FM

JANUARY 1941

Blossom

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2-WAY POLICE SYSTEM

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

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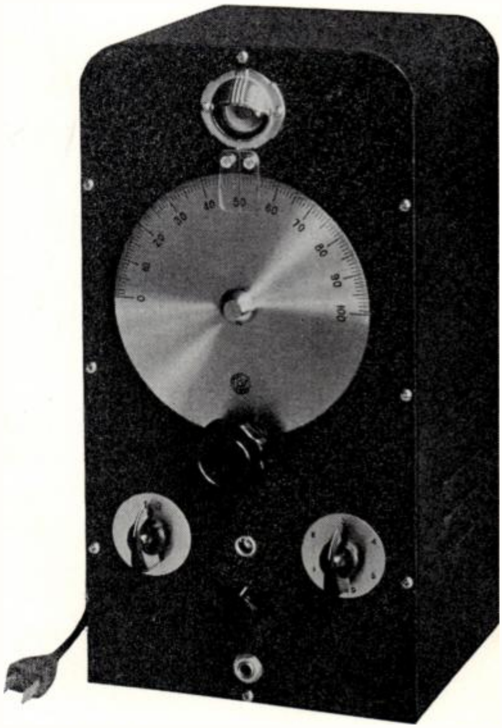
for checking police, fire, and all emergency transmitters

Permits more accurate adjustment because it is easier to read accurately



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WHAT THE FM BROADCASTERS HAVE TO SAY:

A Statement by Charles E. Wilson, President General Electric Company

RADIO engineers of the General Electric Company early became interested in the possibilities of FM broadcasting systems, and have worked closely with Major Edwin H. Armstrong in the development of both receiving and transmitting equipment for various services.

In view of this experience, therefore, it seems only natural that the General Electric Company should have an FM broadcasting station of its own. Thus it came about that, on November 20th of this year, station W2XOY in Schenectady started transmitting on a regular schedule, after having been operated for developmental research work since early in 1937.

The advent of FM may, perhaps, make little difference in the radio entertainment of certain listeners. But to the thousands of families living in rural areas, and to city dwellers in noisy sections where there are no adequate signals for daytime reception, broadcasting by FM will be doubly welcome.

FM has many things to offer the public. They will become increasingly apparent as we move into a period of greater operating experience. FM should stimulate the advancement of programming and studio technique. Of course, by its very nature, FM will allow a great increase in traffic, thus furnishing listeners with a wider selection and variety of entertainment.

A very important advantage of FM is that, since the coverage from each station can be tied fairly definitely to specific trading areas, each station can direct its service to the specific interests of the residents in its own area.

Like the radio art itself, FM programming is in a state of evolution. Techniques and material are already being improved as operating experience is gained. For our own station, we are already planning to provide programs, as far as possible, which will not be available from standard broadcasting stations. With our relay facilities, we hope also to be able to tie in with programs originating from other FM stations.

To bring FM programs to a still greater number of listeners in the Schenectady-Albany-Troy area, General Electric has applied to the FCC for permission to increase the power of W2XOY to 50 kilowatts. Naturally, an increase in power will not increase our audience greatly unless we acquaint our listeners with the special advantages of FM reception. Thus, supplementing our national FM educational efforts, we shall work in conjunction with the dealers in the W2XOY area to make complete information available to the residents in this section.

With FM definitely launched on a career of public service, we can expect rapid progress in the improvement of equipment, program material and technique, and a great increase in the number of FM broadcasting stations. All this will widen the circle of FM enthusiasts. Both as broadcasters and as manufacturers, we are confident of the future of FM, and we consider it a great contribution to the advancement of the radio art.

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

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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.

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

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

POLICE FM PIONEER

THERE is a well established axiom concerning police equipment that if a device may fail in an emergency, it is dangerous to get into the habit of depending upon it. So sound has this policy proved to be that it is possible for innovations of real merit to be lost through lack of the consideration they deserve.

Such could have been the case in Connecticut, when funds were made available for a State Police radio system. Commissioner Hickey could have played safe by refusing to consider the use of other than conventional AM equipment. Or he might have taken a chance with the still untried possibilities of FM.

But he did neither. Instead he determined the limitations of AM, and then made an exhaustive engineering investigation of FM to see if it could deliver greater coverage and a higher degree of dependability. This constructive approach to the problem of providing the best possible radio system for the State of Connecticut showed conclusively that an FM system, laid out to meet the topography of the State, could deliver service superior to that obtainable with AM.

Commissioner Hickey, under whose direction the work was carried out, has thus made an important contribution to the advancement of police communication.

Details of the Connecticut State Police radio system are presented in two articles in this issue of *FM* Magazine, one by Commissioner Hickey, and another by Radio Supervisor Sydney E. Warner.

THE COMPLETE AND AUTHORITATIVE SOURCE OF INFORMATION ON FREQUENCY MODULATION

VOL. 1 JANUARY, 1941 NO. 3

CONTENTS

WHAT THE FM BROADCASTERS HAVE TO SAY . . 1
A statement by Charles E. Wilson

FM GROWS 4
Map showing FM stations in U. S. A.

TWO URGENT MATTERS CONFRONT FCC . . . 5
by M. B. Sleeper

G.E. PREMIERS FM 8
Ceremony marks opening of W2XOY

BROADCAST TRIBUTE TO FM SUCCESS 9
Address by Radio Commissioner George Henry Payne

STATE-WIDE TWO-WAY FM SYSTEM 10
by Connecticut State Police Commissioner Edward J. Hickey

FMBI MAKES RECOMMENDATIONS 13
by John Shepard, 3rd

G.E. ACTIVE IN FM EMERGENCY FIELD 14
by Herbert DuVal

NOTES ON FM RECEIVING ANTENNAS 19
How to overcome static interference

THE MANUFACTURERS SAY 20
by Dr. Ray H. Manson

FM GOES WHERE AM CAN'T 22
by Will Whitmore

PHONOS LEAD PILOT FM SALES 24
An important slant on public buying tastes

TWO-WAY POLICE FM PERFORMANCE 26
by Sydney E. Warner

ZENITH MODELS 10H551, 10H571 31
Data from the Zenith service manual

TECHNICAL DATA ON SCOTT SETS 38
by Marvin Hobbs

FM HANDBOOK, CHAPTER 3 42
by G. H. Browning

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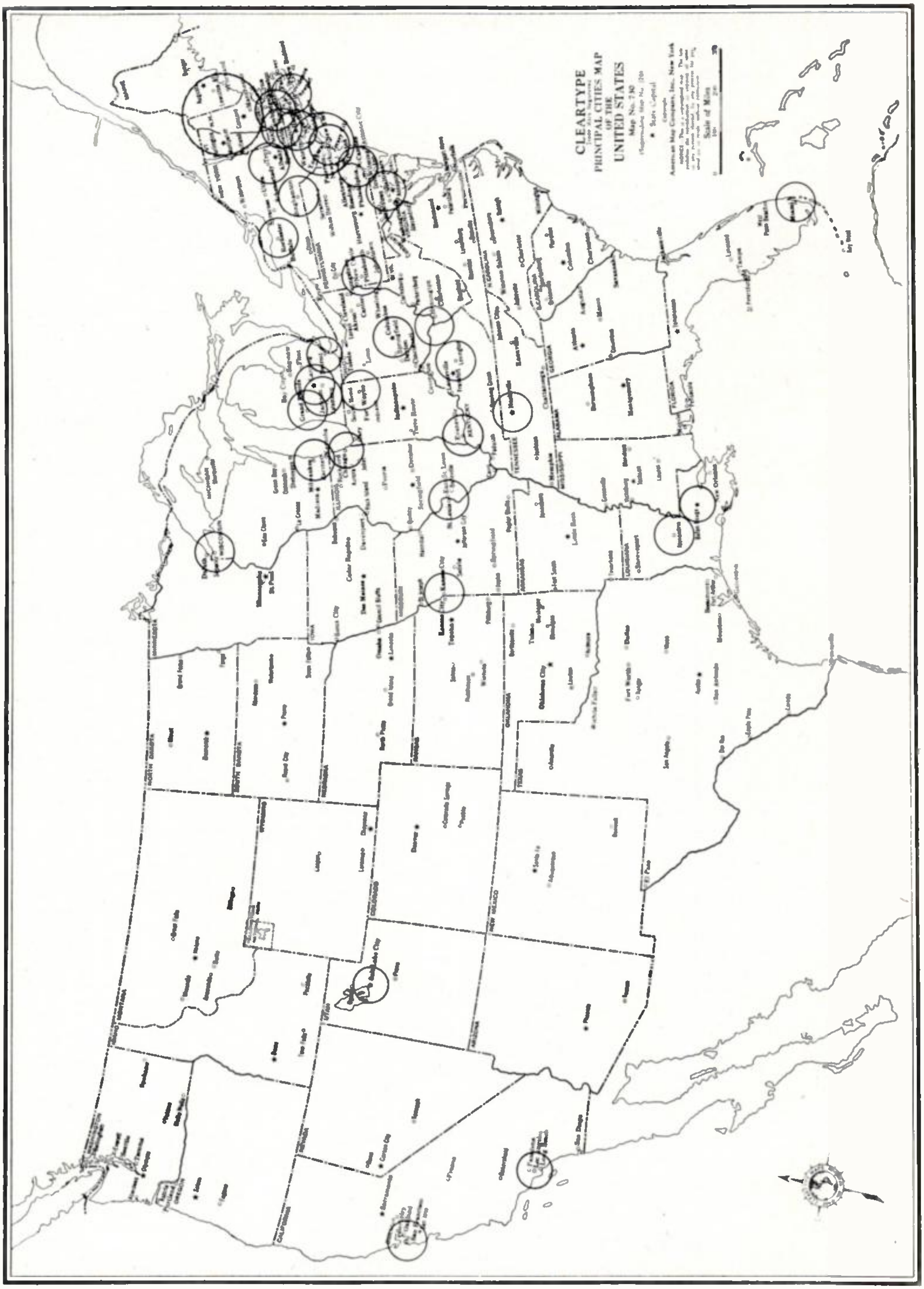


FM GROWS

CIRCLES REPRESENT SERVICE AREAS OF FM STATIONS NOW IN OPERATION OR UNDER CONSTRUCTION, OR FOR WHICH APPLICATIONS HAVE BEEN MADE. IN SOME AREAS, AS MANY AS SIX STATIONS ARE LOCATED. SURPRISINGLY, THE WEST COAST LAGS IN FM PROGRESS

TWO URGENT MATTERS CONFRONT FCC

Immediate Action Needed to Get More Stations on the Air and to Settle Choice of Wire Lines or Radio Links

BY M. B. SLEEPER

THE advent of frequency modulation has given the FCC an unusual opportunity. The errors of omission and commission in the AM band, now known and catalogued, serve as a guide for FM planning.

The thoroughness with which the Commission has gone into this undertaking, has merited the approval of all concerned. By accepting the cooperation of those who are making great investments of time, of engineering effort, and of capital in the development of FM broadcasting, the Commissioners have given the most effective encouragement to this new public service.

Much time has been required, and has been spent, in laying out a coordinated plan for the use of the FM channels. Such a task cannot be completed hastily, nor under pressure of expediency. Its future implications are too grave. It must not be found years hence that public interest would have been better served by more deliberate thinking at the start.

The Economics of Time ★ However, it is equally vital to accommodate the program of FM planning to another essential factor. It is this: Our American people are quick to adopt and make use of technical improvements. But they are an impatient people. If a scientific advancement is widely publicized as being perfected and ready for marketing, it must be produced and delivered. Even though the price is high and the distribution limited, it must be made available. As long as the product represents a genuine contribution, there will be plenty of customers at once, and interest and confidence will be stimulated.

Delay right at that time sets up mistrust. This Country hates a false alarm. If that impression is permitted to gain headway, it sets up sales resistance which may hold back for years a product of great intrinsic worth.

Those who have not learned, through actual merchandising experience, how true this is may say: "If it's really good today, it will still be good tomorrow." Well, that's true — before it has been made known to the public as a fait accompli. Once it has been removed from the laboratory hot house, it must be planted quickly where it can take firm root and flourish commercially. Leave it lying in the sun while experts argue over the proper soil, and it will wither away.

Critical Period ★ FM has now reached a critical period in its progress. To the tremendous publicity given FM, the FCC has added its official approval, and has made known its selection of FM as the exclusive method for high frequency broadcasting.

It is the writer's personal opinion, based on a year's practical experience with the problems of selling FM receivers to the radio trade, that unless broadcasting service is made available promptly in every city represented on the list of applications filed and construction permits granted, serious harm to FM progress will result from the publicity given to the Commission's favorable attitude toward it!

Right now the radio dealers, through whose hands FM receivers must pass to the listening public, are asking: "FM isn't going to wind up as another false alarm, like television, is it?"

A Fair Question ★ That's a fair question, and a mighty important one to be answered definitely and convincingly. "If FM broadcasting is sufficiently perfected that the Commission has approved it, why can't the stations get on the air?" That's what the trade wants to know.

Of course there are reasons for the delays, and good ones, but the radio trade isn't interested in explanations nor impressed by them. Explanations can't be sold at a profit. Right now, many dealers feel that what has been done by the FCC has only hurt their set sales, so far. They believe that people are postponing the purchase of the more expensive models until they know more about the availability of FM programs.

The dealers must, therefore, decide whether they will make the best of the situation at this time, and reduce their stocks in preparation for going actively into selling FM-AM receivers, or if they will deliberately sell their customers away from FM, in order to make immediate AM sales.

The former attitude is discouraged, and the latter encouraged by anything that delays the granting of applications or the licensing of stations for which construction permits have been granted. Furthermore, delays are capital for radio manufacturers who see fit to resist the progress represented by frequency modulation. Recently, for example, at a meeting held by one of the Boston jobbers, a dealer rose to ask the question: "What progress is being made by

FM?" He was answered by a representative of the manufacturer whose products were under discussion: "You can expect public acceptance of television long before there will be any sale of FM receivers!" This is no isolated instance, either.

Great hopes were raised in New Hampshire when it was announced that a construction permit had been issued for Mt. Washington. In most of the area to be covered by this station, there has never been any satisfactory program service. Very little can be heard on AM in the daytime, and at night squeals and cross-talk come in from one end of the dial to the other. Listeners took it for granted that Mt. Washington would go on the air in the immediate future. Dealers are preparing to make the most of this prospective market. But, unless they are given some definite date on which broadcasting will start, to which they can time their merchandising plans, they will soon come to the feeling that FM at Mt. Washington is just another false alarm.

Static Is Best FM Salesman ★ Those who listened to FM programs last summer know that static is the best salesman for this new system. If, right now, the radio trade were to pick out a "must" date for nation-wide FM transmission to be in full swing, it would be April 1st. Most set manufacturers bring out their new models at about that time, so the date is appropriate for them, too.

But what is of the greatest importance is that this date, if definitely established, would give the dealers just the time they need to capitalize on the approaching summer static. This would meet fully the need for something to bolster up low summer volume of radio sales. If FM programs are in full swing on the first of April, FM sales will make 1941 the most profitable year the radio industry has ever known.

If stations are held up beyond that date, the summer season will be lost to FM, for dealers will have to make plans to push summer merchandise other than radio. The next starting time for radio sales is the fall. By that time, the public will have lost the confidence it has now in the improved service provided by FM.

Filing for Protection ★ FM progress can be hampered seriously in another way. It seems certain that some FM station applications have been filed by operators of AM transmitters who do not intend to put FM programs on the air until, and unless, they are compelled to do so by the FCC. These applications have been filed with an if-as-and-when purpose of protecting AM situations.

It should not be difficult for the Commission to recognize these intentions, and such applicants should not be allowed extensions of time beyond the dates set forth in the construction permits. The need for cleaning up conditions on the air is much too great to permit such tactics of obstruction.

Wires or Radio Links ★ The second matter which requires urgent consideration has to do with decisions relating to licenses for radio link transmitters where they are required, for reasons of economy, instead of wires for studio-to-transmitter connections.

No one has any quarrel with the Commission's policy of keeping off the air service which can be as well performed by wires, but FM has brought up a new problem in this connection. In order to locate FM transmitters most advantageously, it is generally necessary to install them at some distance from the broadcasting studios. In many instances, particularly where high ground is selected as the transmitter site, no telephone lines are available.

Therefore, a choice must be made between an investment in special telephone connections and the subsequent rental charges, and the installation of a radio link transmitter and receiver with its attendant maintenance cost. This assumes, of course, that the quality of transmission is the same in both cases, and that both methods meet the FCC requirements as to noise level.

Precedents have been established for both methods in such situations.[1] Where cost and service are approximately equal for the two methods, it seems entirely reasonable that wires be given preference. However, FM stations must not be penalized by being forced to pay substantially more, or to accept a lower quality of service if, in individual cases, wire lines are not competitive with radio links.

Definite policies must be established by the Commission so that, if conditions call for the use of radio links, the construction permit and license can be issued simultaneously with those for the associated broadcast transmitter.

Otherwise, if only the broadcast station permit is issued, the owner must choose between paying a premium for land line, and perhaps accepting inferior service, or submitting to serious delay in getting on the air with a radio link.

April 1st Is Dead-Line ★ If there is one useful, practical idea that *FM* Magazine would like to impress upon the Commissioners, and the broadcasters also, it is the need of planning to get the maximum number of FM broadcasting stations on the air with regular schedules before April 1, 1941.

[1] W1XPW uses land lines from Hartford to Meriden Mountain. (See *FM* Magazine, Dec. 1940.) W1XOJ uses a radio link from Boston to Paxton. (See *FM* Magazine, Nov. 1940.)

There may remain at that time some mopping of secondary details. Some subsequent readjustments may be required. But if a specific time is set as the outside date, and preferably that of April 1st, toward which the FCC and the broadcasters will work, it will give the encouragement and assurance to the set manufacturers, jobbers, and dealers. This is of vital necessity and paramount importance to the immediate creation of an FM audience.

Failure to do this will result in the loss of confidence of the set manufacturers and their jobbers and dealers, the creation of serious sales resistance to the purchase of receivers, and in substantial loss and increased expense to the FM broadcasters before there can be a profitable volume of sponsored FM programs. Surely, it is not beyond the capacity of the Commission to find a way to meet this April 1st dead-line.

UNUSUAL FM DEMONSTRATION FOR A.I.E.E. AT MILWAUKEE

USING two portable FM transmitters, Professor Siskland, of Purdue University, recently staged a graphic demonstration of frequency modulation for the members of the American Institute of Electrical Engineers at the Republican House, in Milwaukee. Assisting him were Gerald Miller, also of Purdue, and Phil Laeser, from the staff of FM station W9XAO.

The lecture, covering all phases of FM broadcasting, was highlighted by the use of an oscillograph to show the actual phase shift of a carrier wave under frequency modulation.

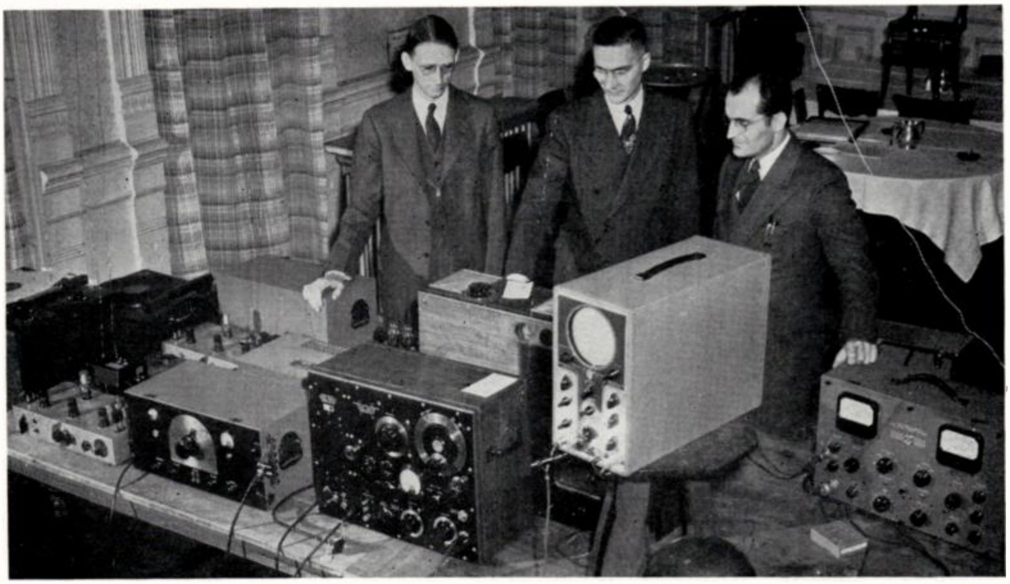
Particularly interesting was Professor Siskland's comparison tests of AM and FM interstation interference. By means of signal generators, he first showed that a power ratio of between 50 and 100 to 1 was required for one AM signal to dominate another.

Then, with identical FM transmitter units, he ran a similar test. Varying the output of one unit, it was shown that, in order to suppress the other, a power ratio of two to one was necessary.

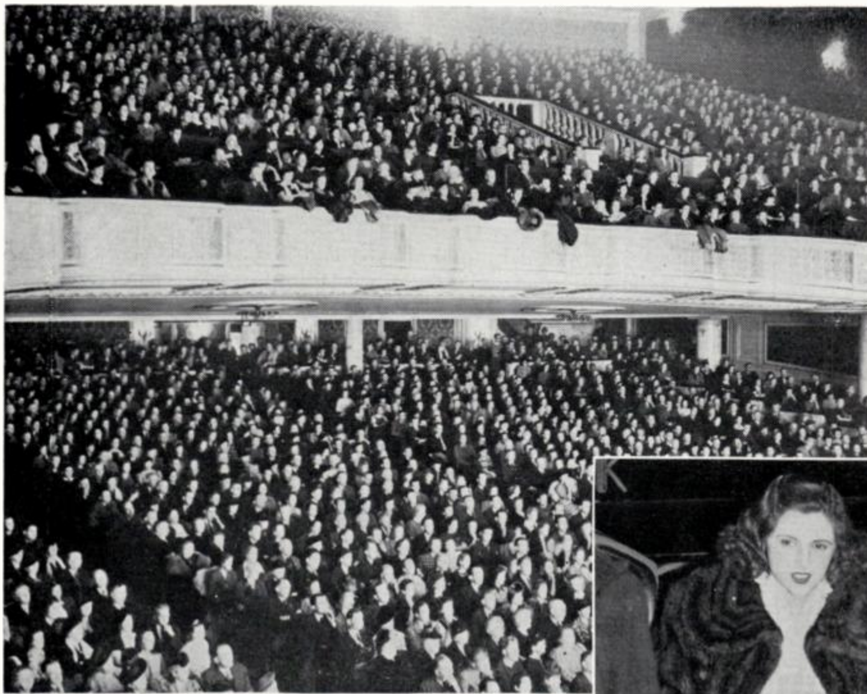
Another part of the lecture was devoted to an audio frequency run on an FM receiver, to show its wide range of response. The majority of the audience was able to hear frequencies from 13 to 15,000 cycles.

