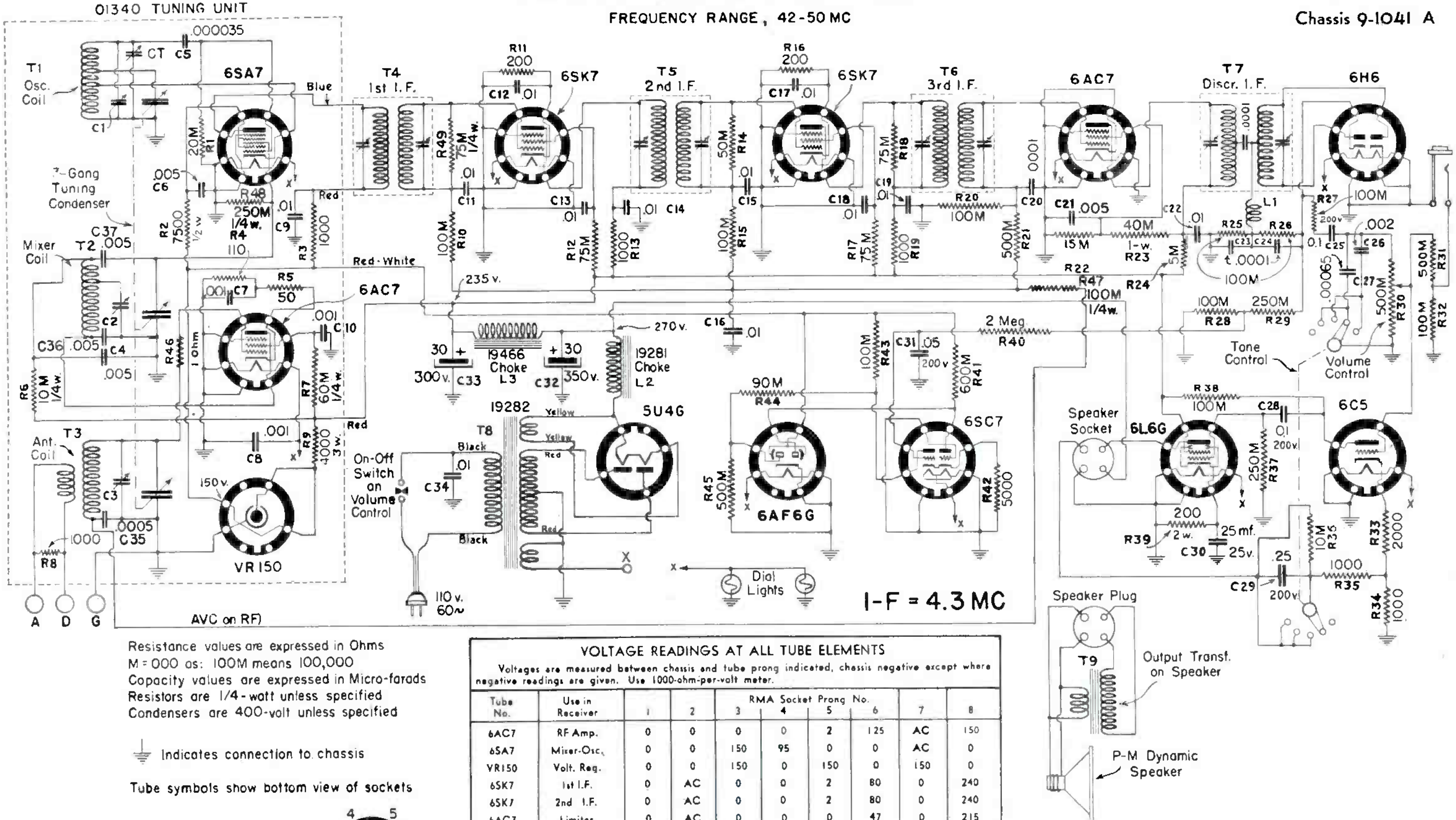
Line Voltage — 117 volts

(CONTINUED ON PAGE 48)

FREQUENCY-MODULATION RECEIVER

FREQUENCY RANGE, 42-50 MC

MODELS 9-1023, 9-1037
Chassis 9-1041 A



Resistance values are expressed in Ohms
M = 000 as: 100M means 100,000
Capacity values are expressed in Micro-farads
Resistors are 1/4-watt unless specified
Condensers are 400-volt unless specified

⏚ Indicates connection to chassis

Tube symbols show bottom view of sockets

RMA Socket Numbering Guide as Used in Voltage Chart

VOLTAGE READINGS AT ALL TUBE ELEMENTS

Voltages are measured between chassis and tube prong indicated, chassis negative except where negative readings are given. Use 1000-ohm-per-volt meter.

