Blossom

FM

DECEMBER 1940

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

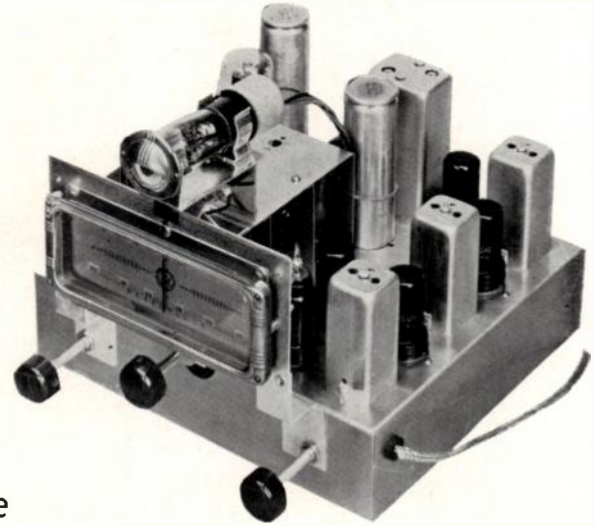
REG.U.S.PAT.OFF.

Give Your Customers

FM RECEPTION

At Whatever Prices They Want to Pay

You Can Do This with the



BROWNING FM TUNER

Use the Browning FM Tuner for:

1. The customer who has severe local interference, but can spend only a limited amount to overcome it. Sell him a Browning FM Tuner, and connect it to his present AM set.

2. The customer who wants FM's superior reproduction and static-less reception. Sell him a Browning FM Tuner, with an audio amplifier and speaker to suit his means.

3. The customer who wants a high-quality receiver built into a special furniture piece. Use the Browning FM Tuner and suitable audio equipment. This arrangement offers the greatest flexibility as to price and method of installation.

4. Clubs and public halls. The Browning FM Tuner, with the proper amplifier and speaker, is easy to use for permanent or rental jobs.

5. Public schools. FM opens the way to selling new installations or bringing old ones up to date. For FM reception at its best, use the Browning FM Tuner.

Here Are Its Special Advantages:

EXTRA receiving range, due to high sensitivity of tuned RF stage — EXTRA noise rejection, due to RF amplification — EXTRA ease of installation, because Tuner has its own built-in power supply — EXTRA ease of tuning, because indicator tube shows resonance exactly — EXTRA low cost, because the Browning FM Tuner can be purchased partly assembled, or as a finished chassis as illustrated, or mounted in a handsome table cabinet.

For EXTRA SALES, use frequency modulation, use your ingenuity, use the Browning FM Tuner.

WRITE FOR DETAILS AND NET PRICES

ORDERS SENT TO THE FACTORY WILL BE FILLED THROUGH YOUR LOCAL JOBBER

FM BROADCAST TRANSMITTING STATIONS

Inquiries are invited concerning the Browning FM modulation monitor, for reading instantaneous frequency swing

BROWNING LABORATORIES, Inc.

755 MAIN STREET • WINCHESTER, MASS.

WHAT THE FM BROADCASTERS HAVE TO SAY:

Statement by Franklin M. Doolittle, General Manager of WDRC and FM Station W1XPW

FREQUENCY modulation has now reached the point where it must pass the crucial test of public acceptance. With regular, commercial operation scheduled to begin January 1st, the final phase of the FM development will soon be with us. The advantages of the FM system are now conceded by practically all engineers; now what will be the public's reaction?

Those of us who have been close to FM for the past several years have no doubt as to its acceptance. We have had the opportunity of seeing, many, many times, the expression of amazement come over the face of a new FM listener when hearing true fidelity and noiseless reception for the first time. It has been felt by some that the public is not interested in high fidelity. The fact of the matter is that actual re-creation of the original studio programs has never before been available. Certain receivers which were presented as "high fidelity" had so much distortion and noise interference that the public refused to accept them. I have observed that as soon as there is a marked improvement in the sound reproduction art, a listener is never entirely satisfied with an inferior grade of sound reproduction which, formerly, might have seemed satisfactory. I believe that this fact will be important in FM's acceptance.

Naturally, we cannot expect that all radio users are going to purchase FM sets during 1941. However, I believe that there is a by no means inconsiderable portion of the radio audience that is interested in something better than has been available in the past. It is to this group that FM will make its first appeal.

It seems to me that each broadcaster entering FM should take advantage of the two-hour special programming required by the FCC regulations for the purpose of producing entertainment that will give new FM listeners the full benefit of FM's possibilities. High-grade programs produced with the full FM capabilities will be the best "salesman" for this improved method of transmission and reception. These programs should be musical or dramatic presentations produced in studios and with equipment which will really deliver 15,000 cycles with low-distortion audio output, and they should of course have high entertainment value in and of themselves. Stunt programs will not long suffice to hold listener interest, although they may be useful in connection with the initial demonstrations of FM to the public.

Radio dealers have been somewhat apathetic toward FM because, with the question of allocation unsettled and receiver production limited, there has doubtless been some interference with the sale of amplitude receivers. This time has now passed fortunately, and excellent FM receivers are in production, for which the FM broadcast stations must now create a demand, by superior public service.

NO. 1 COLUMNIST

NOW radio listeners can hear America's No. 1 columnist — not just that part of her voice that comes in by AM broadcasting and gets out through the constricted throats of midget speakers, but the voice which speaks into the studio microphone, animated by the personality of this Country's most widely read writer on national and international affairs.

The voice, of course, is Dorothy Thompson's, heard by FM on W2XOR New York, and W1XOJ Paxton. Her sponsor is Pilot Radio Corporation, the first radio manufacturer to make a program of such importance available to the FM audience.