A special treat for the members of the A.I.E.E. and their guests was the reception of the opera "Aïda," by FM. This program, originating at the stage of the Pabst Theatre, came over the *Milwaukee Journal's* station W9XAO.

The *Journal*, largely as a result of featuring musical programs of exceptional quality, has created great interest throughout the Milwaukee area in FM reception. In its new studios, now under construction, special provisions have been made for the production of broadcasts which will utilize to the fullest extent the musical possibilities of FM transmission.



PROFESSOR SISKLAND, ASSISTED BY GERALD MILLER AND PHIL LAESER, USED THIS EQUIPMENT IN DEMONSTRATING THE PERFORMANCE OF FREQUENCY MODULATION CIRCUITS



WITH THEATRE FOR STUDIO, SPITALNY'S ORCHESTRA PUT ON W2XOY'S INAUGURAL PROGRAM. RIGHT, STAR FM PERFORMER WAS EVELYN, WITH HER MAGIC VIOLIN

G.E. PREMIERS FM

3,500 at First Scheduled Broadcast from W2XOY Hear Demonstration of FM Reception

ON November 20th, regular broadcast service was inaugurated from General Electric's FM station W2XOY. This transmitter, connected to the Schenectady studios by a 12-mile FM radio link, is located in the Helderberg hills.

Because daytime AM reception is limited in this area of 1,000,000 population, and night time interference is very severe, there are many homes where FM will deliver thoroughly satisfactory radio signals for the first time. To those within the primary service area of the local AM stations, W2XOY will represent an important source of additional entertainment, since G.E. plans to use much program material, such as the Saturday afternoon operas, which will not be available on their associated AM station WGY.

A week before the official opening of W2XOY, an FM demonstration meeting was held for dealers in the Albany-Troy-Schenectady section. Orders were placed at that time for over 350 G.E. FM-AM sets, thus assuring adequate distribution of receivers within this market.

Tremendous publicity was given to the inaugural ceremony at Proctor's Theatre, where the audience saw and heard the first program broadcast from the stage, and listened with astonishment to reception of FM sound effects originating at the studio. A standard G.E. FM-AM console was used for this purpose. Phil Spitalny's All-Girl Orchestra was brought to Schenectady to supply the music for this occasion.

General Electric's president, Charles E. Wilson, one of the speakers on the program, explained the possibilities of FM for finer entertainment. He said: "Frequency modulation has proved itself a superior means for sending programs to your homes, as well as for many kinds of regular and emergency service." Other speakers were Dr. W. R. G. Baker, manager of the G.E. radio and television department, and Radio Commissioner George Henry Payne, whose address appears in full on the page opposite.

FCC Commissioner George Henry Payne Pays Tribute to Major Armstrong and the Success of His FM System, at W2XOY Inaugural Ceremony

EDITOR'S NOTE. — *Following is the text of an address by Commissioner George Henry Payne, delivered at Schenectady, N. Y., on November 20, 1940, and broadcast as part of the first scheduled program over General Electric's FM transmitter, station W2XOY.*

THIS is an important day in the development of radio.

It has been calculated that from the discovery of the first steps in radio until about the present time, hundreds of inventors, scientists and developers were responsible for radio, from its conception up to what we know it to be today.

Tonight the General Electric Company is celebrating not only the latest work of a great contributor to radio, but celebrating his accomplishment and the inauguration of Frequency Modulation under the auspices of their great organization and their great influence.

This event, inaugurating the operations of the General Electric frequency modulation station on a regular basis, combines in this one program two very important features. It is a significant milestone in pioneering for the public a new and better type of broadcast service, which will vastly improve the technical reception of the listening audience.

May I congratulate the General Electric Company as a leader in this field, and, if I am not mistaken, as one of the first commercial organizations with vision enough to make frequency modulation receiving sets commercially available to the general public.

In a larger sense, however, I look upon this program as a tribute and honor to Major Edwin H. Armstrong and as a recognition of his leadership in making available to the public the entire system of frequency modulation as we have it today — a system of which he may justly be called the father.

It gives me a particular feeling of pleasure to represent the Federal Communications Commission in such a tribute to Major Armstrong because, since his system was first publicly described to the Commission at the June, 1936, short-wave allocation hearings, I have seen how Major Armstrong, with great courage and tenacity of purpose, has consistently, in the face of strong opposition, carried his fight through to a successful conclusion. Today, frequency modulation is here — today it is available to the public!

It should be particularly a matter of pride to us here and to the General Electric Company that the contribution of Major Armstrong is an American contribution.

At no time in the history of our country has it been more necessary to emphasize the fact that our people are the leaders in the peaceful arts, and are dedicated to peace and good will on earth. And while we have always been prepared to fight for a noble cause, we have been slow to anger, even if it was a righteous anger. Our responsibility for these things we stand for has never been greater than it is today.

Over three years ago, when I was in a hospital, the great philosopher and scientist, Alexis Carrel, paid me a visit of sympathy and personal interest. Among the many things he said was this:

"War will come in Europe. As I foresee it, neither combatant will be strong enough to conquer the other, and civilization may be driven back to the North American continent for its sustenance and continuance. What are you doing — what is your important Federal Communications Commission doing — to develop the American people spiritually and intellectually to carry that great responsibility?"

Tonight, not only those of you who are here in this hall but those listening to this broadcast and listening to other broadcasts in this country, have the individual duty to develop that spiritual, intellectual, and cultural responsibility on which rest the great tasks that confront us.

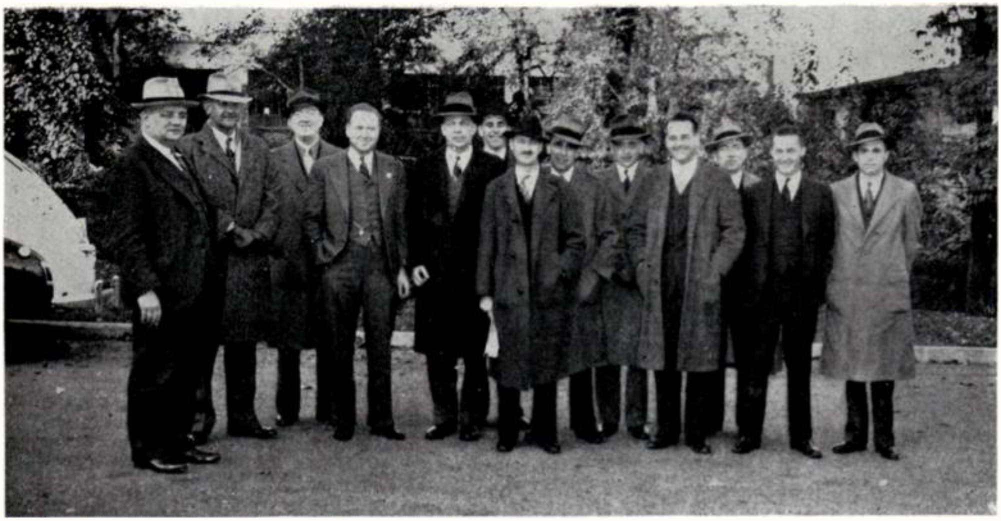
By adding to the greater possibilities of the radio, Major Armstrong, and the inventors who have gone before, and our hosts tonight, are giving to the people of America an even greater opportunity to develop their responsibilities in a civilized world for political and spiritual freedom.

Let me repeat the noble passage of that inspiring philosopher, John Stuart Mill:

"All the great sources of human suffering are in a great degree, many of them almost entirely, conquerable by human care and effort, and though their removal is grievously slow, though a long succession of generations will perish in the breach before the conquest is completed, yet every mind sufficiently intelligent and generous to bear a part, however small and inconspicuous, will draw a noble enjoyment from the contest itself, which he would not for any bribe in the form of selfish indulgence consent to be without."

DECEMBER *FM* IS SOLD OUT

As announced last month, the November issue of *FM* is sold out completely. Now, our supply of extra December copies is also exhausted. We have printed 500 extra copies again this month to take care of new subscribers and orders for single copies. Since *FM* is sold only by subscription, each issue is practically cleaned out as it is published. We have no unsold copies coming back from newsstands.



COMMISSIONER HICKEY, LEFT, AS HOST TO MAJOR ARMSTRONG AND A GROUP[1] OF SIGNAL CORPS OFFICERS AND ENGINEERS FROM FT. MONMOUTH, N. J., ON AN FM INSPECTION TRIP

STATE-WIDE TWO-WAY FM SYSTEM

Connecticut's Pioneering of FM State Police Communication Proves Its Superiority Over AM for This Type of Service

By Edward J. Hickey*

SINCE the completion of our two-way, state-wide FM system, the Connecticut State Police Department can now communicate from Headquarters with any of its ten barracks and to any one of its 225 patrol cars by means of this two-way radio. Thus Connecticut takes the lead in becoming the first state to have complete two-way coverage of its entire area of approximately 4,965 square miles. Such an accomplishment, which represents a distinct step forward in police communication, has been made possible by the adoption of FM.

Two-way communication by radio has been quite common in municipal police work and to some extent over limited areas by state police departments. The existing systems of amplitude modulation have been limited, for reliable two-way communication, to relatively short distances. Man-made static and other noise factors have long been the bug-a-boo of radio. When Major Armstrong announced several years ago that he had invented a new system of radio transmission that would eliminate static, many engineers were skeptical of its practical application. Engineers, however, set about to adapt the system and make it practical for mobile emergency service. One of the men was Professor Daniel E. Noble, of the University of Connecticut. Professor Noble spent much time on experimentation in this field and became convinced of its practicability. As a result of his work, the design of W1XPW, one of the first frequency modulated broadcasting stations to be built, was placed under his supervision. The results obtained at this station substantiated Professor Noble's judgment of FM.

The Connecticut General Assemble of 1939 appropriated approximately $120,000 for a state police radio system. At once, the question arose in the department as to the type of system we should install. Naturally, everyone familiar with police radio knew that a two-way system possessed many advantages over one-way communication. However, existing commercial amplitude equipment could not by any stretch of the imagination provide two-way service over a state-wide area. Proposals were made by various commercial companies for

[1] Left to right, Commissioner Edward J. Hickey, Col. Roger B. Colton director of Signal Corps laboratories, Major O'Connell, Sydney E. Warner, radio supervisor, Conn. State Police, Major Armstrong, Major Soules, William Marks chief civilian engineer, Signal Corps vehicular apparatus, Capt. Langer, William Hessel, E. Townsley, two other civilian engineers, and trooper Schailer.

* Commissioner of State Police, Hartford, Conn.

REMOTE CONTROL UNIT HAS VOLUME INDICATOR, TRANSMITTER FIELD STRENGTH INDICATOR, AND SPEAKER FOR HEARING OTHER BARRACKS

WELDED STEEL SHACK AT BASE OF 200-FT. MAST CONTAINS 250-W. TRANSMITTER (39.5 MC.) AND FIXED-TUNED RECEIVERS (39.5 AND 39.18 MC.) TO PICK UP OTHER BARRACKS AND CARS. ALL VOICE AND CONTROL CURRENTS ARE CARRIED TO BARRACKS BY ONE PAIR OF WIRES

the installation of a one-way system using the medium frequencies combined with a limited two-way service in some parts of the state. When Professor Noble, who had also spent much time in the installation of radio for the State Forestry Service, was consulted, he suggested that FM might present the solution for complete two-way service for the entire state.

Such a proposal represented exactly what we desired, but also brought up additional questions. Foremost among these was the lack of field data, since no comparable system was in operation. There was not even any suitable equipment on the market, and many radio engineers doubted that FM, with its apparent complications, could be applied to the mobile services.

We had complete confidence in Professor Noble, with the result that he was engaged as radio consultant and was given the problem of setting up a complete state-wide, two-way service to use FM. The experimental design of receivers and transmitters was started in October, 1939, and many tests were made before a satisfactory solution was reached.

The main station at Hartford was put in operation at that time. The results obtained were successful beyond our highest expectation, as complete two-way coverage was secured over the entire Hartford patrol area which, in some instances, involved a talk-back range of 25 miles. Having satisfied ourselves by exhaustive tests that FM was the answer to our problem, we immediately contracted with F. M. Link for commercial equipment to complete the entire system.

State police supervision in Connecticut is divided into ten barracks areas, each of which now has its own 250-watt transmitter, operating on 39,500 kc. Each station is located in the approximate center of its respective barracks area, and is operated by remote control from the barracks. Each barracks, therefore, handles its own local traffic as regards routine dispatching service. The car transmitters talk back on 39,180 kc.

Each 250-watt transmitter is located on the highest spot near the center of its service area. Such location is essential due to the fact that we are using the ultra-high frequencies, where height of the antenna above surrounding objects is an important factor. We use concentric antennas on the top of 200-foot poles at each barracks station. Also located at each transmitter are two receivers, connected to the barracks operating desk by telephone wires. One of these receivers picks up the cars as they call in. The other receiver picks up the transmission from the other stations that might go on the air and transmits this also to the barracks by telephone wires.

The reason that the receivers are located at each transmitter is that the antenna is employed for reception when the transmitter is not in actual operation. Thus, the dispatcher in each barrack not only hears his own cars as they call in, but also hears the messages sent out by the other fixed stations in the network. It is also possible, in case of emergency, to talk directly between barracks. Thus, the Westport dispatcher at one end of the state can talk directly to the Stafford dispatcher at the other end of the state, simply by calling him on the radio.

We have found it entirely feasible to operate stations not immediately adjacent simultaneously, without creating any disturbance to the cars listening to their own stations. Such an advantage from the use of FM will also prove of distinct value to municipal police departments.

At the present time, many towns and cities receive interference from transmitters in other cities on the same frequency. If FM is used, the local station will always take control of its local cars, so that any interfering signal from outside transmitters will be eliminated completely. As a practical example of this, if you are listening to one of our FM transmitters and another of our stations on the same frequency comes on the air with a signal twice as strong as the first, the weaker signal is blanked out. Moreover, it does not set up any squeal with the stronger station.

If the same case were applied to amplitude modulation, the weaker station would be heard mixed up with the desired station, and would set up a heterodyne squeal or spoil the wanted signals entirely. In engineering terms, using FM, the ratio between desired and undesired signals has to be only 2 to 1 for complete rejection of the weaker station on the same frequency, whereas in amplitude modulation the stronger signals must be at least 20 times louder, in order to blanket out the interference.

This engineering fact has proven to be a solution to the problem of congestion that now exists on police frequencies due to the large number of states, cities, and towns desiring to operate radio facilities on the limited number of channels available.

Since our equipment has been in operation, we have been privileged to demonstrate its performance to members of the FCC, FBI and officers of the U. S. Signal Corps, as well as to Major Armstrong himself, and we have been honored by visits from police and public officials from nearly every state in the Union.

I am glad to extend, through *FM* Magazine, an invitation to accredited representatives of municipal and state police organizations to visit us at the Connecticut State Police Headquarters at Hartford, and to see and hear our FM communications systems in operation.

SYDNEY E. WARNER AND PROF. DANIEL E. NOBLE WITH THE EXPERIMENTAL MODEL OF THE FIRST 2-WAY FM EQUIPMENT EVER USED FOR POLICE EMERGENCY SERVICE. PHOTO TAKEN AT HARTFORD, CONN.

EFFICIENCY OF RADIATION IS RAISED ABOUT 40 PER CENT AND PATTERN IS MADE CIRCULAR BY MOUNTING ANTENNA ON CAR ROOF. 34-OHM CONCENTRIC LEAD TO ANTENNA IS INSTALLED AT FACTORY DURING ASSEMBLY OF THE CONNECTICUT PATROL CARS

FMBI Summary of recommendations made by FM Broadcasters, Inc., to the FCC, for expediting the progress of FM broadcast service*

November 27, 1940

HON. JAMES LAWRENCE FLY, *Chairman*
Federal Communications Commission
Washington, D. C.

My dear Mr. Chairman:

At the conclusion of our conference today, Mr. Jett suggested that we address this memorandum to you, outlining in a general way, the subjects which were considered. Before proceeding to do so, I want to express the thanks of FM Broadcasters, Incorporated, as well as my personal thanks for the courtesies which were shown us by yourself, Mr. Jett and Mr. Gross, and for the interest which you indicated in our problems.

The suggestions which were discussed were, as you know, based on various factors which members of the Board of Directors of FM Broadcasters, Incorporated, felt were having a tendency to slow up the filing of applications for FM stations, and, of course, our purpose in bringing them to your attention was to make suggestions toward speeding up the whole situation.

1. The first suggestions which we presented related to changing over the present experimental FM stations to their new frequency assignments, assigning to them permanent call letters, and permitting them to operate after January 1st on a regular commercial basis. We feel that such action on the part of the Commission would prevent curtailment of existing FM service during the period required for completing construction in accordance with the new construction permits. In making this suggestion, we do not want to be understood as indicating in any way that our group is encouraging delay. All of the efforts of the FM group are directed towards encouraging the rapid and sound development of FM broadcasting.

2. The second subject which we discussed dealt with the question of permitting new FM stations to commence operation on a regular commercial basis without requiring, at the beginning, that the ultimate service area be covered. For example, we explained that it was the feeling of our group that, if the Commission were to authorize the construction and operation of smaller stations than those contemplated by the regulations in a given area, construction would be expedited in many areas, and a very substantial portion of the ultimate area would benefit from service which otherwise might be long delayed. In making this suggestion, we were not criticizing the Commission's regulations with respect to service areas, but rather, suggesting that in some cases the service areas be made the ultimate, rather than the present or immediate objective.

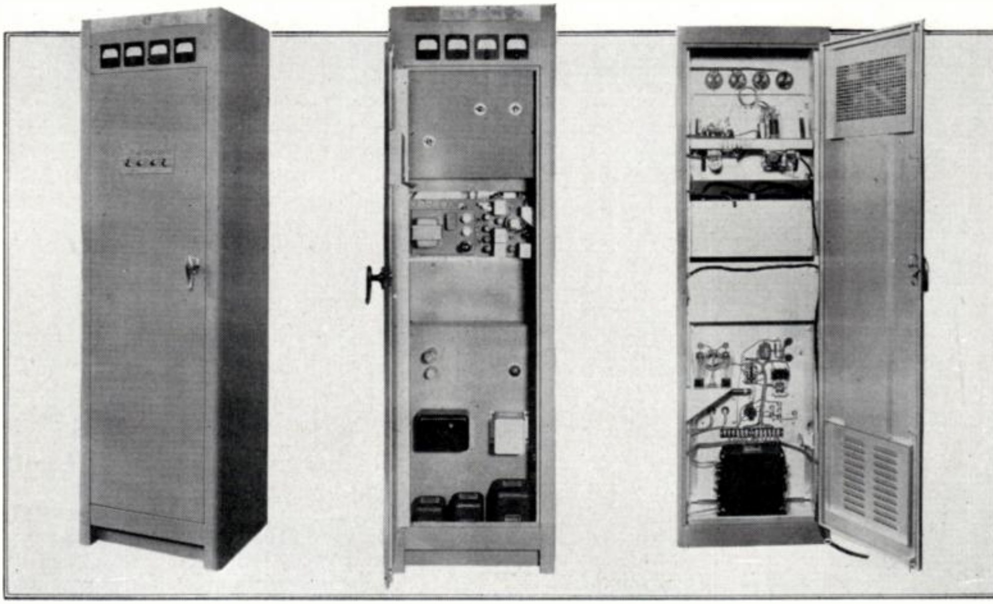
3. The third matter which we discussed related to the necessity for filing a large volume of technical data which, in many cases, serves no very useful purpose in the Commission's consideration of FM applications. It was our suggestion that the Commission dispense with the necessity for supplying this great volume of technical data at the time of the filing of the application, and that the Commission proceed with the consideration of the financial, legal, and public service qualifications of the applicant, and, in cases where applicants are found to be qualified to construct and operate FM stations, that the Commission grant such applications subject to conditions under which they would be required to supply a completely detailed engineering plan which would meet with the approval of the Commission. We recognize that this is a departure from the custom which has heretofore been followed at the Commission in connection with its consideration of amplitude applications, but some recognition of this plan has been given by the Commission in its recent actions upon FM applications. We feel that this would stimulate interest in FM applications among smaller investors, and at the same time would not require the outlay of large sums for the preparation of technical data which may become useless in the light of a grant with revised coverage area, or would become a totally useless expense if the applications were denied.

4. The next suggestion made was that provision be made for control stations to feed programs from studio to FM transmitter, and from FM transmitter to FM transmitter. This was discussed further with Mr. Jett and Mr. Gross after you found it necessary to leave. Mr. Jett and Mr. Gross pointed out the allocation difficulties which were involved, and we are studying the question with a view to making further suggestions. In the meantime, we request permission to use the present bands above 100 megacycles assigned to relay stations for this purpose, in order to expedite development of FM broadcasting, and improved service to the public. In this connection, we explained to Mr. Jett and Mr. Gross the difficulties which have been encountered in several instances due to the nonavailability of telephone lines of an adequate fidelity, except at excessive cost.

5. We next discussed the notice to manufacturers of high-frequency broadcasting equipment dated November 23rd, in regard to an informal engineering conference to be held December 9th. In this notice it states, "high

(CONCLUDED ON PAGE 25)

* Released for publication in *FM* Magazine with the permission of Hon. James Lawrence Fly, Chairman, FCC.



TWO FRONT VIEWS AND REAR OF G.E. 250-WATT FM EMERGENCY TRANSMITTER, 4GF6A1

G.E. ACTIVE IN FM EMERGENCY FIELD

Data on FM Mobile Units Developed for Police and Public Utilities

BY HERBERT DU VAL, JR.*

THE General Electric Company first started investigating frequency modulation for service as entertainment broadcasting. The mathematical analysis of the system as proposed by Major E. H. Armstrong demonstrated the adaptability of this new system of broadcasting to the entertainment world, but it was not until we began actual field tests that the possibilities of using this new method of modulation for the emergency services became apparent.

Early in the experimentation and field tests, the General Electric constructed some model mobile equipment to operate on the 40-kilocycle channel width assigned in the 30- to 40-megacycle band. Field tests with these preliminary models gave such phenomenal results, that it was decided to enter into a full program of development of this method of communication for the emergency services.

Engineers at Schenectady, N. Y., made further refinements on the preliminary samples and after additional field tests, invited engineers of the Federal Communications Commission to Schenectady to witness comparative performances between frequency modulation and amplitude modulation. These field tests were so convincing to the FCC engineers that they have proceeded to issue experimental licenses to many users of emergency communication through the United States.