Tube No.	Use in Receiver	RMA Socket Prong No. 1	2	3	4	5	6	7	8
6AC7	RF Amp.	0	0	0	0	2	125	AC	150
6SA7	Mixer-Osc.	0	0	150	95	0	0	AC	0
VR150	Volt. Reg.	0	0	150	0	150	0	150	0
6SK7	1st I.F.	0	AC	0	0	2	80	0	240
6SK7	2nd I.F.	0	AC	0	0	2	80	0	240
6AC7	Limiter	0	AC	0	0	0	47	0	215
★ 6H6	2nd Det.	0	AC	0	0	0	0	0	0
6SC7	Ind. Amp.	0	88	0	0	45	1.5	0	AC
6C5	1st Audio	0	0	88	0	0	0	AC	3.5
6L6G	Output	0	0	280	250	0	0	AC	13.5
5U4G	Rectifier	0	305	0	390AC	0	390AC	0	305

★ With 6AC7 Limiter tube removed from chassis.

SPEECH INPUT EQUIPMENT FOR FM

(CONTINUED FROM PAGE 39)

crackle finish make a very durable surface with a pleasing appearance. Weighing 110 lbs. and measuring 34″ x 14″ x 10″ the equipment is suitable for table mounting, giving the operator maximum visibility of studio performers. The light weight and compact construction lend themselves especially well to semi-permanent remote set-ups, as well as to studio installation. The equipment is easy to install, since all incoming connections (except to the commercial AC supply of 105–125 volts, 50–60 cycle current) are made at a small terminal panel along one side of the unit. The unit consumes approximately 90 watts.

The power supply unit is completely contained within the cabinet, with the exception of the 12 volts DC needed to operate the loudspeaker cut-off relays. This must be furnished externally.

There are no high voltages used in the equipment and all terminals upon which voltages appear are beneath a protective panel. Fuses are of the "slow-blow for moderate overload, fast-blow for large overload" type.

WHAT THE BROADCASTERS SAY

(CONTINUED FROM PAGE 1)

set owners who do not care for the continuous procession of dramatic shows now on the air. Herein lies an opportunity for the FM broadcaster to awaken interest in daytime radio on the part of those set owners who are now a dead loss so far as AM broadcasting is concerned.

7. Lastly, we believe that the FM broadcaster should always model his programs according to the listening public's demands and should not permit himself to be swayed from his set course by the idiosyncrasies of the advertiser and the advertising agency. Steadfast adherence to a policy based on genuine public service can open up a listening field of unbelievable proportions.

Back Numbers of *FM*

In case you missed the January issue of *FM* Magazine, you can get this number by sending 25¢ in stamps or coin to FM Company, South Norwalk, Conn. However, you must do this at once, for only a few copies are available. As announced previously, we cannot supply copies of November or December, for they are sold out.

FM Magazine is not sold on newsstands, but by subscription only. There is a considerable saving when several subscriptions are filed in a group. Special group subscription rates are shown on the blank which is bound into this magazine.

May We Suggest to the

FM MANUFACTURERS:

WHEN short-wave tuning was added to broadcast sets, we called the new models "all-wave" receivers. That name was a fortunate choice because it was not only descriptive, but it indicated that there was something missing from sets which lacked "all-wave" tuning.

You will recall that, within a year, public demand for this extra feature forced all the manufacturers to include it — despite the fact that the added cost gave the purchaser no commensurate increase in the entertainment that issued from the loudspeaker.

In fact, short-wave transmission was then purely experimental. Sometimes something could be heard on the new bands, but usually there was only the sound of squeals, howls, and static explosions. Dealers couldn't even demonstrate short-wave reception because their stores were usually in unfavorable locations, and if a foreign station could be heard, it was nearly drowned out by interference.

Now, with FM stations going on the air, history repeats itself. The difference is that FM-AM sets, in addition to furnishing the extra entertainment of FM programs, give improved AM reception. Further, FM broadcasting is being increased rapidly now, and will be constantly augmented in the future as new stations get on the air!

Unquestionably, some confusion has been caused among dealers and listeners by the talk about "FM sets." Many people think that these radios only work on FM. They do not know that they tune AM stations as well. Thus, the impression has been created that the new receivers are *limited* in usefulness when, actually, they furnish *additional* entertainment of improved quality.

For exactly that reason, *FM* Magazine has consistently referred to the new sets as "FM-AM receivers." That may sound too complicated, however, to be understood by Mr. Jones and Mr. Smith. What we need is a self-explanatory name, such as was "all-wave radio," for FM-AM sets.

MAY WE SUGGEST that the FM manufacturers give serious thought, at once, to coining a new descriptive name for FM-AM receivers and, if it can be found, that they join in publicizing it as the generic name for modern, all-program receivers. *FM* Magazine will be pleased to cooperate by publishing names suggested by our readers.

The Fourth of a Series of Discussions Concerning the Mutual Problems of the Broadcasters, Set Manufacturers and Radio Dealers

FM MAKES PROGRESS

(CONTINUED FROM PAGE 6)

Instead, take the audio amplifier and speaker system out of an FM-AM set and put it in one from an ordinary AM radio. That will make a BIG reduction in the cost — and in the performance, as well! In other words, the increase is in the cost of fine tone quality.