Actual field tests (not laboratory experiments) demonstrated that frequency modulation had several advantages over amplitude modulation for communication purposes. First, the noise reduction of FM provided a more reliable service in the normal ultra-high frequency communication range and reduced the possibility of so-called dead spots enormously. Second, the communication range was actually increased because the reduction in noise permitted reliable communication with lower signal strength; and third, the elimination of high-level modulation reduced the overall input power requirement for a given output power.

Where formerly amplitude-modulated mobile equipment was limited in practice to a 15-watt carrier level by the battery capacity of the average automobile, the new FM equipment made possible a 25-watt output from a mobile transmitter that required even less battery power than amplitude modulation. This

* Radio and Television Dept., General Electric Company, Schenectady, N. Y.

PATROLMAN JOHN F. GLEASON OPERATES POLICE FM TRANSMITTER AT WATERTOWN, MASS., ONE OF G.E.'S FIRST INSTALLATIONS

FM-EQUIPPED CAR AT WATERTOWN. THIS CITY WAS FORMERLY SERVED BY ADJACENT AM TRANSMITTER AT NEWTON, MASS.

means that a greater communication range and a more reliable signal are obtainable from the FM equipment at less power input than the old AM system allowed.

Another point that will be of interest to the user of emergency communication facilities is the fact that FM is cheaper to maintain than AM when equipment of equal power rating is used as the basis of comparison. This is because all tubes used in FM radio-frequency circuits are operated under Class C telegraph rating and because of the elimination of speech input and modulator tubes. For a 250-watt fixed transmitter, this saving may be anywhere from two to four times. The power cost is also reduced because of the decrease in power input requirement.

The FM communication equipment that General Electric is now producing has all the features of operation and control that have been found desirable in ultra-high-frequency apparatus as a result of operating experience. Transmitters and receivers are directly crystal controlled with low temperature coefficient crystals. They have a temperature-frequency stability of .01%. The receivers have a positive-acting, tube-controlled "squelch circuit" that is adjustable for operation below 1 microvolt, and the usable receiver sensitivity and limiter action are well below 1 microvolt.

Our engineers have developed two basic units for the G.E. FM emergency communication line — a receiver and a separate 25-watt transmitter. Each can be used for either fixed or mobile service; only the power supply need be changed. For fixed station operation, a 115-volt, 60-cycle, AC power pack is supplied. For mobile work, all tubes operate direct from the 6-volt car battery; a vibrator or dynamotor is furnished for converting the 6-volt power to the high voltages required for screen grid and plate circuits.

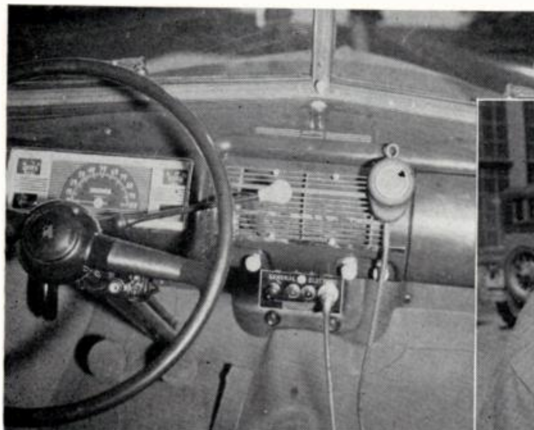
Where higher power is required, the 25-watt transmitter, operated on 115-volt alternating current, is used as an exciter for a 250-watt power-amplifier. All units are designed for greatest dependability, compactness and accessibility.

The transmitter is of the direct, crystal-controlled, phase modulation type using 32 times multiplication to obtain the desired carrier frequency. Frequency modulation is obtained by balanced modulators which furnish the out-of-phase radio-frequency voltage for displacing the phase of the signal. The outputs of the balanced modulator tubes are amplitude modulated directly from the microphone or line transformer. The combined output of the fundamental frequency amplifier and balanced modulators is amplified and its frequency multiplied by means of two frequency-quadrupler stages and one frequency-doubler stage to produce sufficient power and output frequency to excite the power-amplifier tube in the final stage.

Both the 250-watt and the 25-watt station transmitters may be remotely controlled either for short distances or over telephone lines extending many miles.

That frequency modulation for emergency communication is being widely recognized is evidenced from the rather impressive list of FM systems purchased from the General Electric Company that are now in operation or will be in operation soon. As of November 1, 1940, these are:

Sheriff's Office — Douglas County, Nebraska
Indianapolis Power & Light of Indiana



MICROPHONE, SPEAKER, AND CONTROL PANEL OF PATROL CAR FM INSTALLATION. BALANCE OF EQUIPMENT IS AT REAR

G.E. TRANSMITTER UNIT 4GFA1, LEFT, AND RECEIVER 4SFJA1, COMPLETELY INSTALLED IN CAR, AND READY TO OPERATE

U. S. Board of Health of Boston, Massachusetts
City of Watertown, Massachusetts
City of Maywood, Illinois
San Diego Gas & Electric of California
San Antonio Public Service of Texas
City of Riverside, Illinois
North Carolina State Police
United Illuminating Company of New Haven, Connecticut
United Illuminating Company of Bridgeport, Connecticut
Philippine Islands
City of Lynn, Massachusetts
Commonwealth Edison of Chicago, Illinois
City of Gary, Indiana
City of Nashville, Tennessee
San Joaquin County, California

Two of the above systems are to replace amplitude-modulated equipment that has been in service for some time. The other systems will provide new communication facilities, several of which would have been impracticable with amplitude modulation.

The following specifications are presented for the information of those who are interested in the details of mobile emergency equipment:

G.E. 25-WATT FM TRANSMITTER

Standard Equipment ★ One 25-watt transmitter unit; crystal; one set of G.E. tubes; microphone, cord, and plug; one mobile control unit or one station-type control unit; interconnecting cables; vertical antenna (with mobile unit only); and an operating and service manual.

Power Output ★ 25 watts with either alternating current, or with direct-current dynamotor supply.

Frequency Range ★ 30–42 megacycles.

Frequency Stability ★ $\pm$ 0.01%; crystal controlled.

Frequency Modulation ★ Up to $\pm$ 15 kc. at all audio frequencies between 500 and 3000 cycles with suitable input.

Audio-Frequency Characteristic: Improved signal-to-noise ratio is provided by planned pre-emphasis of high audio frequencies. Response increases logarithmically by 15 db from 500 to 3000 cycles. High attenuation above 3000 cycles prevents excessive side-band frequencies.

Audio Input Level ★ – 10 db at 500 cycles with gain control set at maximum for $\pm$ 15-kc. frequency modulation.

Power Supply ★ The Type E-1-A mobile transmitter uses a dynamotor, and the Type E-1-B station transmitter is equipped with a 115-volt, 60-cycle rectifier unit.

Power Consumption

For 6-volt DC supply:	
Filaments only	3 amperes
Transmitting	25 amperes
For 115-volt AC operation:	
Standby	50 watts
Transmitting	200 watts

Circuit Design ★ The transmitter is of the direct, crystal-controlled, phase-modulation type. A 6SF5 triode is used as the crystal oscillator. It drives a 6SJ7 amplifier and two 6SA7 balanced modulators. The 6SJ7 is a fundamental-frequency amplifier. The balanced modulators furnish the out-of-phase radio-frequency voltage for displacing the phase of the signal, thereby impressing the required frequency modulation. The outputs of the balanced modulator tubes are amplitude-modulated directly from the microphone or line transformer. The combined output of the fundamental-frequency amplifier and balanced modulators is amplified and its frequency multiplied by means of two frequency-quadrupler stages (using 6SJ7 tubes) and one frequency doubler (6V6) stage to produce sufficient power at output frequency to excite the GL-807 power-amplifier tube.

Jacks are provided so that all current readings necessary to put the complete unit in proper adjustment can be obtained with a single multirange meter.

For AC operation, one 5T4 rectifier tube is required.

Control Units ★ The mobile control unit for 6-volt DC operation consists of a small metal plate which mounts the "Filament On" green pilot light, the transmitter "Plate On" red pilot light, and the transmitter filament switch ganged with the receiver volume control and the microphone jack. In addition, a microphone jack is located on the transmitter chassis for testing purposes. An airplane-type microphone with push-to-talk button is standard equipment.

The fixed-station control unit for 115-volt AC operation is similar to the mobile unit except that an additional pilot light, for transmitter stand-by, is provided.

Remote Control ★ A remote-control unit containing a low-level microphone preamplifier can be supplied with automatic level control, push-to-talk button, and indicating lights for the fixed station transmitter.

Mechanical Design ★ Over-all size: 8 inches by 17 inches by 10¾ inches high. Subbase, 3½ inches deep.

All tuning controls and meter jacks are accessible from the top of the chassis, and are protected from accidental misadjustment by means of a steel cover held in place by two thumbscrews. When the cover is in place, no controls except those on the control unit are accessible. All tuning controls have positive locks.

A heavy base plate serves as a substantial mounting for mobile installations and as a protective bottom plate for fixed station use. The chassis itself can be quickly removed from the base plate by removing two cap screws located in the front corners of the chassis. These screws cannot be removed when the cover is in place.

G.E. FM COMMUNICATION RECEIVERS

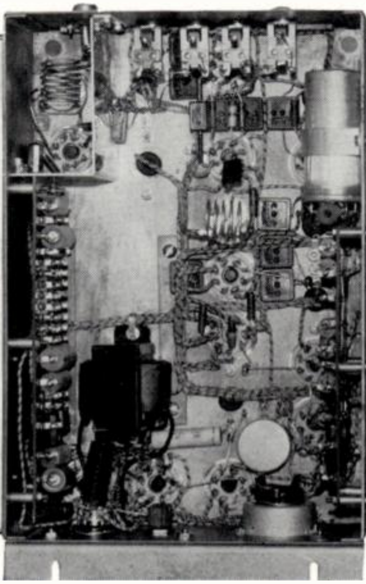
Standard Equipment ★ Frequency-modulation receiver; loud-speaker; crystal; one set of G.E. tubes; control unit; interconnecting cables; operating and service manual.

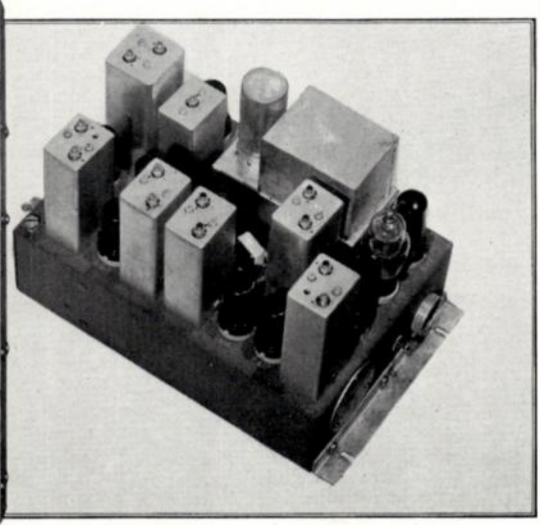
Frequency Range ★ 30 to 42 megacycles.

Audio-Frequency Characteristics ★ Output, 1 watt with either power supply.

Carrier-Off Noise Suppression ★ Adjustable in the field from noise levels of one-half microvolt to 5 microvolts input. This circuit actually discriminates against AM in favor of FM.

Radio-Frequency Characteristics ★ With a signal input of 1 microvolt, the band width of the receiver is approximately 40 kc. When the signal is increased 60 db, the band width is less than





BOTTOM AND TOP VIEWS OF FM EMERGENCY RECEIVER. NOTE SIMPLICITY OF DESIGN

150 kc. The receiver limiter tube is substantially saturated when the signal input reaches 1 microvolt.

This signal level provides reliable communication. Comparable AM equipment requires 10 to 15 microvolts input for equivalent signal-to-noise ratio.

Audio-Frequency Response ★ Logarithmic attenuation of frequencies, above 500 cycles per second, providing reasonably flat response up to 2800 cycles when used with a transmitter having 15 db of pre-emphasis between 500 and 3000 cycles. Signal-to-noise ratio is improved by rapid attenuation of frequencies above 2800 cycles.

Power Supply ★ The Type E-3-A mobile receiving equipment, Model 4SF1A1, uses a dynamotor (battery drain approximately 6 amperes), while Model 4SF1B1 uses a synchronous low-drain vibrator. The station receiver, Type E-3-B, is supplied with a 115-volt, 50/60-cycle rectifier unit, drawing approximately 60 watts.

Circuit Design ★ The receiver employs a double-conversion superheterodyne circuit with a single low-temperature-coefficient crystal to control both heterodyning frequencies. The receiver is equipped with the following:

First RF amplifier	Type 1852
First converter	6SJ7
First IF amplifier (5 mc.)	6SJ7
Second converter	6K8
Harmonic amplifier	6SJ7
Second IF amplifier (455 kc.)	1853
Limiter	6SJ7
Audio amplifier, and carrier-off noise suppression	6C8G
Discriminator	6H6
Audio output	6V6
Rectifier (used with Type E-3-B receiver only)	5W4

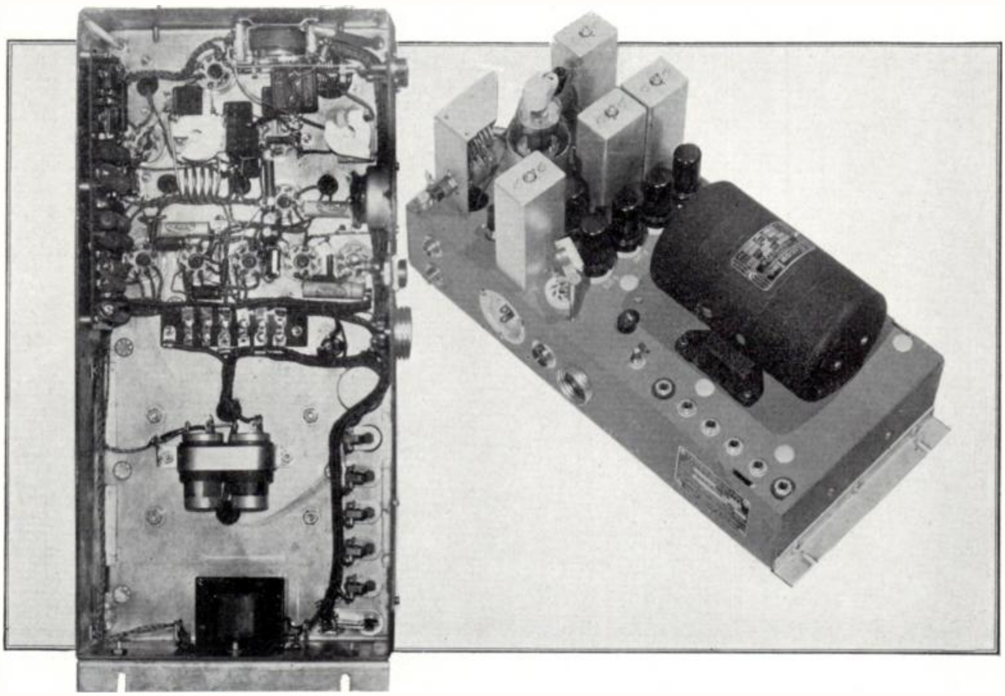
Jacks are provided to allow current and voltage readings as are necessary to check proper adjustment.

Control Units ★ When the receiver is used with Type E-1-A, E-1-B, or E-2-A transmitting equipment, the receiver is connected directly into the transmitter control unit. The same control unit is also supplied for single-receiver installation. This simplifies the ultimate installation of two-way equipment.

Mechanical Design ★ The complete receiver, including power supply, is 8 inches wide, 12 inches long, and 10¾ inches high. All tuning controls are accessible from the top of the chassis when the cover is removed. The mechanical design is essentially the same as that of the transmitter.

For station service the loud-speaker is housed in a suitable gray wrinkle-finish metal case which can be supplied with volume control and "Receiver On" indicating light.

FM EMERGENCY TRANSMITTER HAS MOTOR-GENERATOR FOR 6-VOLT CAR OPERATION



NOTES ON FM RECEIVING ANTENNAS

If FM Reception Is Noisy, the Fault Probably Lies in the Antenna

"I THOUGHT you said that there was no noise on FM reception!" This remark from a radio dealer is generally accompanied by a knowing smile that means, "You can't fool me with this talk about eliminating static." — Or if the remark comes from a B.C.L., there is a note of dismay which says, "You told me that the FM band would be completely clear of all noise!"

Well, a telescope is supposed to make distant things look nearer, but the actual result of looking through it depends upon the way you use it.

Similarly, an FM-AM receiver which is perfectly capable of giving staticless reception can bring in a lot of noise if it is not installed correctly.

Let's look at it this way: At any place where a radio receiver may be installed, there is a certain amount of electrical disturbance present. It will be picked up by the antenna, whether it is an outside antenna or a built-in loop, and passed on to the receiver circuits.

Now, keep this in mind: The FM circuits, of themselves, do not eliminate static! If they did they would have to do guard duty at the antenna terminals and say to static, "You can't come in!" But they don't do that at all. Static can go into an FM receiver and run around the circuits just as it does in AM sets.

Actually, the elimination of static effects is accomplished by signal impulses of the FM type, picked up at the antenna.

This distinction is essential to an understanding of the proper functioning of FM receivers.

To make this more emphatic, let us state it even more simply: Not the FM receiving circuits themselves but the reception of FM signals keeps static noises from getting into the loudspeaker.

Most FM sets employ suppressor circuits to stop the noise when no signals are coming in. That is the purpose of the "carrier-off noise suppressor" feature listed in receiver specifications.

In order for FM signals to eliminate static interference, it is necessary, of course, to feed into the receiver signals strong enough for them to do their work. It is this point that causes so much misunderstanding of FM's staticless performance.

Obviously, if the transmitter is too far away, or if the antenna pick-up is inadequate, the incoming signals will be too weak to do the static eliminating work. In certain installations, the signal may be sufficient to eliminate most interference, but not adequate to stop noise from some particularly powerful source.

In any location where FM signals come in, but without enough strength to give perfectly quiet reception, there are two elementary remedies:

1. Increase the signal pick-up at the antenna by (a) turning the di-pole, (b) move it away from the source of interference, (c) increase the elevation of the di-pole. The last is the most certain method. Increased elevation makes much more difference in signal pick-up at ultra-high FM frequencies than at broadcast frequencies.

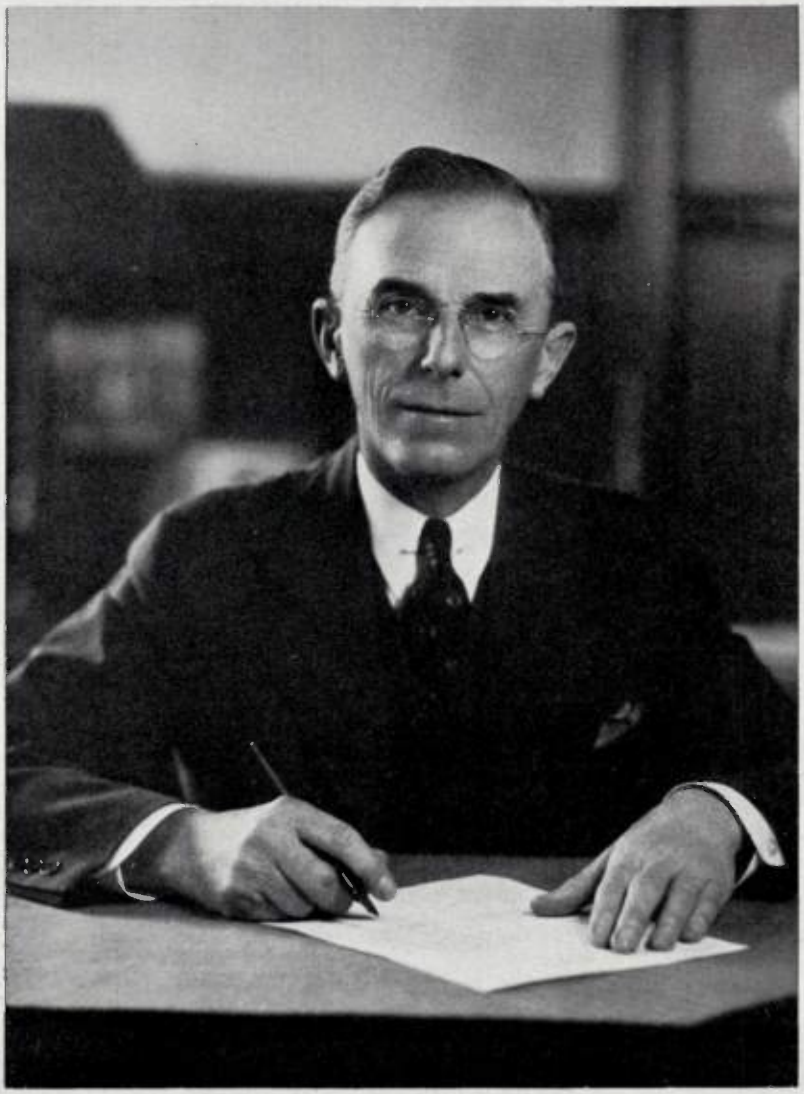
2. If the receiver does not have tuned RF amplification on the FM band, try a model that does. A tuned RF stage puts a stronger signal into the limiter. This is the same result as is accomplished by increasing the antenna pick-up.

You may say: "Oh, if that's the case, why do we need FM at all? There's no noise on AM reception if the signals are strong enough."

That's quite right — as far as it goes. The only trouble is that the "static-less reception" range of even the 50-kc. broadcast stations is limited to a few miles. From the smaller stations it may be only a mile or two. As a concrete example: Last summer, at Great Barrington, Mass., 50-kw. WABC could be heard on AM, but it was so cut up with noise that no one would listen to it. However, the same program came up from 30-kw. W2XMN, Alpine, perfectly clean and clear of all interference.

Furthermore, AM reception cannot duplicate FM performance (1) in audio frequency and dynamic range and (2) in eliminating interstation squeals and cross-talk. Finally, FM is needed to relieve the crowded conditions which exist on the AM band, and to make room for additional program service.

Thus, not for merely one reason but for four, each of great importance, frequency modulation tuning is coming to be recognized as an essential feature of modern radio broadcast receivers.



DR. RAY H. MANSON

FIRST AND FOREMOST A TELEPHONE ENGINEER, DR. MANSON HAS TAKEN A KEEN AND ACTIVE INTEREST IN THE MANUFACTURE OF FM RECEIVERS BECAUSE, SINCE NO LIMITATIONS ARE IMPOSED ON AUDIO QUALITY, ALL THE RESOURCES OF TELEPHONE PRACTICE CAN BE APPLIED TO THE COMPLETE AND PERFECT REPRODUCTION OF BROADCAST SPEECH AND MUSIC.

THE MANUFACTURERS SAY:

A Statement by Dr. Ray H. Manson, Vice President and General Manager of Stromberg-Carlson Telephone Manufacturing Company, Rochester, N. Y.

THE merchandising of FM radio receivers has been rather limited up to this time (December, 1940), due, primarily, to uncertainty as to the where and when of FM broadcasting. The placing of FM broadcasting on the same commercial basis as regular AM broadcasting by the FCC, as of Jan. 1, 1941, clears the last official obstacle in the way of building up a large FM listener audience through the marketing of radio sets with combined FM and AM tuning systems. However, there is much education to be done to overcome the misinformation which has been handed out in the past to radio jobbers and dealers on the general subject of FM versus AM. Some of these "stories" went so far as to state, with assurance, that FM was an abandoned experiment and that it had no future. No doubt, much of this propaganda against FM was inspired by radio set manufacturers who did not anticipate that FM would be technically standardized and made commercial by the FCC and, therefore, were caught with large stocks of AM receivers of which they had to dispose.

During the period of uncertainty as to FCC action on FM, there was a logical excuse for holding back on FM receiver design and production by those who were not willing to pioneer in this new system of broadcasting. Now, however, FM has passed the experimental stage both for communications use by the police and the Army as well as for home entertainment broadcasting, and has been given the full "Go Ahead" signal by the FCC. Thus, every jobber and dealer in radio must recognize FM as a commercial system with all the opportunities ever offered by standard AM broadcasting, and with many worth-while advantages which provide a marked improvement in radio reception over AM.

While there were many questions as to the future of FM in May of 1940, these are all answered today in the many FM construction permits for commercial FM stations which are already granted by the FCC and by the large backlog of applications on file and in the many more in the making.

The public is being told by makers of FM receivers and by broadcast stations transmitting on FM and AM that it is advisable, when buying a *good receiver*, to be sure that it has a built-in FM tuning system, along with the AM tuning system. In other words, that it is not a good investment if the receiver is straight AM without the FM tuning.

The question has been raised many times as to whether there will be any sale for AM receivers in the future. I believe it is the consensus of opinion in the radio industry that, in the lower priced brackets, AM radios will continue to be sold for many years to come, due to the fact that AM broadcasting, especially on cleared channels, will continue as a regular service for an indefinite period in the future. Thus, these little, low-cost AM receivers will give a service in keeping with the small investment in these particular units.

The real question is as to where the dividing line will come between AM and FM receivers, as regards price classification. A combination receiver capable of tuning both AM and FM must cost more than an equivalent quality of AM receiver, due to the addition of a complete FM tuning system. Thus, we can expect that these combination AM-FM receivers will always cost more than the single purpose AM receiver of equivalent quality. Furthermore, if good audio reproduction is to be provided in this combination AM-FM receiver, to take advantage of FM operation, then there must be an additional cost to provide for this improved audio quality. On the other hand, FM operation, with low noise background and absence of cross-talk, can be obtained with an FM system which does not incorporate any better audio system or loud speaker than now provided in average AM receivers. Here, again, the public will get only as much in the way of performance capabilities as it is willing to buy.

There is a way to use good present-day standard AM receivers on FM programs, through the use of a separate FM tuner, plugged into the phonograph jack of the AM set. This will allow for several advantages of FM operation, such as reduction in static noises and overcoming of cross-talk but, naturally, will not provide for the better audio quality which is possible with good FM receivers, as the audio and speaker system provided in the best standard AM receivers falls far short of the average fidelity requirements of FM broadcasting. Moreover, external tuners are cumbersome in operation, compared to built-in tuning systems with one dial and one set of control knobs for both FM and AM. In the early days of short-wave operation, external short-wave tuners were promoted, but the public preferred the built-in short-wave tuning system and, as a consequence, very few were made and sold. The external FM tuner is destined to the same short life.

FM GOES WHERE AM CAN'T

A Practical Check of Reception from W2XOR in New York's Toughest Spots

BY WILL WHITMORE*

WHEN WOR went on the air with its Western Electric one-kilowatt synchronized FM transmitter, it seemed like a good time to put FM on the spot. "Let's put that transmitter of yours through its paces," we told Jack Poppele, WOR's chief engineer. "For once, let's forget all about your elaborate signal measuring equipment and make a test entirely from the listener's point of view. We won't bother about millivolts and the rest of your fine engineering lingo, little or none of which is understood by the public who will in the end put thumbs up or down to FM. Let's make the test as tough as possible for FM and see what happens."

If you think Jack hesitated at such a challenge, then you don't know your Poppele! "Okay," said Jack. "Name your own poison and we'll supply you with it."

"What we want is an outfit on wheels with which we can come as close as possible to duplicating average conditions to be encountered by the average listener," we told him. "Give us a medium-priced FM receiver hooked up in a car with some sort of antenna no more elaborate than our average listener can hang on the side of his house."

Well that's exactly what we got. The receiver was a small table model retailing for seventy dollars, modified to operate from the car storage battery and dry cell B batteries. The receiver was connected through a short transmission line to an untuned di-pole antenna mounted slap-dab against the rear side of a big sedan.

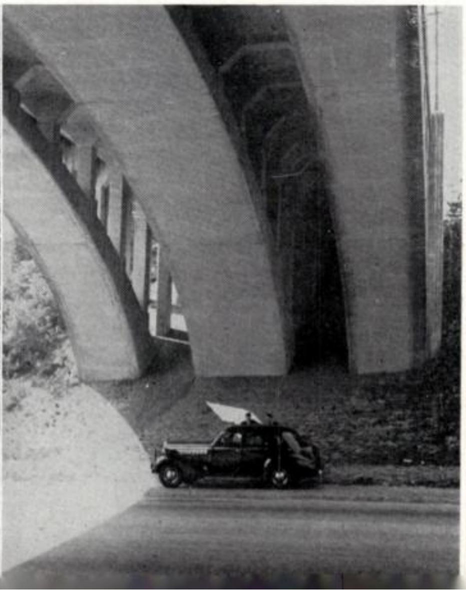
The expedition began at eleven o'clock one bright Friday morning when Charlie Singer, supervisor of WOR-W2XOR transmitters, picked us up in the car at the Howard Johnson restaurant on Queens Boulevard about six miles from New York. As we got in the car, W2XOR was coming in on the FM receiver like a house afire. Our first stop was in Forest Hills, on a tree-shaded street surrounded by big six-story apartment houses. These houses completely shielded the car receiver from a line-of-sight view of the transmitter, but we noticed no decrease in signal strength or increase in noise level, even though we were just a stone's throw from a boulevard alive with whizzing traffic. Not a sound of ignition noise was apparent in the receiver.

The expedition headed on out Queens Boulevard and thence to Grand Central Parkway. Cars whizzed by us on this busy four-lane highway. A huge metal-armored payroll truck pulled along side and continued to keep pace with us for a mile or so. Our antenna was on the side of the car opposite the van and not more than an arm's length away. Result: same old signal without a trace of ignition. As we continued out the Island, we passed under numerous steel reinforced bridges. Each time we passed under a bridge, background noise increased in the standard car receiver tuned to WOR's 50-kw. transmitter. But our FM signal came through the same as ever.

Twelve miles from New York, we passed

* Editor, "Pick-Ups," Western Electric Co., Inc., New York City.

APARTMENT HOUSES DID NOT CUT OFF W2XOR, NOR DID THIS BRIDGE, WHOSE SHADOW STOPPED WOR



over a large bridge. Here was just the opportunity we were seeking. We cut off the highway and circled around until we were directly under the bridge. The bridge cast a sharp AM shadow. As we entered it, the WOR signal went from high volume to complete unintelligibility within two or three feet. The FM signal from W2XOR showed no change whatsoever, even though we explored every nook and crany of the AM shadow. No matter where or in what position we placed the car under that bridge, the FM signal continued to perk in its accustomed manner.

The sand pit I had in mind is approximately 25 miles from New York. Close to the shore of Hempstead Harbor lies a high ridge ranging from 50 to 150 feet above sea level. Into this ridge steam shovels have gouged out a miniature "grand Canyon." As we neared it, Singer took one look and remarked that if the signal didn't die a sudden death there, he would have to toss out his last conception of FM's limitations. The perpendicular wall of the pit lay directly between us and W2XOR. We drove our car right up to the foot of the wall. Steam shovels and trucks worked all around us. We turned on the receiver. There was W2XOR practically the same as ever, the only noticeable difference being a slight decrease in level, but the signal was more than acceptable from a listener's point of view. We drove the car around the bottom of the pit, trying to find at least one shadow in which to hide from the signal, but it searched us out wherever we moved.

Then we raised another di-pole on a wooden rod mounted on the front of the car. Although the di-pole reached about twice as high as the permanent antenna on the rear, we could discern little difference in signal strength. When the di-pole was rotated to provide horizontal polarization[1] and was turned directionally for maximum signal, there was no noticeable difference between it and the rear antenna. It was sharply directional, however, and at the minimum signal point, the receiver response was considerably reduced. Interesting to note was the fact that the horizontal di-pole, for maximum signal, pointed nearly at right angles from the direction toward the transmitter.

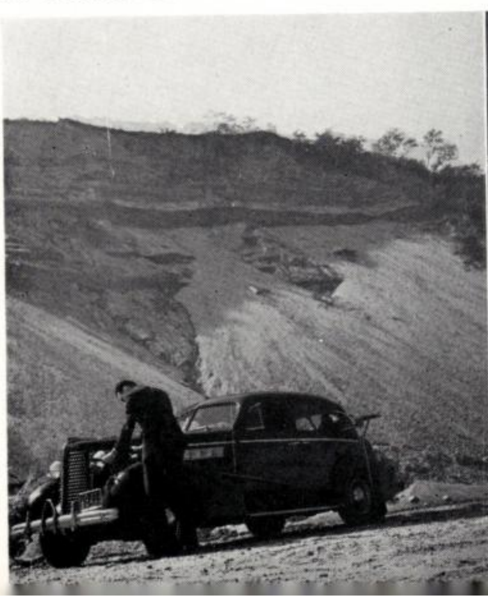
Knowing no worse location on the Island, we headed back toward town, crossing Whitestone Bridge, to the Hutchinson River Parkway, and on up the Parkway for a distance of approximately 25 miles north of New York. On this long drive we encountered places where the signal strength momentarily dropped or the signal seemed to wobble a bit. In each case, however, it was noticed that the position of the car placed the car between the path of the signal and the antenna.

Returning to New York, we passed over the lower level of the double-deck bridge across the Spuyten Duyvil. The signal from WOR was completely mixed up with car ignition noise while W2XOR continued with full strength. Back in the city we cruised under elevated railway lines, through streets lined with New York's highest buildings, and filled with rush hour traffic. Signal strength did not vary.

From this report of a practical FM test, unscientific and unrehearsed as it was, you may read any significance or none at all. To us, it seemed to indicate that FM is perfectly capable of serving the entire metropolitan area of the greatest city on earth. It further indicates that the average listener may receive his FM with complete satisfaction, irrespective of location. And, also, should not our ideas about FM and car reception, with vertically polarized transmission, be changed?

[1] Station W2XOR employs a vertically polarized transmitting antenna.

FM SIGNALS POURED RIGHT INTO THIS SANDPIT, AND KNOCKED DOWN THE WORST CITY STATIC



THIS AUTOMATIC COMBINATION HAS FM-AM TUNING, HAS COMPARTMENTS FOR RECORDS, RETAILS AT $299.50

PHONOS LEAD PILOT FM-AM LINE

Automatic Combinations Out-Sell Consoles by a Substantial Margin

IT HAS been quite a surprise to the very conservative management of Pilot Radio Corporation to find that the people who buy FM-AM receivers are inclined to go all the way up in price to models which include automatic phonographs, rather than stopping at the less expensive table models or consoles.

According to Pilot officials, combined sales of the two automatic combinations shown on these pages are approximately double those of the table model, with the console ranking third in number of units.

This throws a particularly significant light on the public taste, because all Pilot models use the same FM-AM chassis and power pack. The only difference, except for the phonograph mechanism, is that the Pilot table model has a single 10-in. speaker, while the console and combinations have a 12-in. bass speaker plus a tweeter.

Thus, purchasers are not influenced by such factors as the number of tubes, or a difference in any mechanical features.

Further information on this subject is given by a comparison of the prices of these receivers. They are:

Table model FM-12	$139.50
Console CFM-12	179.50
Combination HFM-12	249.50
Combination LFM-12	299.50

Complete details, together with circuit diagrams of the chassis used in these receivers, were published in *FM* Magazine for November, 1940.

Pilot's success with these FM-AM receivers indicates conclusively that the market for sets in the higher price brackets affords radio dealers the real opportunity for increased profits. It also gives a definite answer to dealers who say: "I'm going to wait until they get the prices down before I stock any FM-AM models."

While it is too early to draw definite conclusions for the future, Pilot executives are inclined to think that the introduction of cheaper models would work out to the disadvantage of the dealers.

To put it differently, it appears that the dealers who talk about wanting cheaper FM-AM sets probably wouldn't put them in if they were made available; and those who are succeeding with the present models would not increase their profits by adding lower priced models.

There seems to be a general agreement among the dealers who are doing the largest FM-AM business that the most effective method of merchandising the new sets is to emphasize the "plus value" of FM tuning as a feature lacking in straight AM receivers, added to the greatly improved reception which they deliver on regular broadcasting.

In this way, the salesman does not give the customer an opening to start an argument over the relative performance of FM and AM. Neither does the salesman find that he has put himself on the spot by over-selling frequency modulation after the set has been delivered and installed.

FMBI RECOMMENDATIONS TO FCC

(CONTINUED FROM PAGE 13)

frequency broadcast stations are required to submit proof of audio performance during tests as a complete station, before a license will be issued by the Commission." We suggested that to require this proof before a license is issued will greatly delay the issuing of licenses, and inasmuch as the Commission is giving licensees of FM stations one year to submit the results of field surveys, we suggest that permittees be given the same length of time to submit their proof of audio performance. This matter was further discussed with Mr. Jett and Mr. Gross, who pointed out that this matter would receive consideration at the time of the December 9th conference.

6. With respect to the assignment of special call signs for FM stations embodying numerical reference to specific channels, Mr. Jett and Mr. Gross explained that the number of appropriate four-letter call signs is definitely limited, and this limitation is increasing with the growing requirements of ship licensing. This, it was explained, was due to the fact that ship licensing takes priority over all other licensing in the matter of four-letter call signs. We discussed this matter at some length, and it is still our opinion that four-letter call signs for FM stations are preferable to call signs embodying numerals, because of the familiarity and acceptability to the listening public.

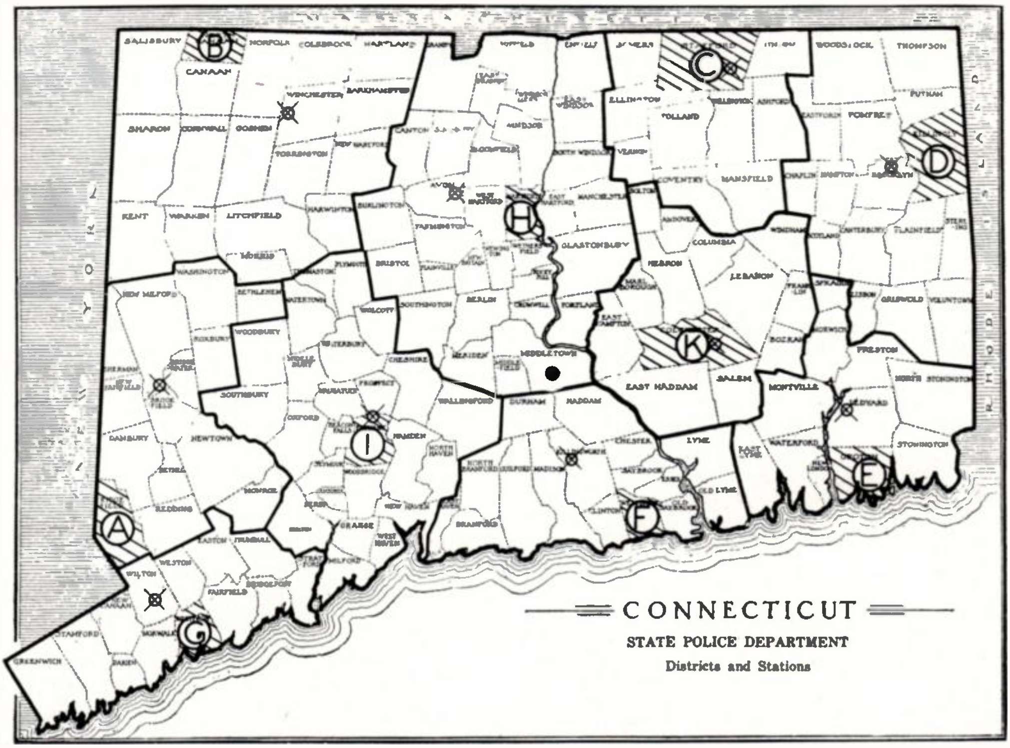
In the light of existing conditions as explained to us by Mr. Jett and Mr. Gross, however, we made the following alternate suggestion:

That the calls be, for example, W55F, K33C, etc. In other words, the second letter should be at the end of the call and after the numerals. It was felt that this would sound better and be a more easily remembered call. It was also requested that instead of assigning as the second letter "A" to the first station on each frequency, the stations be allowed to request any second letter available. The first letter and the numerals, of course, would be automatic. This would not put on the air at the start such a large number of stations all ending in the same letter, and would be a means of establishing, in many cases, an identity where the letter might have a certain significance tieing it up with the station ownership or the locality.

On behalf of Mr. Streibert, Mr. Jansky, Mr. Loucks and myself, I again express our thanks for your sympathetic consideration of our suggestions.

Respectfully,
(Signed) John Shepard, 3rd,
President

SAME CHASSIS AND RECORD CHANGER IN THIS CABINET RETAIL AT $249.50. FINISH IS WALNUT OR MAHOGANY



LOCATIONS OF THE TEN STATE POLICE BARRACKS AND THE CORRESPONDING TRANSMITTERS

TWO-WAY POLICE FM PERFORMANCE

Including Explanation of Three-Way Operation of Two-Way Connecticut State Police System

BY SYDNEY E. WARNER*

THE speed with which communications are handled between the barracks and patrol cars of the Connecticut State Police is a source of amazement to visiting officials, and affords a sense of security to our citizens. The information which follows is presented for the benefit of those who have not yet had an opportunity to learn, from first-hand observation, of the superiority of FM over AM transmission where two-way or three-way telephone communication is required over a large area of irregular terrain.

Arrangement of Main Stations ★ As the accompanying map shows, our State, of 4965 square miles, is divided into ten barracks areas. The barracks are located on main highways. These are not the most advantageous locations for the respective transmitters, however, because (1) they are not centrally situated in the barracks areas, (2) it is important to have the transmitting mast on the highest ground possible, since antenna height is a function of transmitting range, and (3) by using the transmitting antenna for reception, the maximum receiving range is achieved.

The letters on the map show the locations of the barracks, and the crosses, those of the remotely controlled transmitting and receiving installations. The objection has been made that equipment located at a distance from the barracks, and thus unprotected, can be put out of commission by those of criminal intent. That is a serious objection where an entire system is dependent upon a single transmitter. However, in this particular system, there is ample overlap in the range of each transmitter so that if, for any reason, one fails, its

* Radio Supervisor, Connecticut State Police, Hartford, Conn.

traffic can be handled through other barracks.

This plan of overlapping is so satisfactory that if, through any cause or failure, one of the transmitters should go off the air during the night, it would not be repaired until the morning. Thus we do not have to maintain 24-hour emergency repair service.

As a result of locating the main transmitters on the highest ground available, we are able to communicate over far greater distances than is possible with conventional installations where the transmitters are arbitrarily located at police stations or barracks. Further, we gain additional range by using the high transmitting antennas for receiving when the transmitters are not in operation.

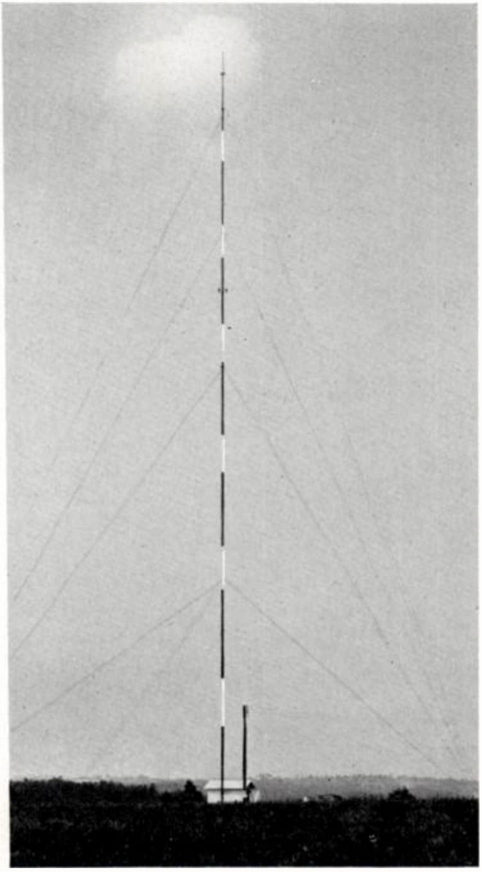
Main Station Equipment ★ At each main transmitting point we have a 200-ft. guyed mast, furnished by the Pole & Tube Works, and a welded steel radio shack, housing the radio equipment. This comprises a 250-watt FM transmitter, shown in detail in the accompanying illustrations, and two fixed-tuned receivers. The transmitting and receiving apparatus were designed and built by F. M. Link, New York City.

All the main transmitters work on 39.5 mc. One of the receivers is tuned to 39.5 mc., so as to pick up transmissions from the other fixed stations, while the second receiver is tuned to 39.18 mc., the transmitting frequency of the cars. Due to the favorable locations of the receivers, and the absence of local noise, they are adjusted so that the receiver squelch operates on signals of 1 microvolt or less. This equipment is operated by remote control from the desk at the barracks. Only a single pair of wires is needed between the radio shack and the barracks.

Operation of the Main Stations ★ Normally, the dispatcher at the barracks hears both the cars and the other fixed stations. When the station is called, or wishes to call, the dispatcher picks up a push-to-talk handset. This does three things: it (1) opens his speaker circuit for transmission periods and operates a relay circuit which shorts the audio output of the main station receiver to ground. In the earpiece, therefore, the dispatcher hears only the car transmission. The same relay also opens the squelch on the remote car receiver to give maximum sensitivity and to eliminate the clipping effect due to standing waves which exist on weak signals.