The dealers who are doing a real job with FM-AM sets sell three important advantages over AM sets. They are:

(1) The superior performance and tone quality on AM broadcast reception. (2) The ability to receive such FM programs as are on the air. (3) The protection against obsolescence.

Thus, the owner of an FM-AM set is assured of the maximum enjoyment of all programs now and in the future through the ownership of a completely modern radio.

MEISSNER MODELS 9-1023, 9-1037

(CONTINUED FROM PAGE 44)

Volume Control — Maximum
No Signal Being Received

Readings are taken with a 1000-ohm-per-volt meter. Plate and screen voltages are read on the 500-volt scale. All readings under 50 volts are read on the 50-volt scale.

CARTER TAKES OVER BOSCH MAGMOTOR DIVISION

The Carter Motor Company of 1608 Milwaukee Av., Chicago, makers of Dynamotors and Converters for Aircraft, Police, Marine Radio, and general use since 1932, announce the purchase of the Magmotor Police Radio Power Supply Division from the American Bosch Corporation of Springfield, Massachusetts. All patents covering permanent magnet Dynamotors together with tools, dies, patterns, and trade marks, become the property of the Carter Motor Company who will maintain full service for all former American Bosch customers.

The Magmotor is unique in principle; no field coils are used. Alnico permanent magnets take their place providing increasing efficiency, reducing size and weight, and eliminating heat. Magmotors will run continuously for more than 5,000 hours before brushes require changing. They are the ideal power supply for frequency modulation police radio.

The Magmotor addition to an already large line of dynamotors and converters makes the Carter Motor Company the sole manufacturers of permanent magnet dynamotors. Licenses under the permanent magnet Dynamotor patents will be available to others.

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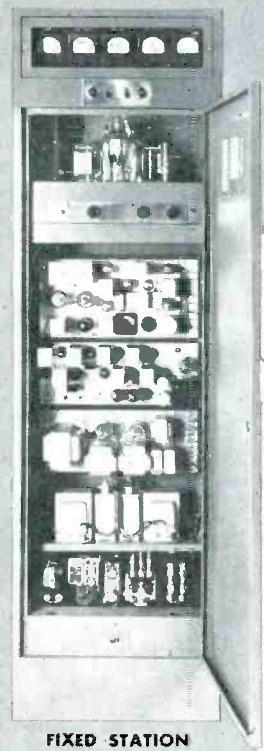
CONCORD, N. H.

FREQUENCY MODULATION

GOVERNMENT • PUBLIC UTILITY • POLICE • FIRE



FIXED STATION
Type 250 UFS
250/400 watts

The

CONNECTICUT

state-wide

F-M POLICE SYSTEM

manufactured by

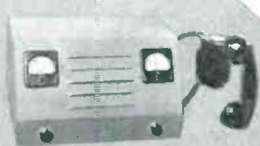
LINK

Other Link F-M emergency radio communication equipment is in use by:

POLICE	PUBLIC UTILITIES	GOVERNMENT
Ohio State Police	Ind. & Mich. Elec. Co.	U. S. Signal Corps. Labs.
Maryland State	The Ohio Power Co.	U. S. Coast Guard
North Carolina State	The Penna. Elec. Co.	U. S. Aircraft Radio Labs.

Plus many more users in the above three and other classifications.

Write for new eight page bulletin describing Link F-M emergency equipment.



CONTROL UNIT
two-wire remote control
for fixed station

FMTR MOBILE ASSEMBLY
Type 25 UFM 25/30 watt transmitter
Type 11 UF receiver and power supply

F-M by LINK

Fred M. Link
Engineer • Manufacturer

125 WEST 17th ST., NEW YORK, N.Y.
Telephone: CHELSEA 2-4462

Two Distinguished Pilot FM-AM Phonographs
Above: Continental, in Walnut Cabinet $299.50
Left: Hepplewhite, Walnut or Mahogany $249.50

Pilot FM-AM Phonographs Give

ALL THAT FM HAS TO OFFER

PILOT FM-AM instruments disclose hitherto unrealized possibilities for radio entertainment. Anyone who listens to one of these new instruments in his home is immediately delighted with its amazing results.

First, there is an astounding improvement in reception of the familiar AM broadcast stations, due to advanced Pilot engineering methods.

Second, there is the actual re-creation, on FM programs, of music, speech and sound effects, free of interference, just as they originate at the studio.

Finally, the Pilot FM-AM automatic phonographs shown above provide superb recorded music through the medium of *two* speakers, giving a perfect combination of lows and highs.

Note that all these Pilot features are available in the table model at $139.50, console model at $179.50 and the console combinations pictured above: 12 tubes plus tuning beacon; Improved superheterodyne circuit; 3-gang condenser; Tuned R.F. stage on both bands; Tuning range — FM — 42–50 mc. — AM — 540–1750 kc.; Interstation silencer (QAVC); Balance detector for accurate visual tuning indication on FM; Push-Pull audio output with inverse feed-back; Inverse feed-back tone control; Fly-wheel gyro-tuner. For further information, Address:

PILOT RADIO CORPORATION, Long Island City, New York

"The Standard **Pilot RADIO** of Excellence"