Due to the limiting action inherent to the FM system, all audio signals are at substantially constant level, regardless of the distance of the car or main station from the receiver. Thus the signals from a nearby car are heard at about the same level as those from a car 20 miles away, even though the ratio of the RF signals may be large. This is a characteristic that impresses a listener who is hearing our system in operation for the first time. Signal blocking does not occur on FM.

ONE OF THE TEN 200-FT. STEEL MASTS. THIS INSTALLATION IS AT WILTON, CONN.



Car Equipment ★ One of the unique features of our installation has been the use of an antenna mounted directly in the center of the car top. This gives a uniform pattern of radiation as it puts the antenna itself in the middle with respect to ground which is the body of the car. Tests with a field intensity meter have shown that the efficiency of radiation is raised about 40% and that the radiation pattern is circular.

With the antenna mounted on the rear, as is customary, the same antenna produces a cardioid pattern towards the front of the car since this is the direction of the maximum ground surface. This directional effect is of the order of signal strength ratio of 4 to 1. Thus the transmitter produces a signal four times as great towards its front as towards the back. In order to locate the antenna on top a unique spring mounting was designed so that the antenna is entirely flexible around its mounting and the shock of hitting obstructions is taken up by the spring mounting, the antenna returning to its vertical position after impact.

The antenna feed line is a 34-ohm concentric cable and the antenna length was determined so that a 34-ohm resistive load (¼ wave length) is reflected to the transmitter. This cable is mounted at the car factory during fabrication so that no removing of upholstery is necessary.

The F.M. Link car receiver and transmitter [1] are mounted in the rear baggage compartment. While this system is described as two-way communication, it is actually three-way in practical use, for it provides talk-back between the cars and main stations, and also between cars. This is accomplished in the following manner:

Normally, the cars talk to the main stations on 39.18 mc., and the receivers are set at 39.5, the frequency of the main stations. Therefore, one car does not pick up the signals of another car talking to a main station.

However, there are two crystals in the car transmitter, one for 39.18-mc. transmission, and another for 39.5 mc. When one car wants to talk to another, the 39.5-mc. crystal, to which the car receivers are tuned, can be cut in. The circuits oscillate at this higher frequency, and the drop in output is small.

Another purpose is served by this arrangement. If one of our main transmitters goes off the air, a car can be sent to high ground and, with a two-way range of 20 to 25 miles, it can be used as a dispatching point. Again, if some emergency should put all our main stations out of commission, cars can be sent to strategic points throughout the state, and our system of communications will be maintained intact.

In manhunts, in the handling of large gatherings, parades or congested traffic conditions, we have made advantageous use of such an arrangement. We have a completely equipped emergency service truck from which we are able to direct operations from the scene of any disaster by means of car-to-car transmission.

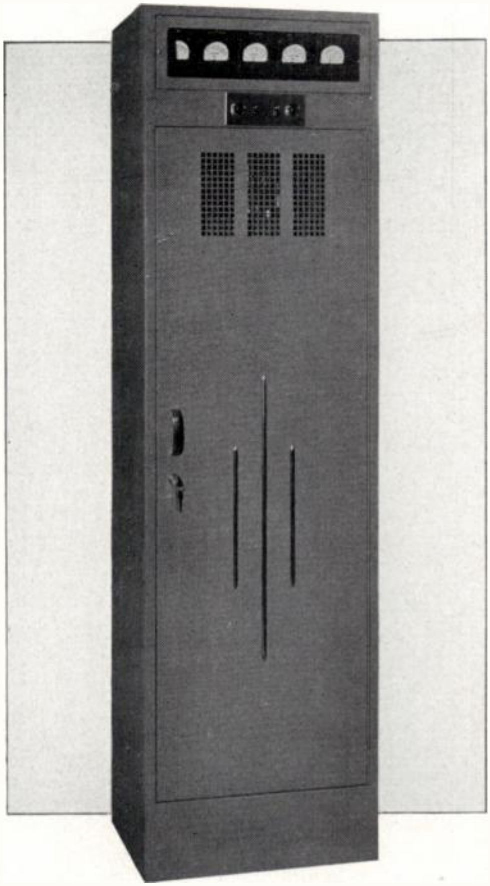
We are equipping two planes belonging to the State Aviation Department with two-way transmitting and receiving units. From these planes it will be possible to talk to any of our Police barracks in the state and also to mobile units on the ground from any locations.

Cost of Operation and Maintenance ★ To those interested in the cost angle of such an installation, it may be stated very generally that the cost is slightly higher than existing amplitude installations. However, we have found that the operating costs are considerably reduced because of the remote control operation of the ultra-high frequency stations, thus eliminating transmitter attendants. Also, the tube complements, transmitter parts, etc., are all of small size and therefore, do not represent a costly maintenance problem.

Although the output of the Link FM transmitter is 25 watts, compared to 15 watts from standard AM mobile transmitters, there is no increase in battery drain, our FM units requiring only 25 amperes during operation. Therefore, no special generators are needed for FM transmitters.

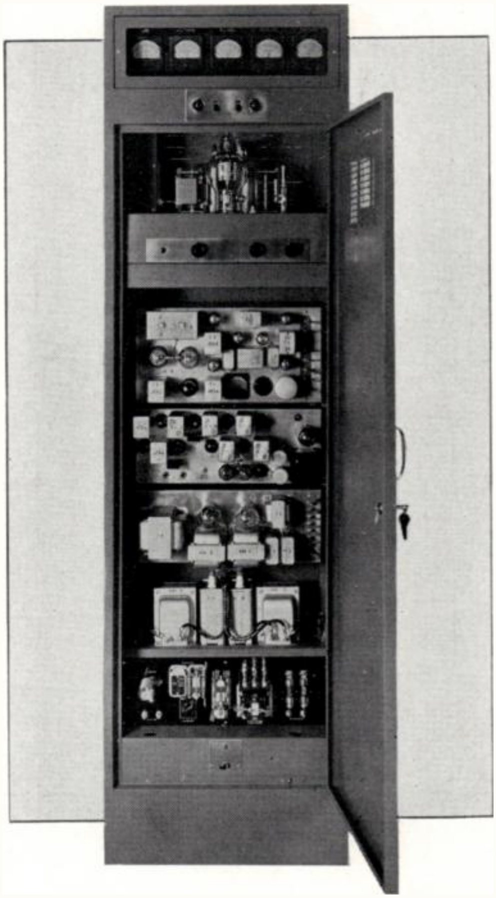
An important factor of economy is the remote control of our main transmitters. The perfect operation of the control system, plus the dependability of the FM transmitters and receivers, eliminates the need of attendants at the radio shacks.

Our maintenance division has one supervisor and four technicians. Being limited by Statute as to the number of police officers in the Department, we had to assign thirty officers from



250-WATT MAIN STATION TRANSMITTER BUILT BY F. M. LINK. FULL REMOTE CONTROL IS USED

[1] See *FM* Magazine, December, 1940, for description and detailed photographs.



SIMILAR TRANSMITTERS ARE USED BY PUBLIC UTILITIES FOR EMERGENCY COMMUNICATION

our patrol unit to act as dispatchers. To remove thirty officers from any highway patrol would ordinarily cripple the system. However, this was not our experience. We now have definite contact with officers assigned to wider patrol areas. We have abolished our so-called barracks detail. No longer do we wait in the station for accident calls. The patrol officer is now dispatched to the scene from his regular patrol route and we have immediate report from him at the accident scene as soon as he has gathered the facts. Thus we find our patrol system more effective. It is my belief that our records show that the results obtained through this two-way system fully warrant the expenditures entailed.

Performance ★ Many of our performance tests have been extremely interesting in the results obtained. We have secured car-to-car transmission over distances as great as 30 miles by choosing favorable locations. Car-to-car transmission over distances of 10 to 12 miles is easily obtainable without choosing strategic locations for the car. The Federal Bureau of Investigation was represented at one of these car-to-car tests and the results obtained using FM were far superior to anything heretofore accomplished with AM equipment.

We ran a car-to-car test in the City of New York for the representatives of the United States Army. One of our cars was parked at the Battery and another car sent uptown. Radio engineers present at the start of the test stated that the greatest distance obtained using amplitude modulation in previous tests was about 9 or 10 city blocks (up to ½ mile) before noise eliminated signal.

Our car was able to maintain communication uptown as far as 46th Street, a distance of approximately 5 miles. During the complete circuit uptown, only 2 transmissions were missed, a result that was amazing not only to ourselves but to all the engineers present. Remember, this two-way contact was simply from car-to-car with an output of only 25 watts.

We have talked back to the Hartford station from every section of the state of Connecticut. Many of these distances have been of the order of 70 or 80 miles and such transmission has become commonplace to us. As another interesting test, we obtained perfect two-way contact from a hill near Nashua, N. H. to Hartford, Conn. This distance was approximately 100 miles and perfect two-way contact was readily obtained. As a matter of fact, it was not even necessary to go to the top of this hill as contact was established as we started to drive up the road and reached an elevation above that of the surrounding trees.

Colonel Edward White of the Federal Communications Commission visited our Westport station to obtain a practical demonstration of what frequency modulation would do in the police service. As a part of the demonstration, an amplitude modulated two-way car was sent out along with one of our FM cars. At a distance of 7 miles from the home station, the amplitude system had lost contact due to noise conditions.

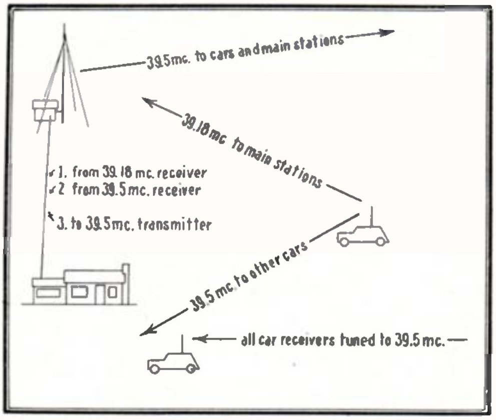
To further demonstrate the system, Colonel White was driven on Sunday afternoon to the Merritt Parkway and into the New York City parkway system and down to the George Washington Bridge. Perfect two-way contact was obtained over the entire trip despite the fact that the FM car was traveling through one of the heaviest ignition interference areas of New York City. When our FM car reached Riverside Drive, we still had perfect two-way contact with our Westport Barracks. This represented a transmission distance of about 45 miles through heavy ignition noise conditions. It also gave further proof of the advantages of FM over amplitude modulation.

Our tests have also shown that we have secondary coverage of the entire state of Connecticut using the Hartford transmitter with a power of 250 watts to any location in the state. By going to a nearby hill any car can contact Hartford direct without any difficulty. The system as set up does not propose such transmission as a regular routine. It does, however, indicate that the system is practically foolproof.

For instance, our Hartford station broke down for about two hours. The Stafford station, located 35 miles away, was called and told to handle transmission of all Hartford cars. Such service while perhaps not as free from noise as usual was entirely satisfactory and not a single message was lost either in dispatching from the station or from a Hartford car calling the Stafford station. We, therefore, know that in cases of emergency such as hurricanes, floods, or power interruptions our system can still go on functioning, and give quick service to the entire state. As a matter of fact, our tests have also shown that by placing a car on the frequency of the main station at a high location near the center of a territory without service, that an area of from 15 to 20 miles can be covered just by using the car as a dispatching point. Thus, we also know that even if all our ten fixed stations were put out of service, that strategic placing of cars around the state would still enable the State Police radio system to function.

We have received many inquiries concerning our system, particularly as to the cost of the original equipment. Briefly, the cost of the Connecticut system was slightly higher than the same equipment would cost now, since the initial engineering has been completed, and the apparatus is now available from factory production. There is no basis for comparing cost with an AM installation, since performance could not be obtained from AM.

We feel that great credit is due Commissioner Hickey for his foresight and courage in pioneering this new type of police service, and it is a source of gratification to all concerned that the results have so fully warranted his confidence in those who were responsible for this undertaking.



THREE-WAY CAR COMMUNICATION

FM APPLICATIONS AND PERMITS

Since issuing the 15 FM construction permits listed in *FM* Magazine of December, 1940, the FCC has authorized 9 more.

Travelers Brcstg. Svc. Corp., Hartford, Conn.
45.3 mc., 6,100 sq. miles, 1,118,000 population

General Electric Co., Schenectady, N. Y.
Frequency not specified, 6,600 sq. miles, 968,000 population

Bamberger Broadcasting Service, Inc., N. Y. City
47.1 mc., 8,500 sq. miles, 12,000,000 population

Metropolitan Television, Inc., New York City
47.5 mc., 8,500 sq. miles, 12,000,000 population

WDRC, Inc., Hartford, Conn.
46.5 mc., 6,100 sq. miles, 1,118,000 population

National Broadcasting Co., Chicago, Ill.
46.3 mc., 10,800 sq. miles, 4,500,000 population

WGN, Inc., Chicago, Ill.
45.9 mc., 10,800 sq. miles, 4,500,000 population

Walker-Downing Radio Corp., Pittsburgh, Pa.
Frequency and population not specified, 8,400 sq. miles

N'tl Life & Accident Ins. Co., Nashville, Tenn.
44.7 mc., 16,000 sq. miles, 819,000 population

Twelve new applications for FM construction permits filed with the FCC are as follows:

South Bend Tribune, South Bend, Ind.
47.1 mc., 4,330 sq. miles, 448,300 population

Rockford Broadcasters, Inc., Rockford, Ill.
45.1 mc., 6,000 sq. miles, 394,500 population

Columbia Broadcasting System, Inc., N. Y. City
44.9 mc., 14,150 sq. miles, 14,954,000 population

Westinghouse Radio Stations, Inc., Boston, Mass.
46.5 mc., 6,652 sq. miles, 3,389,700 population

Westinghouse Radio Stations, Inc., Springfield, Mass.
48.1 mc., 2,022 sq. miles, 499,000 population

Westinghouse Radio Stations, Inc., Ft. Wayne, Ind.
44.9 mc., 6,150 sq. miles, 420,100 population

Westinghouse Radio Stations, Inc., Phila., Pa.
45.5 mc., 11,492 sq. miles, 4,787,000 population

Westinghouse Radio Stations, Inc., Pittsburgh, Pa.
47.5 mc., 14,700 sq. miles, 3,881,000 population

Federated Publications, Inc., Lansing, Mich.
47.1 mc., 3,820 sq. miles, 278,100 population

Federated Publications, Inc., Battle Creek, Mich.
48.1 mc., 4,100 sq. miles, 278,700 population

Federated Publications, Inc., Grand Rapids, Mich.
46.1 mc., 5,300 sq. miles, 518,700 population

Wodaam Corp., New York City
45.3 mc., 8,500 sq. miles, 11,417,000 population

ZENITH MODELS 10H551, 10H571

Complete Service Data on Zenith FM-AM Sets, with 10A3 Chassis*

IDENTIFICATION TABLE

Model	*Power Supply*	*Chassis*	*Cabinet*	*Speaker*
10H551	110-125V., 50-60 cy.	10A3	Chairside	49-424
10H571	110-125V., 50-60 cy.	10A3	Spinet	49-424

SPECIFICATIONS

Type of Circuit:
FM-Superheterodyne

Tuning Range:
Broadcast, 540-1600 kc.
Shortwave, 1.5-5.2 mc.
Shortwave, 5.7-18.5 mc.
FM, 41.5-50.5 mc.

MODEL 10H551 HAS CHAIR-SIDE CABINET

Types of Tubes:
1 — 1852 RF amplifier
1 — 7J7 Converter
1 — 1232 1st IF amplifier for both AM and FM
1 — 7B6 2nd detector, AVC and 1st audio
1 — 6V6G Power amplifier
1 — 5Y4G Rectifier
1 — 1852 2nd IF amplifier, FM
1 — 7C7 1st limiter, FM
1 — 7C7 2nd limiter, FM
1 — 7A6 2nd detector, FM

Input Power Rating:
(117-volt line) 90 watts

Intermediate Frequency:
AM, 455 kc.
FM, 4,300 kc.

* As given in the official Zenith service manual.

ZENITH FM receivers differ in many respects from other FM receivers on the market, and while no attempt will be made here to explain the theory of FM, an explanation of the circuit design will be of aid in successfully servicing these receivers.

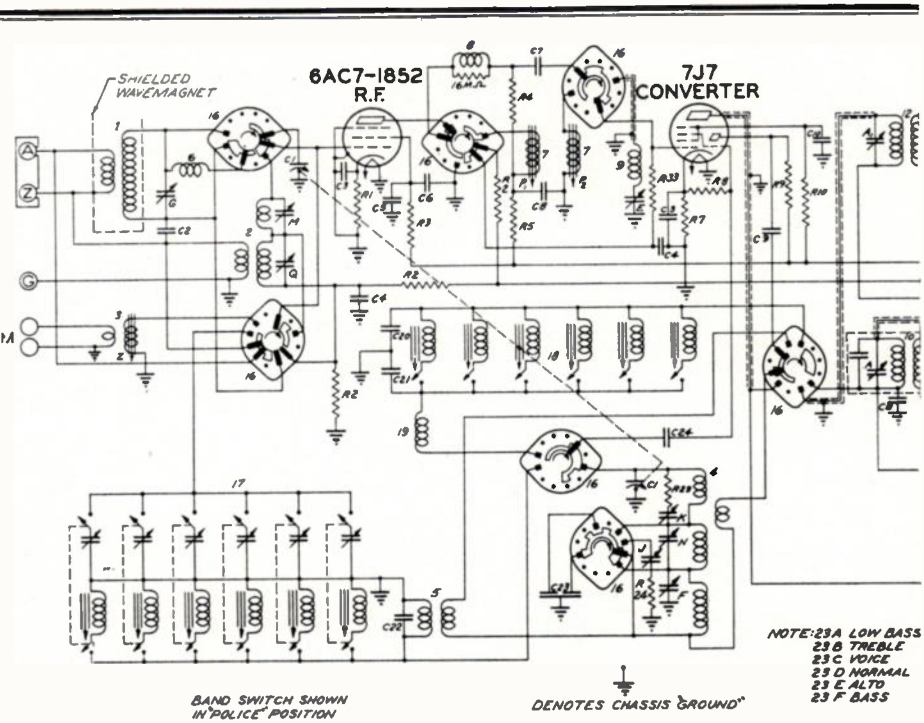
Antenna ★ The receiver contains two built-in antennas, one a standard wavemagnet effective on the broadcast and short wave bands, and the other a folded dipole for use on FM.

The FM wavemagnet used in the Zenith receiver is vertically polarized, and if the local FM station is of the horizontal type, an external FM dipole antenna kit should be used.

RF Tuning ★ Due to the wide frequency coverage of each FM channel (200 kc.) a high degree of selectivity in the RF and converter stages is undesirable. The use of a sufficiently high intermediate frequency prevents difficulty with image reception. These considerations allow

MODEL 10H571 HAS SPINET TYPE CONSOLE

the use of a wide band RF amplifier which is aperiodic over the entire FM band, and also provides an exceptional amount of RF amplification. The circuits are adjusted to the proper frequency by means of an electrolytic copper slug coupled to each coil. Varying the degree of coupling between the copper slug and the coil varies the inductance of the winding. This means is also used to tune the oscillator in

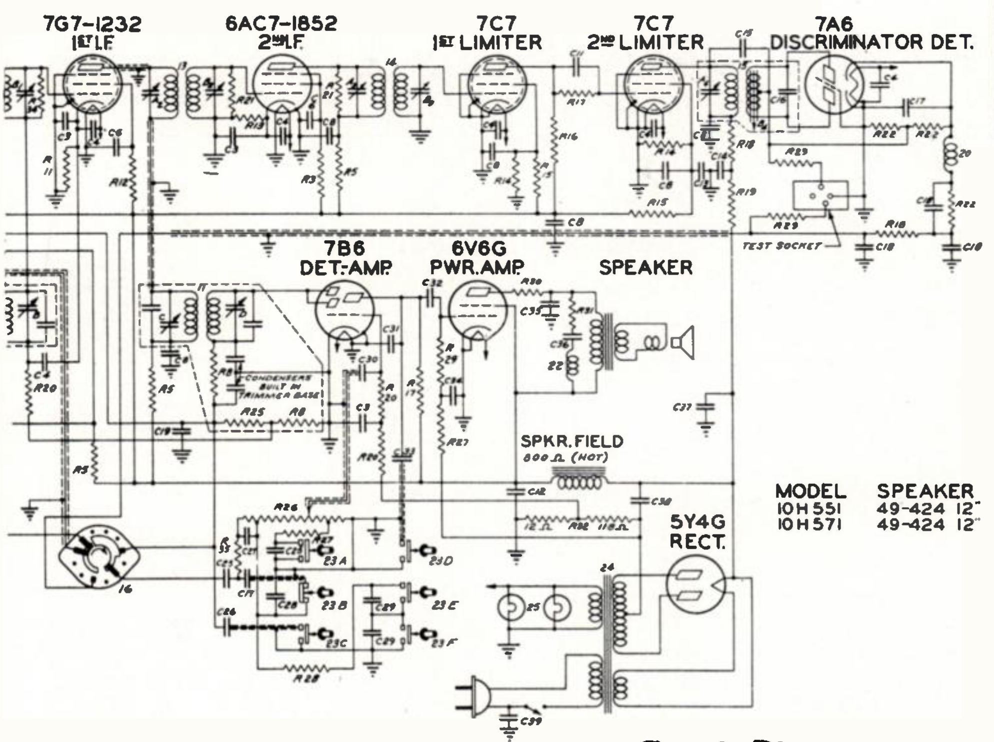


DIAG Nº	PART Nº	DESCRIPTION		DIAG Nº	PART Nº	DESCRIPTION		DIAG Nº	PART Nº	DESCRIPTION	
C1	22-1121	TWO GANG VARIABLE		C30	22-188	.02 MFD.	400V.	R17	63-296	220 M OHM	½ W.
C2	22-319	.005 MFD.	200 V.	C31	22-1136	.00025 MFD.	600V.	R18	63-583	1000 OHM	½ W.
C3	22-827	.1 MFD.	200 V.	C32	22-830	.02 MFD.	600 V.	R19	63-679	82 M OHM	1 W.
C4	22-829	.05 MFD.	200 V.	C33	22-448	.004 MFD.	600 V.	R20	63-271	1 MEGOHM	½ W.
C5	22-1123	5 MFD. ELECTROLYTIC	300 V.	C34	22-219	.03 MFD.	200V.	R21	63-658	120M OHM	½ W.
C6	22-243	.01 MFD.	400 V.	C35	22-1134	.002 MFD.	1000 V.	R22	63-160	100 M OHM	½ W.
C7	22-162	.0001 MFD.	600 V.	C36	22-1128	.02 MFD.	600V.	R23	63-576	68 OHM	½ W.
C8	22-825	.1 MFD.	400 V.	C37	22-1129	.0005 MFD.	1000 V.	R24	63-572	15 OHM	½ W.
C9	22-358	.002 MFD.	600 V.	C38	22-1124	30 MFD. ELECTROLYTIC	450V.	R25	63-773	180 M OHM	½ W.
C10	22-828	.05 MFD.	400 V.	C39	22-1041	.005 MFD.	600 V.	R26	63-1074	VOLUME CONTROL	
C11	22-127	25 MMFD.	600 V.					R27	63-593	47M OHM	½ W.
C12	22-1125	15 MFD. ELECTROLYTIC	450 V.					R28	63-594	68M OHM	½ W.
C13		5 MFD. ELECTROLYTIC	300 V.					R29	63-597	470 M OHM	½ W.
C14		15 MFD. ELECTROLYTIC	250 V.	R1	63-741	150 OHM	½ W.	R30	63-1158	100 OHM	½ W.
C15	22-956	.0005 MFD.	600 V.	R2	63-600	2.2 MEGOHM	½ W.	R31	63-150	10 M OHM	1 W.
C16	22-1143	25 MMFD.	600 V.	R3	63-1159	39M OHM	1 W.	R32	63-1142	2 SECTION CANDOHM	
C17	22-209	50 MMFD.	600 V.	R4	63-1163	2200 OHM	½ W.	R33	63-715	100M OHM	½ W.
C18	22-1138	.0005 MFD.	600 V.	R5	63-605	1000 OHM	½ W.	R34	63-589	10M OHM	½ W.
C19	22-348	.001 MFD.	600 V.	R6	63-595	100 M OHM	½ W.	R35	63-701	470 OHM	½ W.
C20	22-1146	50 MMFD. COMP.	600 V.	R7	63-1164	300 OHM	½ W.	1		WAVEMAGNET ASSEMBLY	
C21	22-1139	50 MMFD. COMP.	600 V.	R8	63-713	47M OHM	½ W.	2	S9075	ANTENNA COIL -	(S.W.)
C22	22-868	COMPENSATING COND.		R9	63-608	15M OHM	1 W.	3	S9065	ANTENNA COIL -	(F.M.)
C23	22-1039	DUAL PADDER		R10	63-1160	56M OHM	1 W.	4	S9074	OSCILLATOR COIL -	
C24	22-1140	50 MMFD.	600 V.	R11	63-1161	270 OHM	½ W.	5	S8466	OSCILLATOR COUPLING COIL	
C25	22-1127	.02 MFD.	400 V.	R12	63-1109	75M OHM	1 W.	6	S9044	LOOP LOADING COIL	
C26	22-1135	.005 MFD.	600 V.	R13	63-246	150 OHM	½ W.	7	S9066	DETECTOR COIL ASSEM.	(F.M.)
C27	22-1130	15 MMFD.	600 V.	R14	63-607	15 M OHM	½ W.	8	S8359	COIL & RES. ASSEMBLY	
C28	22-1137	.00015 MFD.	600 V.	R15	63-1162	33 M OHM	1 W.	9	S8326	WAVETRAP -	
C29	22-1126	.01 MFD.	400 V.	R16	63-961	47 M OHM	1 W.	10	95-765	1ST I.F. TRANSFORMER	(A.M.)

COMPLETE SCHEMATIC DIAGRAM OF ZENITH FM-AM CHASSIS NO. 10A3, USED IN BOTH

which the coupling between the copper slug and the oscillator coil is varied by means of a cam on the variable condenser shaft. This also allows the use of a very efficient, easily adjusted system of electrical automatic tuning in which it is only necessary to make one adjustment (tuning the oscillator) for each automatic button.

IF Amplifier ★ Most designs of FM receivers have used an intermediate frequency of approximately 2 megacycles in order to obtain sufficient amplification. The Zenith receiver, by using exceptionally low loss transformers, and a television type tube (1852) incorporates more than sufficient amplification with an intermediate frequency of 4.3 megacycles. This eliminates the need of staggering or overcoupling the tuning of the IF stages and allows all adjustments to be made at 4.3 megacycles while retaining a 200-kilocycle band width.



DIAG. Nº	PART Nº	DESCRIPTION	DIAG. Nº	PART Nº	DESCRIPTION
11	95-766	2ND I.F. TRANSFORMER (A.M.)	A4		4TH I.F. TRANS. PRI. (F.M.)
12	95-767	1ST I.F. " (F.M.)	B4		4TH I.F. " SEC. (F.M.)
13	95-768	2ND I.F. " (F.M.)	E	22-1015	WAVE TRAP
14	95-769	3RD I.F. " (F.M.)	F		BROADCAST OSC. NOTE 1
15	95-772	4TH I.F. " (F.M.)	G	22-1042	BROADCAST ANTENNA
16	85-234	BAND SELECTOR SWITCH	J	22-688	BROADCAST PADDER
17		AUTOMATIC TUNING UNIT (BC)	K		SHORTWAVE OSC. NOTE 1
18		AUTOMATIC TUNING UNIT (FM)	M		SHORTWAVE ANT. NOTE 2
19	S9350	PEAKING COIL	N		POLICE BAND OSC. NOTE 1
20	S8998	F.M. I.F. WAVETRAP	P		ULTRA HIGH FREQ. DET. (PLATE)
			P2		ULTRA HIGH FREQ. DET. (GRID)
22	20-236	SPEAKER COMP. FILTER	Q		POLICE BAND ANT. NOTE 2
23	S8690	TONE CONTROL SW. ASSEM	Z		ULTRA HIGH FREQ. ANTENNA
24	95-771 / 95-773	POWER TRANS. 50-60~ / 25~			
25	100-36	PILOT LIGHT 6.3V .25A			NOTE: (1) TRIMMERS F, K & N ARE MOUNTED ON STRIP # 22-850
A		1ST I.F. TRANS. PRI. (A.M.)			(2) TRIMMERS M & Q ARE MOUNTED ON STRIP # 22-1045
B		1ST I.F. " SEC. (A.M.)			
C		2ND I.F. " PRI. (A.M.)			
D		2ND I.F. " SEC. (A.M.)			
A1		1ST I.F. " PRI. (F.M.)			
B1		1ST I.F. " SEC. (F.M.)			
A2		2ND I.F. " PRI. (F.M.)			
B2		2ND I.F. " SEC. (F.M.)			
A3		3RD I.F. " PRI. (F.M.)			
B3		3RD I.F. " SEC. (F.M.)			

Circuit Diagram

Models 10H551-10H571

Chassis No. 10A3

AMP. MOD. I.F. FREQUENCY 455 KC.
FREQ. MOD. I.F. FREQUENCY 4.3 MC.
10 TUBE SUPERHETERODYNE
CHASSIS Nº 10A3-A.C.-4 BAND
ZENITH RADIO CORPORATION
CHICAGO, ILL.

CONSOLE AND CHAIR-SIDE CABINETS. LISTS SHOW CONSTANTS OF COMPONENTS

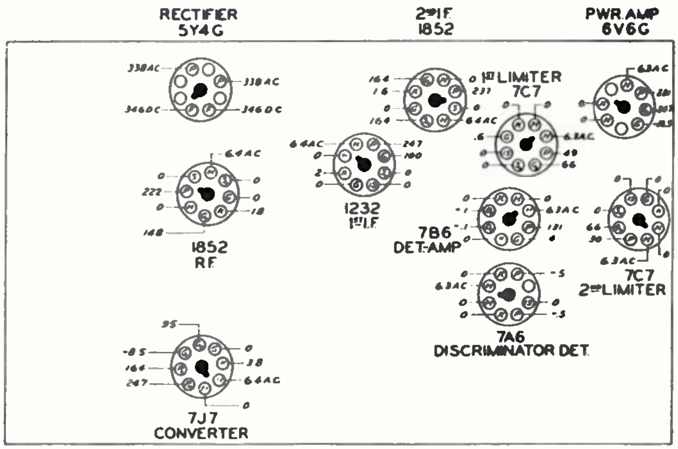
Two stages of IF are used on FM with one stage being used on standard broadcast and short wave by merely placing the 4.3 megacycle and 455 kc. transformer windings in series.

ALIGNMENT INSTRUCTIONS

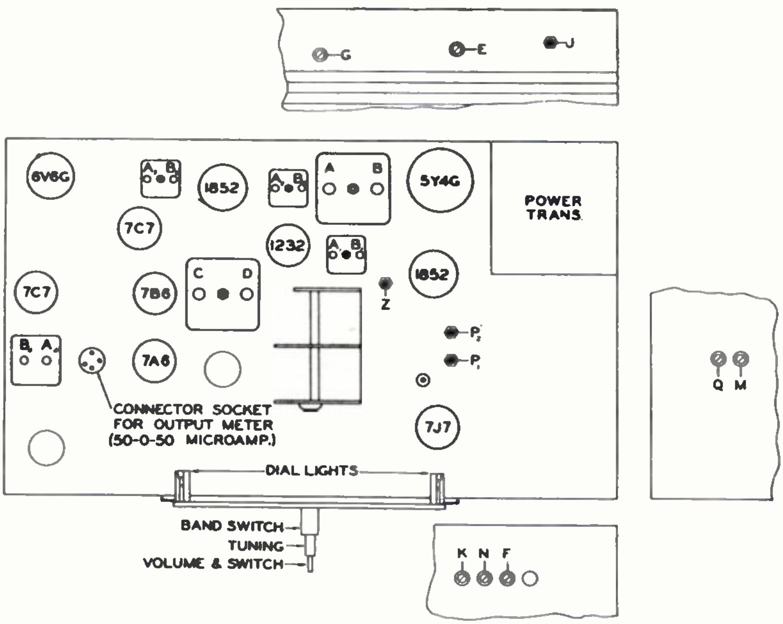
The signal generator should be connected to the antenna and ground terminals of the receiver with 10 ohms shunted across the output of the signal generator as a dummy antenna (unless otherwise specified).

The chassis drawing shows all trimmers which are lettered to correspond to the alignment chart. Corresponding letters are also shown adjacent to each trimmer on the circuit diagrams.

The use of a wavemagnet requires two adjustments for each automatic button. These adjustments are made with a special wrench (part No. 68-1) supplied with each receiver. The center or screw adjustment controls the



SOCKET VOLTAGES



TUBE AND TRIMMER POSITIONS

VOLTAGES ARE MEASURED WITH A 1,000-OHM PER VOLT METER TO THE CHASSIS

oscillator circuit and the nut tunes the wavemagnet or antenna input.

Wave Magnet ★ The primary winding of the wavemagnets used on 1941 models is of the high impedance type and the natural period of this winding is within the broadcast band. When an antenna is connected to the primary winding the additional capacity tunes it below broadcast frequencies which is very desirable for energy transfer.

However, this requires that the primary winding be short circuited whenever an external antenna is not attached in order to preserve the tuning characteristics of the loop winding. A shorting bar is provided for this purpose, and should *always* be in place when the receiver is operated on the wavemagnet alone.

Voltage Charts ★ All voltages measured with a 1,000 ohm per volt meter from chassis to socket contact indicated.

All voltages are positive D.C. unless marked otherwise.

Volume control on full.

Allowance should be made for variations in line voltage or if a voltmeter of different rating is used in making tests.

STAGE GAINS

Data on the average amplification of different portions of each type chassis is included for the use of service men equipped with vacuum tube voltmeters or similar voltage measuring equipment.

Bc. and 455 Kc. — IF

Ant. to RF grid — 6.5 × at 1,000 kc.
RF grid to conv. grid — 28.1 × at 1,000 kc.
Conv. grid to IF grid — 31.3 × at 455 kc.
Overall audio — 1,640 × at 1 watt, 400 cycles.

FM and 4.3 Mc. — IF

Ant. to RF grid — 1.8 × at 46 mc.
RF grid to conv. grid — 7.9 × at 46 mc.
Conv. grid to 1st IF grid — 2.7 × at 4.3 mc.
1st IF grid to 2nd IF grid — 80 × at 4.3 mc.
2nd IF grid to Limiter grid — 25 × at 4.3 mc.

ALIGNMENT PROCEDURE

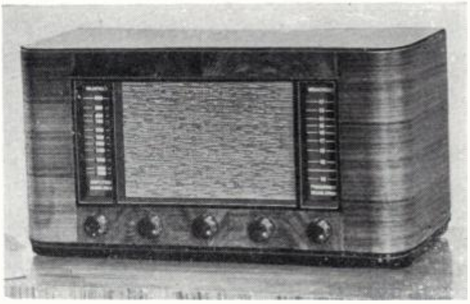
Operation	*Connect Test Oscillator to*	*Dummy Antenna*	*Input Signal Frequency*	*Band*	*Set Dial At*	*Connect Output Meter to*	*Trimmers*	*Purpose*
1	Con. Grid	0.5 mfd.	455 kc.	B.C.	600 kc.	6V6G Output	A B C D	Align IF
2	RF Grid	0.5 mfd.	455 kc.	B.C.	600 kc.	6V6G Output	E	IF Trap Adjust for Minimum
3	Ant. terminals marked Z and G	400 ohms	18 mc.	S.W.	18 mc.	"	K	Set to Scale
4	"	"	16 mc.	S.W.	16 mc.	"	M	Align Ant.
5	"	"	5.0 mc.	Med.	5.0 mc.	"	N	Set to Scale
6	"	"	4.5 mc.	Med.	4.5 mc.	"	Q	Align Ant.
7	Single turn Loop Loosely coupled to loop		1400 kc.	B.C.	1400 kc.	"	F	Set Osc. to Scale
8	"		1400	B.C.	1400 kc.	"	G	Align Ant.
9	"	"	600 kc.	B.C.	600 kc.	"	J (Rock Gang)	Broadcast Padder
10	1852 Grid	0.5 mfd.	4.3 mc.	Manual F.M.	4.3 mc.	FM Output Meter Across Full Disc. Load	B4	Align for Zero Deflection
11	"	"	"	"	"	FM Output Meter Across Half Disc. Load	A4	Align for Max. Deflection
12	"	"	"	"	"	"	A3B3	"
13	767-1232 Grid	"	"	"	"	"	A2B2	"
14	7J7 Grid	"	"	"	"	"	A B	"
15	FM Ant. Terminals	100 ohms	46.0 mc.	"	46.0 mc.	"	Adjust cam on gang shaft for scale	"
16	"	"	42.5 mc.	"	42.5 mc.	"	P	"
17	"	"	49 mc.	"	49 mc.	"	P2	"
18	"	"	46 mc.	"	46 mc.	"	Z	"

During F.M. Alignment keep input low, to obtain max. sensitivity for alignment. This is necessary because with large inputs the limiting action of the limiters masks alignment operations.

NOTE — A 10M ohm per volt or higher voltmeter may be used as an F.M. output meter.

FREED ADDS TO FM-AM MODELS

Line Includes AC and AC-DC Sets, in Table, Console, Phonograph Cabinets



14-TUBE TABLE MODEL FOR FM-AM TUNING

AN OLD-TIMER among radio manufacturers, Joseph D. R. Freed is building sets again, and FM-AM models exclusively. "That," he explained, "shows how important I think FM is to the development of radio sales now and in the immediate future." His attitude is further confirmed by a statement contained in the Freed FM News bulletin concerning dealers who sell their customers away from FM to straight AM models priced at $100 or more: "These dealers are going to be faced with irate customers, within the next few months, when they realize that they were sold what were already obsolete receivers — those that do not receive FM."

The present Freed line is comprised of five models, illustrated here. These are a table model, console, and three automatic phonograph combinations, representing three different chassis.

A very interesting arrangement is represented in the table model and console. Instead of putting the FM and AM tuning condensers on one shaft, they are mounted separately, at opposite ends of the chassis, with individual scales. This not only makes an attractive design for the table model, with the speaker located at the center, but it affords the dealers an opportunity to use an impressive method of comparing FM and AM.

That is, when a program is being transmitted by both FM and AM, the respective tuning circuits can be set for both methods of broadcasting. Then, by changing the FM-AM switch on the set, it is possible to hear the same speech or music first one way and then the other, with no delay for readjustment.

The circuit of this chassis employs separate FM and AM tuning circuits with 2-gang condensers, and separate IF amplifiers of 4.3 mc. and 456 kc., respectively. Designed for AC-DC operation, the tube compliment is: two 6K8, three 7H7, two 6SJ7, one 6H6, one 6SQ7, two 25L6, two 25Z6, and one 6SK7. On FM, the range is 42 to 50 mc., and on AM, 530 to 1700 kc. The output is rated at 5 watts to an 8-in. electrodynamic speaker in the table model, or a 12-in. electrodynamic speaker in the console. An off-channel-silence circuit is used on FM tuning. Terminals are provided for the attachment of a record player, and for connecting the FM detector circuit to an external amplifier and speaker, if the tuner is to be used with a public address system or for special demonstrations.

The first model in the series of automatic combinations is shown below, at the center. This is a 16-tube receiver, designed for AC operation. However, it is also available for DC current. Tuning circuits cover the FM and standard AM bands. A cathode ray tuning is used to show resonance. There are two speakers in this set. The same chassis and

FM-AM MODELS. LEFT, 14-TUBE AC-DC WITH SAME CHASSIS AS IN TABLE SET. CENTER AND RIGHT, 16-TUBE PHONOGRAPH COMBINATIONS OPERATE ON AC, ALSO AVAILABLE FOR DC CURRENT

speaker system is used for the second combination, right below, housed in a modern cabinet of simple, dignified lines.

None of the four of the Freed models just described has short-wave bands. This is also true of a number of models in lines produced by other manufacturers. Undoubtedly, the feeling prevails that FM-AM sets are bought primarily for high-quality entertainment.

In the most expensive Freed combination, shown on page 37, short-wave circuits are included. This set has twenty tubes and a cathode ray tuning indicator. The cabinet, 44 ins. high, 32 ins. wide, and 18 ins. deep, houses two loudspeakers.

FCC CONFERS WITH FM TRANSMITTER MANUFACTURERS

An informal engineering conference was held at the offices of the Federal Communications Commission on Monday, December 9, to discuss transmitting equipment for high frequency broadcast stations. Two subjects were discussed, namely: 1. Maximum power rating and operating power range of standard high frequency (FM) transmitters. 2. Performance characteristics of audio amplifying equipment when obtained separately and as a complete unit.

The Commission had been informed that it would facilitate the manufacture of standard FM broadcast transmitting equipment if maximum power ratings could be standardized. Also, that the operating power range of the transmitters of different maximum power ratings should be standardized for the equipment made by different manufacturers. As the Commission regulates only the external performance characteristics, it ordinarily would not be particularly concerned with power rating except in so far as it must be considered in obtaining the necessary performance. It was agreed, however, to discuss these matters with the several manufacturers so as to standardize the power ratings in order to expedite manufacture at this time when most of the engineering facilities of the manufacturers are devoted to defense engineering.

The following power ratings were offered as a basis of discussion:

Maximum Power Rating	*Operating Power Range*
250 watts	50 to 250 watts
1,250 "	250 " 1,250 "
5,000 "	1,250 " 5,000 "
25,000 "	5,000 " 25,000 "
100,000 "	25,000 " 100,000 "

High frequency broadcast stations are *not* rated on the basis of power output. They *are* rated on the basis of service area. The service area is established from economic data and certain technical considerations. Since all stations serving the same city must have substantially the same service area and as the antenna height and antenna gain vary in all cases, the operating power will, in most cases, be odd values (such as 1,190 watts, or 19.2 kw.). While stations are not to be rated on the basis of operating power, consideration must also be given the determination of the operating power for the authorized coverage.

Even though standard maximum ratings as given above are adopted, it may be desirable to make provision for immediate steps by reducing the number of tubes or using tubes of different power ratings in the last radio stage when the operating power is considerably below the maximum power rating. This was suggested for economy only.

It has been brought to the attention of the Commission that the performance characteristics of the speech input equipment are dependent upon the input and output circuits employed. Unless each unit is designed for the impedance characteristics of the load, the performance (frequency and amplitude) may be different from the published data. The claims for overall performance of high frequency broadcast equipment are, in many cases, based upon the performance of individual units which may not, in some cases, if not matched, give performance meeting the requirements unless all units are equalized as a whole. These problems were discussed with the view of standardizing a method of specifying characteristics and load conditions. High frequency broadcast stations are required to submit proof of audio performance during tests as a complete station before a license will be issued by the Commission.

Findings of this conference will be published in *FM* Magazine as soon as they are made available by the FCC.

20-TUBE FM AND ALL-WAVE AM RECEIVER WITH PHONO. HAS AC OR DC POWER SUPPLY

TECHNICAL DATA ON SCOTT SETS

Part 2—Method of Aligning the FM Tuner and the FM-AM Receivers—by Marvin Hobbs *

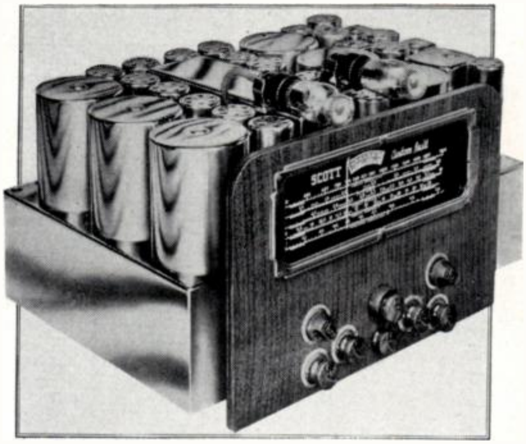


FIG. 3. PHANTOM DE LUXE FM-AM CHASSIS

Alignment Procedure ★ The following equipment is necessary for the accurate alignment of the FM sections of the Scott FM tuner and the FM sections of the FM-AM receivers:

1 — 0–1 ma. DC milliammeter.
1 — 25–0–25 ma. DC microammeter with 500,000-ohm series resistor.
1 — IF signal generator having a frequency range of at least 5 to 5.5 megacycles with maximum dial bandspread, and 100 microvolts or less minimum to 2 or 3 volts maximum output voltage. Modulation is unnecessary.
1 — RF signal generator having frequency range of 40 to 50 megacycles with RF output attenuator and output range of 1 microvolt to 100,000 microvolts. Modulation not essential, but variable frequency modulation is desirable.

Discriminator Alignment ★ After removing the chassis bottom plate, the discriminator alignment point can be located readily. It will be found on the 6H6 socket at terminal No. 4 or after the 50,000 ohms resistor in series with this point.

In the FM tuner, the 6H6 socket is located in the upper left-hand corner of the chassis near the air trimmer adjustment screw of the discriminator transformer.

A circuit diagram of the connections for this operation is shown in Figure 4. Connect the zero-center microammeter with series resistor as shown, and connect the output of the IF signal generator (tuned to 5.25 mc.) through a .05 mfd. condenser to the grid cap of the 2nd 6J7G limiter. If the generator has a high output impedance, the grid cap and lead of the 6J7G should be removed and instead a 1-megohm grid leak should be inserted. Increase the output of the IF signal generator to the 2- or 3-volt level. Rotate the plate trimmer condenser at the top of the discriminator transformer shield can until the zero-center microammeter swings to maximum deflection in either direction from zero. Then rotate the secondary trimmer condenser at the bottom of the discriminator transformer until the meter indicator swings through zero with increasing or decreasing current, depending upon the direction of rotation of the trimmer adjustment. Adjust for zero meter indication under these conditions.

Detune the signal generator back and forth about ±150 kc. If the discriminator circuit is operating properly, the indicator meter will swing through a positive peak in one direction and through a negative peak in the other direction. However, these peaks may not be of equal amplitude. They can now be adjusted for equality by going back to the plate trimmer at the top of the discriminator transformer and making a slight readjustment. If the high frequency peak is of greater amplitude than the low frequency peak, the plate trimmer should be readjusted so that the amplitude of the former is reduced slightly. Then, by detuning the generator back and forth, the low frequency peak will be seen to have increased. By compromising between the two peak levels and going back over the plate trimmer adjustment, it is relatively simple to attain peak equality in the discriminator circuit.

The peaks should be about 250 kc. apart or ±125 kc. from the resonance frequency, which is 5.25 mc., and the variation of the zero center meter current should be linear on either side up to at least ±80 kc. The final goal of discriminator alignment is to attain this linearity over at least ±80 kc. After obtaining peak linearity, finally readjust the plate trimmer slightly to obtain this result even at a sacrifice of peak equality. The linearity and equality of the ±80 kc. deviation characteristics are essential to distortionless audio reproduction for a wide-band FM receiver. If

* E. H. Scott Radio Laboratories, Chicago, Ill.

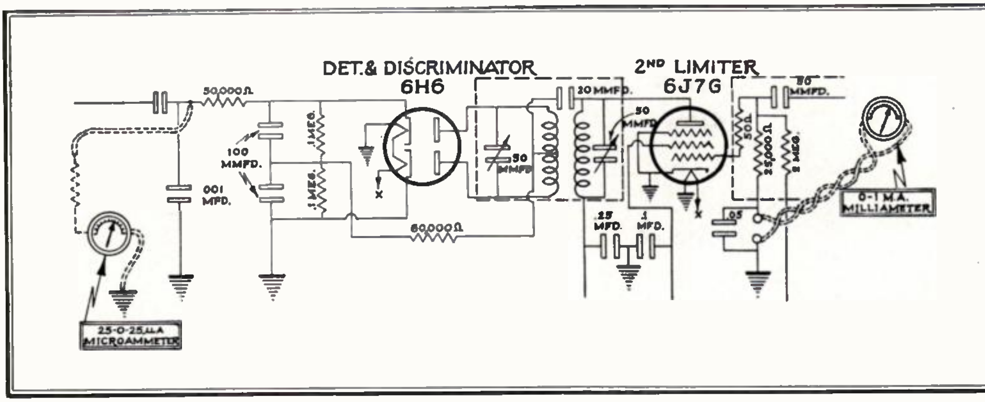


FIG. 4. ALIGNMENT CONNECTIONS FOR THE FM TUNER AND ALL FM-AM RECEIVERS

it is found to be linear out to ±100 kc. when finally adjusted, it is so much the better to allow for overmodulation at the transmitter.

When the adjustment of the discriminator transformer is completed, the zero-center meter should indicate zero when the signal generator is tuned to 5.25 megacycles.

IF Amplifier Alignment ★ The 0–1 milliammeter should be inserted in the ground side of the 25,000-ohm grid leak in the input circuit of the 2nd 6J7G limiter tube. A jumper connection and by-pass condenser have been provided under the chassis at this point in each receiver. In the FM tuner, it is located under the fourth IF transformer, near the socket of the 2nd 6J7G. In the combination receivers, it is under the FM extension section near the fourth IF transformer. The wire from the IF transformer is color-coded slate and white.

After the meter is inserted, the IF signal generator (tuned to 5.25 mc.) should be connected through a .05 mfd. condenser to the grid cap of the 1st 6J7G limiter, and the primary and secondary alignment screws of the fourth IF transformer should be adjusted for maximum limiter grid leak current. The output of the signal generator should be adjusted so that the limiter current is about .2 milliampere while the tuning adjustments are being made. Since it is possible to align the IF coils with the cores either out or in, it is important to make sure that they are peaked with the adjustment screws in the outward position in order to insure proper coupling between the coils. The receivers in the field will be found to have their adjustments made in this manner.

The third, second and first IF transformers should be aligned in this order, by moving the signal generator input progressively forward to the 2nd 1232, 1st 1232 and the 6SA7 grid. All of these connections are on the respective sockets, because of the single-ended construction of these tubes. Each transformer alignment screw should be adjusted for maximum 2nd limiter grid current, as the signal input is fed into the amplifying tube directly in front of it. After all of these adjustments have been made, the individual stages should *not* be realigned except by the above procedure; that is, the IF adjustments should be made individually for each stage by the point-to-point method and no overall readjustments should be made.

The overall IF selectivity characteristic may be checked by detuning the signal generator at least ±75 kc. or more from the 5.25 mc. point and observing the amount of attenuation. A certain amount of dissymmetry can be tolerated in the plotted curve, because of the limiting characteristic of the Scott receivers.

RF Circuit Alignment ★ With the 0–1 ma. meter in the 2nd limiter grid leak circuit, connect the RF signal generator output through a .05 mfd. condenser to the grid terminal of the 6SA7 mixer tube. Observe whether the dial pointer stops at 41 mc. when it is turned fully to the end of the scale. If it does not, slide it along the drive cable until that condition exists when against the stop at that end. Then turn the tuning knob to rotate the pointer to 50 mc. and adjust the signal generator for a 50 mc. signal. With sufficient output from the generator to enable an easy location of the signal (1000 to 5000 microvolts) rotate the oscillator trimmer until a peak of limiter grid current is reached. The oscillator must be peaked on the low frequency side of the incoming signal and, while the capacity values in the oscillator circuit are such that it is difficult to align on the high frequency side, this condition might happen if some defective part should be present. Therefore, the best procedure is to make sure that the oscillator is on the low frequency side

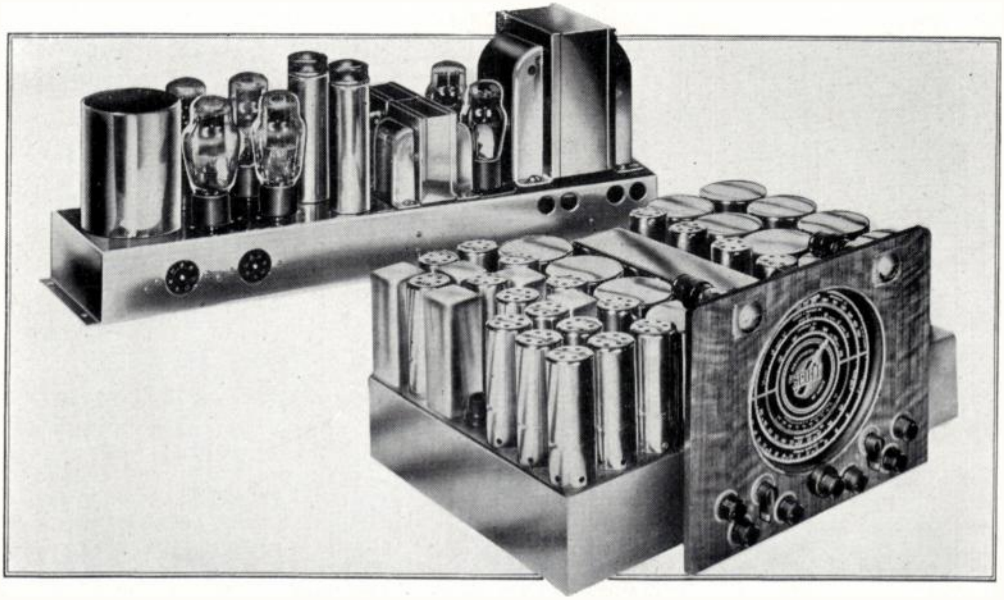


FIG. 5. SCOTT PHILHARMONIC FM-AM CHASSIS WITH THE AMPLIFIER AND POWER SUPPLY

by observing that the image signal is on that side. This check can be made rather easily after a peak is reached by simply tuning the signal generator to approximately 39.5 mc. and noting that a repeat signal of about equal intensity comes in at that point. When this check shows the correct alignment, the oscillator is properly adjusted.

Connect the signal generator output to the grid of the 1853 RF tube and align the trimmer of the RF circuit following that tube for maximum output, that is, maximum limiter grid current; and proceed to the antenna terminals. In the Philharmonic, connect the generator to the IF grids, moving progressively toward the receiver input point and aligning each trimmer in that order.

The output of the signal generator should be fed to the antenna terminals through a 100-ohm resistor, provided the signal generator has a low internal impedance. If its internal impedance is high, the dummy resistor will have little effect; but a value of 100 ohms can still be used to avoid a complete short-circuit of the generator output. If one side of the generator output is grounded, the receiver antenna terminal adjacent to the ground terminal should also be connected to ground by the jumper wire. With signal generator still tuned to 50 mc. the antenna shunt trimmer should be aligned for maximum limiter grid current.

After this alignment at the high frequency end of the band is completed, the dial should be rotated to the low frequency end, about 43 mc., and the sensitivity level at that point should be compared with that which was noted at 50 mc. It should be substantially the same. Since fixed padding condensers are used in the antenna and RF circuits, a lack of sensitivity would indicate that the value of one of these might have changed or that the inductance of the coils might have shifted. An examination of these parts and the replacement of any defective ones should restore the sensitivity to normal. If the RF or antenna secondary inductance is off slightly, this may be remedied by pushing end turns slightly to obtain maximum sensitivity.

The RF signal generator output should be kept at a level which results in a 2nd limiter grid current of about .2 milliampere during the alignment operations.

Observation of Limiter Operation ★ When the RF alignment is completed, it is important to observe that the limiters are functioning properly. This action can be observed best by detuning the RF generator either +75 kc. or −75 kc. with the zero-center meter connected across the discriminator load, as was done for the alignment of that circuit.

Set the output of the RF signal generator to about 25 microvolts, and observe the reading of the zero-center meter. Then increase the output of the generator to the full 100,000 microvolts and observe the meter reading as this change is made. It should remain substantially constant. If it changes noticeably, the limiter tubes may be defective or their

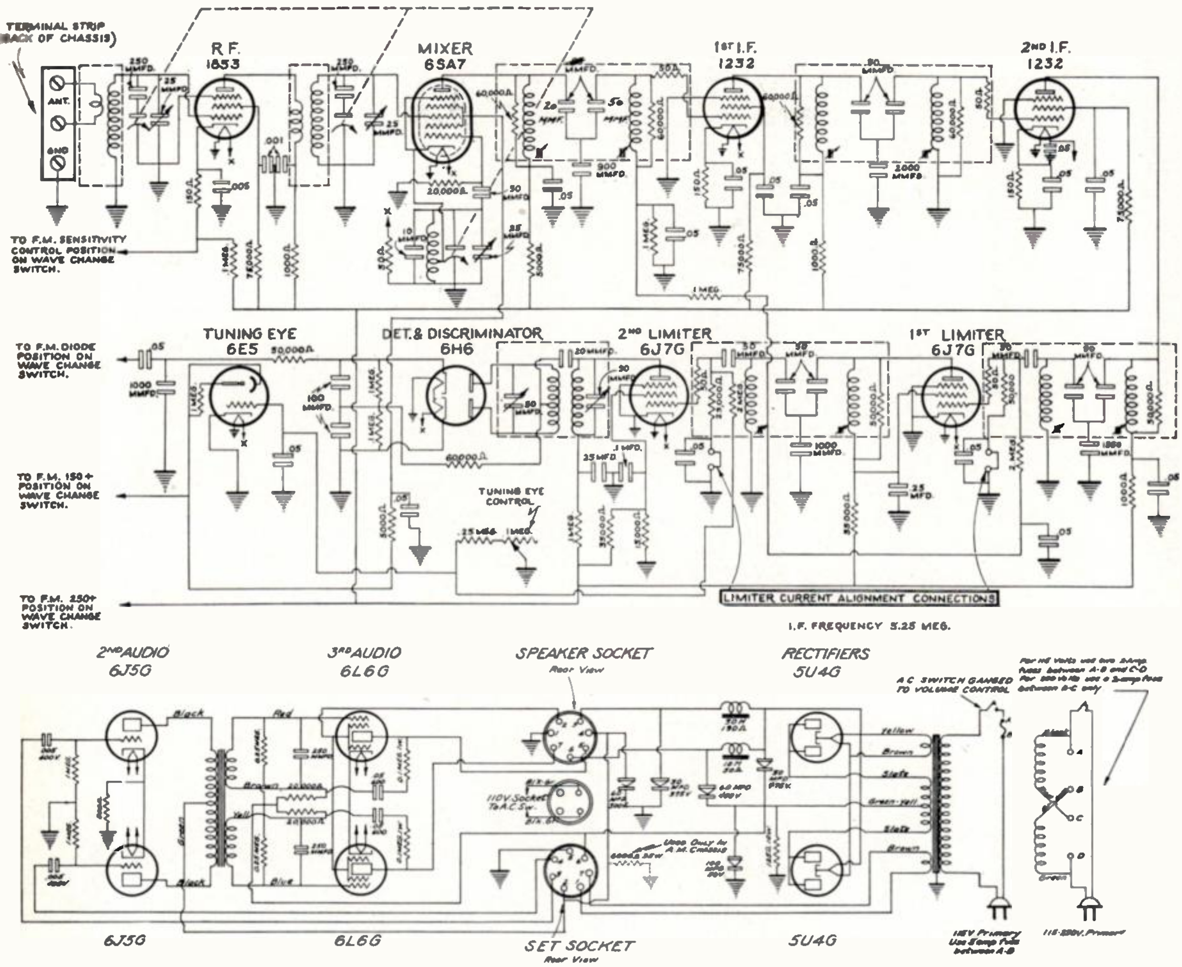


FIG. 6. SCHEMATIC WIRING DIAGRAM OF SCOTT PHANTOM DE LUXE FM CIRCUITS. BELOW, DIAGRAM OF POWER SUPPLY. RADIO CHASSIS IS SHOWN IN FIG. 3

supply resistors may have become defective. Another cause for change in this reading is oscillator frequency shift due to a defective 6SA7. However, the latter defect will manifest itself in a different way, and can be definitely isolated by tuning the signal generator to resonance, which is indicated by zero discriminator voltage, and observing whether this zero point shifts when the signal level is varied from 25 to 100,000 microvolts. If the oscillator frequency remains constant with varying signal input, the zero center point will not vary.

If the limiter characteristic is not flat, distortion will be noticed and the noise elimination will be somewhat less complete than normal.

The following table gives the voltage and current readings for the FM tuner:

Voltages and Currents for FM Tuner

Tube Type	*Function*	E_f	E_k	E_{g1}	E_{g2}	E_p
1853	1st RF Amplifier	5.9	1.2	105	0	230
6SA7	Mixer-Oscillator	5.9	0	102	–	225
1232	1st IF Amplifier	5.9	1.2	87	0	230
1232	2nd IF Amplifier	5.9	1.2	85	0	230
6J7G	1st Limiter	5.9	0	75	0	75
6J7G	2nd Limiter	5.9	0	60	0	45
6H6	Detector	5.9	0			

Power Consumption

FM Philharmonic	270 watts
FM Phantom	220 "
FM Masterpiece	150 "
FM Tuner	60 "

FM HANDBOOK

Chapter 3: The Method of Receiving FM Signals

BY GLENN H. BROWNING

THE principles involved in the reception of FM signals differ in several respects from those of amplitude modulated signals. However, the same methods of amplification are used. As has been explained, the FM transmitter varies its frequency in proportion to the modulating audio amplitude, while the rate of change of frequency variation is proportional to the frequency of the audio signal. Therefore, it is necessary to have an entirely new type of detecting system which will change frequency variations so as to recover the audio modulation.

Elementary Receiving Circuit ★ Probably the simplest way to accomplish this result would be to use a tuned circuit, such as shown in Fig. 1, but instead of tuning to the center of the carrier, adjusting the circuit so that when the station was not modulated, the tuning point would be as indicated at *A*. In other words, the tuned circuit would be so adjusted that the un-

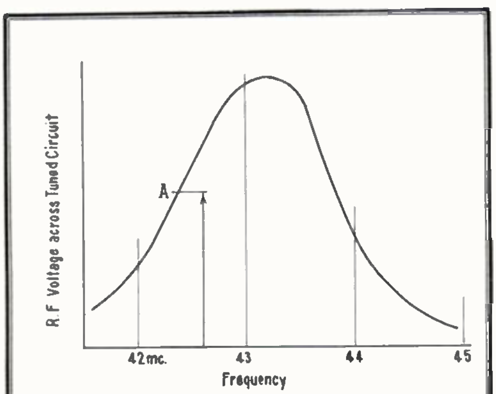


FIG. 1. FM RECEIVER RESONANCE CURVE

modulated signal would develop only about half the voltage or response that could be obtained by tuning it to exact resonance with the incoming unmodulated signal. Then, if the carrier frequency is increased, the RF voltage in the tuning circuit is increased in a proportional amount, and if the carrier frequency is decreased, the RF voltage in the tuned circuit is decreased by a similar amount, provided the side of the resonance curve being employed is substantially a straight line, as it would be for a tuned circuit with a reasonable Q at frequencies of 42 mc. or higher.

It will be readily observed that as the frequency of the transmitter increases and decreases, the amplitude of the radio frequency voltage across the tuned circuit likewise increases and decreases. If the tuned circuit (LC) is connected to a detector tube such as a diode shown in Fig. 2, this increase and decrease in radio frequency amplitude in the tuned circuit will cause a pulsating DC current to flow through the resistor R and thus a voltage will be developed across R, the magnitude of which will depend upon the variation in carrier frequency, and the rate of variation will

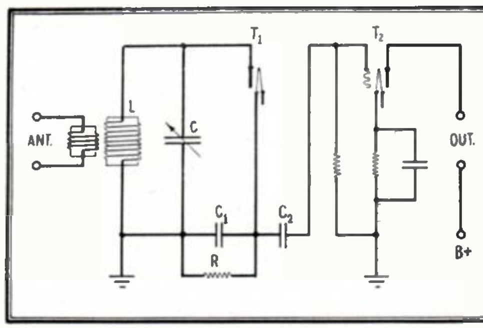


FIG. 2. SIMPLE CIRCUIT FOR FM RECEPTION

depend upon the audio frequency of the modulating signals.

The variations in DC voltage may be passed through the capacitor C_2, and the resulting voltage impressed on the grid of the audio amplifier tube T_2 will be a reproduction of the audio signals modulating the FM transmitter. It will be noted that the detection process results in the ordinary audio signals with which we are familiar. In practice, the by-pass capacitor C_1 would be connected in parallel with R to allow the total RF voltage to be impressed on the diode detector T_1. Thus it would be possible to construct an FM receiver by employing a tuned circuit (tuned off resonance), a diode detector, and an audio amplifier. Of course such a receiver would be very insensitive. It would be difficult to tune to the correct portion of the resonance curve, and noise would not be eliminated, but this serves to illustrate the detection system necessary for receiving FM signals in terms familiar to all. It also explains the reason that FM signals can be heard, under certain conditions, with a receiver designed for AM.

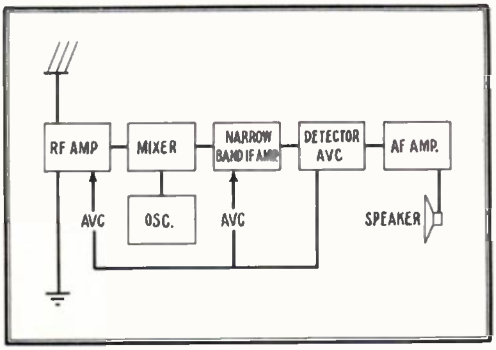


FIG. 3-A. ELEMENTS OF AM SUPERHETERODYNE

Superheterodyne Type of FM Receiver ★ The superheterodyne type of receiver lends itself very much more readily to the reception of FM signals, for in this case circuits may be incorporated which in themselves will tend to eliminate any amplitude changes due to man-made or atmospheric static, and the detection of frequency modulated signals may be accomplished more readily from a practical standpoint than in the method previously described.

Fundamentally, a superheterodyne designed for the reception of FM signals differs in several respects from the conventional superheterodyne receiver with which the service man is thoroughly familiar. These differences may be more clearly noted by reference to the block diagrams shown in Fig. 3. Both the AM and FM receivers have an RF amplifier, a mixer, an oscillator, an IF amplifier, a detection system, an audio amplifier, and a speaker. The AM receiver has an automatic volume control circuit which is employed to maintain a substantially constant output from the speaker over a considerable range of signal input. An AVC system is not only unnecessary in the case of an FM superheterodyne, but it is objectionable. Any system which tends to decrease signal strength before the signal passes through the limiter circuits increases the signal-to-noise ratio. Furthermore, as will be explained later, the limiter circuit in the FM receiver not only performs the function of eliminating signal amplitude variations, but also keeps the audio voltage fed to the amplifier practically independent of the carrier strength when sufficient signal is obtained from the transmitter to operate the limiter properly. Thus the limiter also performs the same function as an AVC system.

The AM receiver has a narrow-channel IF system, while the FM receiver has a broad-band high-gain IF amplifier, followed by a limiter circuit, composed of one or more sharp cut-off tubes, which on low signal levels act as amplifiers as well as limiters. Both the receivers have detector systems, but the two methods of recovering the audio voltage from the carrier frequency are entirely different, as has been explained. A de-emphasis network is incorporated as an integral part of the FM receiver and has a function which will be taken up in detail subsequently. The audio amplifier and speaker system are the only parts which can be identical in the two systems. It should be noted, however, that in order to enjoy the high-fidelity which may be obtained from FM transmission, the audio amplifier and speaker must be distinctly superior in design to those used in conventional AM receivers.

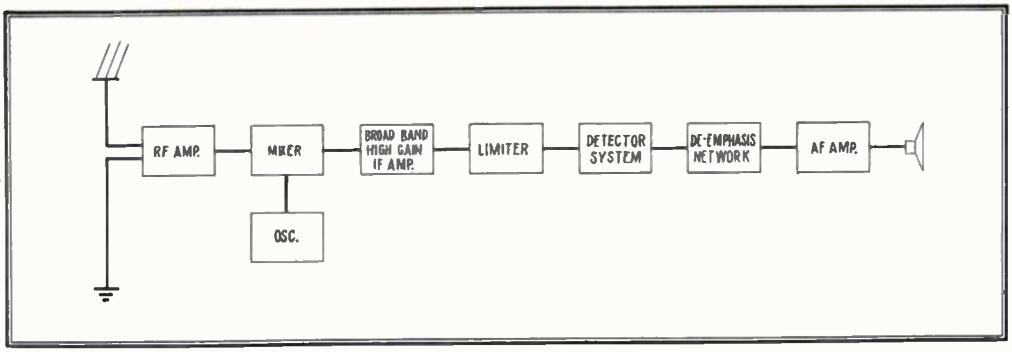


FIG. 3-B. ARRANGEMENT OF FM RECEIVER CIRCUIT IS ENTIRELY DIFFERENT FROM AM TYPE

Tuned Antenna System and RF Amplifier for FM ★ There are only a few fundamental differences in the RF amplifiers employed for FM and AM reception, and most of these differences are due to the frequencies at which the RF amplifier must operate. In the AM receiver, the tuned antenna circuit and RF amplifier are usually not required to amplify signals whose frequencies are above 30 mc., though in the case of communication receivers, signal frequencies as high as 100 mc. or more have been included in the all-wave type of receiver. As has been pointed out, the band of frequencies assigned by the FCC for FM broadcasting is from 42 to 50 mc., and these frequencies present some problems in amplification. The functions performed by the FM tuned antenna system and RF amplifier are three-fold. First, and foremost, this system should amplify the high frequencies as much as possible. Second, the selectivity of the RF amplifier should be such that image signals will be rejected. Third, signals picked up by the antenna at the intermediate frequency must not be allowed to pass through the RF amplifier and enter the IF channel. Otherwise interference would result.

The design of the FM tuned antenna circuit should be such that it allows a doublet antenna to be employed for picking up signals. A low impedance line connects the antenna system proper to the low-impedance primary winding of the tuned antenna circuit. The RF tube must be so chosen that it will satisfactorily amplify the required frequencies. If expense were no item, the acorn type of amplifier tube would probably be universally employed since its mutual conductance is relatively high, its input capacitance very low, and the RF resistance between grid and cathode at even 100 mc. is relatively high.

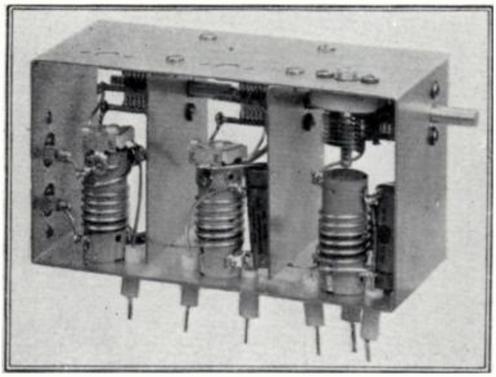


FIG. 4. ARRANGEMENT OF FM TUNING CIRCUIT

The mechanical layout of the RF amplifier must be made most carefully. While this is a design problem, fundamentally concerning the manufacturer, the service man should have an understanding of the problems involved, for this may save hours in service work on the high-frequency system.

For maximum performance, the leads between the coils, the tuning and trimming condensers, must be as short as possible. A direct ground wire between the coil and tuning condensers should be employed, for if the coil is grounded to one place on the chassis or metal structure, and the condenser is grounded to another point on the metal chassis, high-frequency chassis currents will be set up which may cause oscillation or degeneration, both of which are to be avoided.

Fig. 4 shows a very compact RF tuner in which each tuning condenser has both stator and rotor plates insulated from the chassis and has the coils associated with these tuning condensers so placed that the leads connecting them are very short. Partition shields are placed between the tuned antenna system, the RF amplifier, and the oscillator section which substantially eliminate any capacitance coupling from one tuned circuit to the next, and reduce to a large extent any magnetic coupling between coils. All grounding of the low-potential ends of the tuning circuits to the chassis is made at one point and all by-passing of + B leads, etc., is at a common ground point. At frequencies of 50 mc., the inductance of long leads on by-pass condensers may be appreciable, and service men should keep in mind that if it is necessary to replace a short-circuited or open by-pass condenser in the high-frequency portion of the FM receiver, the lead length of the condenser replacing the defective one should be about the same as that originally used, and the placement of the condenser must be as nearly as possible that of the original one.

The RF amplifier in an FM receiver is called upon to amplify a band of frequencies at least 75 kc. either side of the carrier frequency. Assume a station were operating on 43,000 kc. under a 100% modulation. The carrier of this station would swing between 42,925 and 43,075 kc., and these frequencies must be amplified by the RF system. There is a misconception that the RF amplifier cannot be made wide enough to pass this band of frequencies with equal amplitude. In practice, such is not the case, for with ordinary tuning circuits, even employing an acorn tube, the total Q of the tuned circuit with associated tube will be sufficiently small so that an overall RF amplifier selectivity curve will appear similar to that shown in Fig. 1. It will be noted that the top of this resonance curve is substantially flat for at least 200 kc. so that unless a material amount of regeneration is introduced in the RF circuit, its resonance curve will be sufficiently broad for frequency modulation reception. In passing, it also will be noted that the RF amplifier does not add a great deal of adjacent channel selectivity. This adjacent channel selectivity must be obtained in the IF amplifier. The RF selectivity curve is sufficient to give a very pronounced image rejection if a reasonably high intermediate frequency is employed, since adjacent channels for FM transmitters serving the same community are 400 kc. apart. This will be taken up in greater detail when the functions and performance of the IF amplifier is covered.

High Frequency Oscillator ★ As is well known, the operation of a superheterodyne type of receiver depends upon mixing the incoming signal frequencies with the frequencies generated in a suitable oscillator circuit. The function of the oscillator is then to impress an RF voltage on the mixer tube, whereupon if the RF amplifier impresses the signal frequency also on the mixer tube, the result will be four frequencies in the plate circuit of the mixer. These are as follows: (1) the sum of the oscillator and signal frequency, (2) the difference between the oscillator and signal frequency, (3) the oscillator frequency and (4) the signal frequency.

If the oscillator supplies a sufficient RF voltage to the mixer tube and if this frequency is constant at any setting of the oscillator tuning condenser, its function has been completely fulfilled. True, the difference between the oscillator and the signal frequency must be the intermediate frequency, and when the superheterodyne covers a band of frequencies, there is the problem of so designing oscillator and RF circuits that this difference, the IF frequency, is a constant over the band covered.

For the band of frequencies between 42 and 50 mc., it is not too difficult to have the output of the oscillator sufficiently constant over the band to meet practical requirements. However, the stability of oscillators at these frequencies presents some problems. Tuned circuits can be so designed that with changes in temperature, the change in capacitance of the condensers will be offset, from the standpoint of the frequency generated, by the change in inductance of the associated coils. However, the tube or section of tubes used to generate the high-frequency current will change its equivalent input capacitance considerably with temperature.

Various means have been taken to compensate for the frequency drift resulting from this change in tube capacitance. The design engineer can do a materially amount towards combatting this effect by using a very small inductance and a large capacitance in the oscillator circuit. Thus, a change in capacitance of a given quantity in the tube will result in less frequency change in the tuned circuit. Negative temperature co-efficient condensers have been employed, such as capacitors made up of bimetallic strips which change their capacitance with temperature. The fundamental difficulty with this type of system is that compensation is being made for a change in tube capacitance which will vary materially with different tubes. For instance, in the same type of tube, the change in capacitance due to

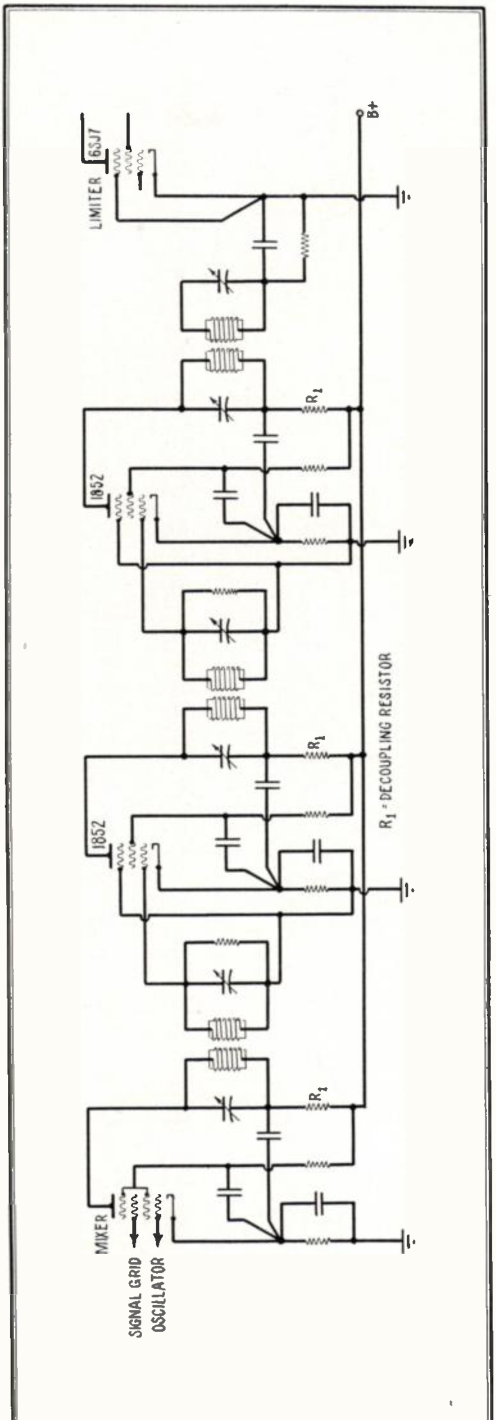


FIG. 5. TYPICAL 2-STAGE, HIGH-GAIN, BROADBAND IF AMPLIFIER FOR FM RECEIVING SET

temperature may be as large as five times, and therefore any compensating means is difficult. It would appear that much constructive work could be done by tube manufacturers in making available high-frequency oscillators with a relatively small input capacity change with temperature. This would practically solve the oscillator stability problems.

In FM receivers, the oscillator frequency may be made either higher or lower than the signal frequency, so that the resulting difference will produce the intermediate frequency. An oscillator can always be constructed so that with a given change in capacity (rotation of the tuning condenser) it will tune over a definite band of frequencies. Thus, the difference between the signal frequency and the oscillator frequency may be made exactly the intermediate frequency at two points (this is two-point tracking), and the difference between the two throughout the band will be approximately the intermediate frequency. This is true at least where the IF amplifier is of the broad-band type.

There is a slight advantage in operating the oscillator frequency below the signal frequency, because in general lower frequency oscillators are more stable. However, in this case, the tracking between the oscillator and the RF amplifier is not as good as if the oscillator frequency were higher than the signal frequency. Thus, a compromise is necessary, and some manufacturers have chosen to operate the oscillator higher in frequency while others operate the oscillator at a frequency lower than the signal. While this does not particularly concern the service man, he should know on which side of the signal frequency the oscillator was supposed to be set, for there is a possibility of aligning the RF amplifier to so change its frequency by means of the trimmer condensers that the oscillator would be changed to the low-frequency side of the signal, or vice-versa. However, in this case, the dial calibration would be in error by twice the intermediate frequency. This is usually an appreciable difference, as higher intermediate frequencies are used in FM receivers than in AM types.

The Mixer Tube ★ The function of the mixer tube is to produce the intermediate frequency by mixing the signal and the oscillator voltage. This is its only requirement. The efficiency of the mixer is dependent upon the conversion conductance, and the larger this factor the better the mixer, other things being equal. The mixer may be a separate tube or it may be combined with the oscillator. In the latter case, the oscillator voltage and the signal voltage are both impressed upon, and vary, a common electron stream. There are various types of mixer oscillators which may be employed at high frequencies. The 6K8 operates satisfactorily, as well as the 6SA7. The methods of coupling between the two voltages must not be such as to produce locking effects between the tuned RF system and the oscillator circuit. The locking effect manifests itself when alignment is being made. For instance, if a signal generator is connected to the input of the receiver, and the receiver is tuned to the signal of the generator, the adjustment of the RF trimmer condenser should not affect the receiver's oscillator frequency unless there is

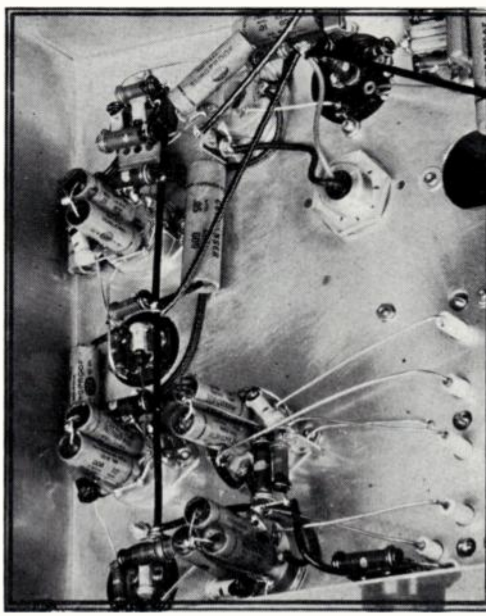


FIG. 6. ARRANGEMENT OF IF CIRCUITS FOR FM

reaction between these two circuits. If interaction occurs, it will be observed that after the RF trimmer has been adjusted for maximum response, changing the signal generator frequency slightly produces still greater gain, and in this case it is necessary to "rock" the signal generator while adjusting the RF trimmer. While this effect is primarily a design problem, abnormal locking effects might be caused from open by-pass condensers in the RF section.

The IF Channel ★ As has been pointed out, the IF channel in an FM receiver is materially different from the AM receiver. In the latter case, the band of frequencies passed by the IF amplifier is little more than 10 kc. wide, and the gain may be of the order of 6000 times. In the FM receiver, the IF channel should be approximately 150 kc. wide, the gain should be as high as possible, and the frequency chosen for the IF should be high, in order to obtain good image rejection ratios. The requirement of the broad-band in the IF channel is obvious as it must pass, with very little attenuation, the complete band of frequencies transmitted. A broad-band IF channel may be more readily obtained at high frequencies. However, as high gain is also a prerequisite, there are definite frequency limits with the present tubes. If too high a frequency is chosen for the IF channel, it will be very difficult to obtain high gain without regeneration. Furthermore, the design of the IF transformers in themselves present

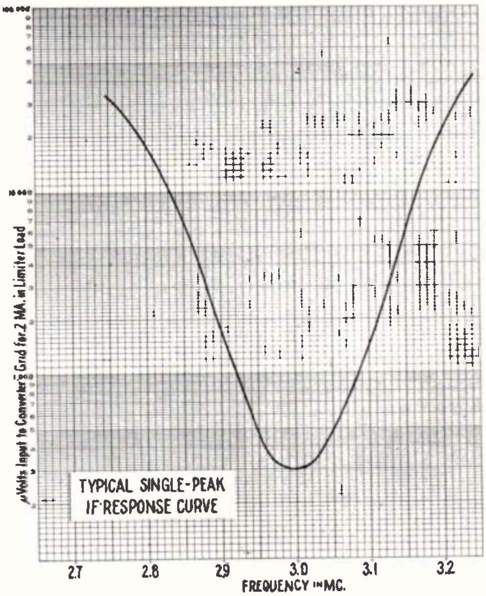


FIG. 7. FM BROAD-BAND IF RESPONSE CURVE

somewhat of a problem at frequencies about 5 mc. Thus, there is some compromise necessary, and most manufacturers have employed frequencies between 2 and 5 mc. With a 3-mc. IF channel, ample image rejection will be obtained, for the image frequency is higher or lower than the signal frequency by twice the intermediate frequency. If the receiver is tuned to 43.4 mc., the image frequency will be either 49.4 or 37.4 mc., depending upon whether the oscillator is operated above or below the signal. It will be noted by reference to Fig. 1 that ample image rejection is thus obtained in the RF amplifier.

High-gain is required because the higher the amplification in the IF amplifier, the better the signal-to-noise ratio which will be obtained in FM reception for, with a high-gain IF amplifier, the signal is sufficiently amplified so that the limiter operates satisfactorily with weak signals. When the limiter is properly saturated, even tube hiss generated in the receiver itself will be practically eliminated. This is not so with an IF amplifier used in amplitude-modulated receivers because, if the gain is made extremely high, the tube hiss is appreciable, and this produces noise.

With a two-stage broad-band IF amplifier employing 1852 tubes which have a mutual conductance of some 9000 micromhos, a total gain of more than 15,000 may be obtained. This gain is measured between the grid of the mixer and the input of the limiter tube, and does not even include the gain obtained in the limiter circuits, which may be appreciable at low signal levels. Stability of such an amplifier, shown in Fig. 5, is obtained by carefully by-passing plates and screens and employing decoupling resistors in the plate circuits of each tube. It will be noted that the by-passing is done to the cathode rather than to ground, and that the leads of the condensers are brought to a common cathode point. Further stability is obtained by mounting the by-pass condensers vertically at the base of the tube socket in such a position as to act as a shield between the grid and plate circuits of the tubes. This type of construction is shown in Fig. 6. Fig. 7 shows the selectivity curve of this particular IF amplifier.

It has already been pointed out that no AVC control is placed on the IF amplifier, for this would tend to reduce its gain and result in poor limiter action.

To eliminate what are termed as "fuzz" frequencies, the IF amplifier should be so loaded by resistors or other means so that the tuned circuits are relatively broad. As the FM transmitter is continually varying its frequency under modulation, any sharply tuned circuits in the IF amplifier would tend to sustain their oscillations at a definite frequency and this "hold-over" causes fuzziness in the sound emerging from the loud speaker. Thus, most IF amplifiers have resistors from 10,000 to 60,000 ohms placed across the tuned circuits, with the exception of the stage feeding the limiter which is automatically loaded by the tube.

Erroneous ideas have been prevalent as to what happens if the IF amplifier is too sharp in its frequency response characteristics. In an AM receiver, too sharp an IF amplifier causes attenuation of the high audio frequencies, resulting in poor quality. Such is not the case with frequency modulation. There is, in general, no loss in high frequencies due to too sharp an IF channel. The higher audio frequencies do require a greater frequency band width, but the noticeable effect of too narrow an IF channel is to compress the high-level audio modulation when the carrier deviation of the transmitter is greatest. Thus the effect is upon audio amplitude rather than tone.

May We Suggest to the
FM BROADCASTERS:

BEFORE any FM station can have a listening audience, people within the station's service area must buy FM-AM sets from the local dealers. That makes the station directly dependent for its own success upon the coöperation of the radio stores.

When dealers learn that an FM transmitter is projected for their territory, they ask immediately: "When will broadcasting start?" They want to sell the higher-priced FM-AM receivers as soon as there are programs to create public demand but: "When will that be?" They must know definitely, in advance, so they can schedule the purchase of sets.

Up to now, this has been the one piece of information they couldn't get. Or, if they were told, it didn't work out that way. Never mind why, or who was at fault. Consider the situation in Portland, Me.:

When it was announced that WGAN would have an FM transmitter, there was great enthusiasm among the dealers. Local publicity was most effective in creating public interest. An application had been filed with the FCC, and work would be started on the station shortly. Programs would be on the air soon. People who had been planning to buy AM sets decided to wait for the new FM-AM models. The dealers promised to get in the new sets, and made immediate inquiries of their jobbers.

But they didn't actually order FM-AM sets. No. When dealers buy merchandise, they have to know that they can sell it within a reasonable time. So the Portland dealers waited for definite word of FM programs. Meanwhile, their AM set business suffered. Each day's delay meant lost profits.

WGAN was doing business on its AM station as usual in the meantime, but the delay in its FM plans was hurting the dealers seriously. After a reasonable period, still with no definite date set for putting FM on the air, the dealers did the obvious thing: They told their customers that frequency modulation was a false alarm, and sold everyone away from it. If they hadn't, there might not be any radio stores in Portland now, for WGAN has *never* carried out its FM plans.

If and when it now sets a date to start FM broadcasting, the local dealers will simply say: "So what?" Radio listeners in Portland will say: "Well, my dealer told me that FM is the bunk."

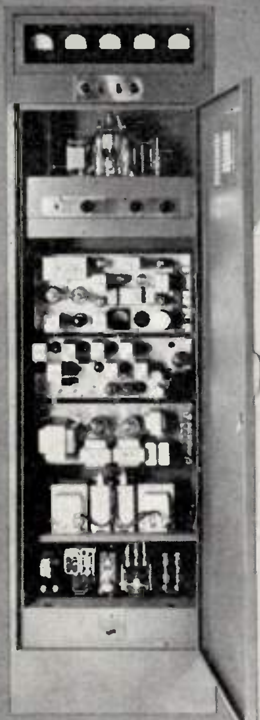
The above is not intended to be personal to WGAN. This is merely a specific case, typical to a greater or lesser degree of the treatment accorded dealers in many other cities. These situations add up to a very serious handicap to rapid FM progress.

MAY WE SUGGEST that the FM broadcasters can better serve their own interests by (1) giving dealers in their service areas definite information concerning the timing of their plans and (2) by saying as little as possible publicly about *what* they are going to do until they know *when* they will do it.

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

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

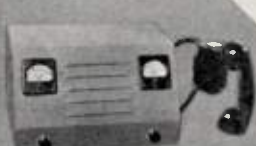
LINK

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 [illegible]

PILOT FM-AM COMBINATION IN A NEW YORK CITY RESIDENCE

To Be the Latest in Radio Receivers, It Must Have

PILOT FM-AM TUNING

THE ADDITION of FM broadcasting to AM service is as logical a step in radio progress as the addition of sound to motion pictures. True, people who wanted to sleep in the movies didn't welcome this innovation. Some theatre owners opposed it, because it required additional equipment. Certain producers resolutely hid their heads in the sand. Their names are forgotten now.

The most convincing arguments against talking pictures failed to consider one paramount factor: No one can withhold progress from the American people!

Only by adding FM broadcasting can present congestion be cleared up on AM bands. To that definite need are added FM's elimination of noise and static, and its truly magnificent quality of reproduction. The four Pilot FM-AM receivers deliver the finest entertainment afforded by both systems.

Pilot Radio's confidence in the immediate importance of FM is confirmed by the success of dealers who are merchandising Pilot FM-AM sets aggressively. *For further information, address:*

PILOT RADIO CORP., Long Island City, N.Y.

HEAR DOROTHY THOMPSON on PILOT'S SUNDAY NIGHT PROGRAM, at 8:45, on STATIONS W2XOR, WOR, W2XOJ, and WAAB

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