Pilot Radio, in doing this, is to be congratulated on performing a service to radio listeners and to the dealers who, by their sales of FM sets, make these broadcasts possible.

In the first place, FM reception of women's voices is greatly superior to the reproduction afforded by AM. The contrast is really striking. Listeners say that when they hear Dorothy Thompson on FM, they are as conscious of the character traits conveyed by her voice as if she were right in the room.

In the second place, since this Pilot program is transmitted by AM also, there is the opportunity to make a direct comparison between the two systems of broadcasting. The marked difference is a matter of enjoyment and satisfaction to those who have bought FM-AM receivers.

FM

THE COMPLETE AND AUTHORITATIVE SOURCE OF INFORMATION ON FREQUENCY MODULATION

VOL. 1 DECEMBER, 1940 NO. 2

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M. B. SLEEPER, *Editor*
F. A. SKELTON, *Publisher*

Published by: *FM* COMPANY

Publication Office: South Norwalk, Conn. Tel. Norwalk 5112

Editorial and Advertising Office: 41 Washington Street, Newton, Mass. Tel. Lassell 0808

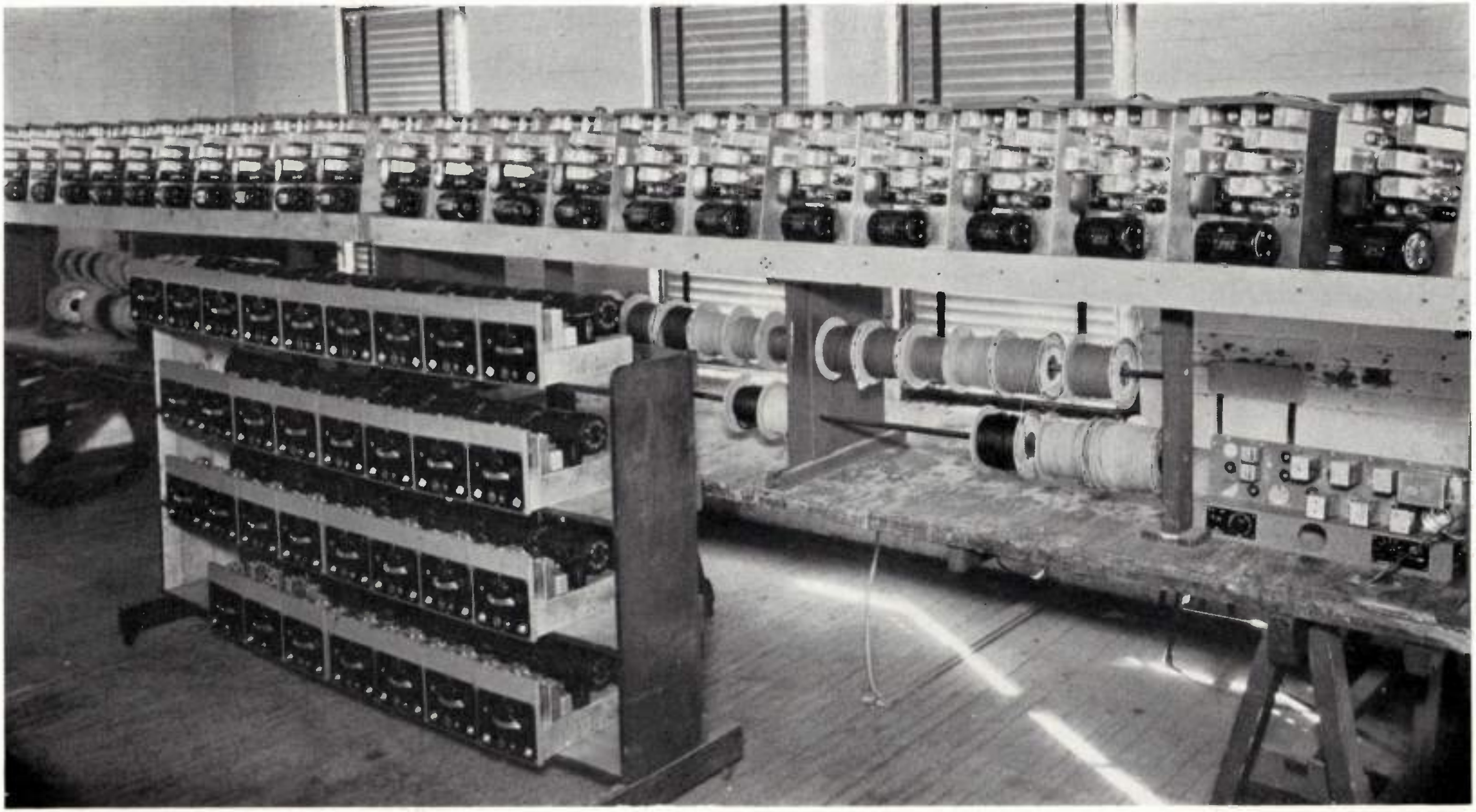
FM Magazine is issued on the 10th of each month. Single copies 25¢ — Yearly subscription in the U.S.A. and foreign countries $3.00. Subscriptions should be sent to the publication office, at South Norwalk, Conn. Make checks or money orders payable to: *FM* Company.

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

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

FM MAGAZINE IS SOLD BY SUBSCRIPTION ONLY

LAST-MINUTE FCC NEWS IS REPORTED ON PAGE 48



FM PRODUCTION SPEED-UP

BY STANDARDIZING FM TRANSMITTER AND RECEIVER DESIGNS, RADIO ENGINEERING LABORATORIES, LONG ISLAND CITY, N. Y., HAVE SPEEDED UP QUANTITY PRODUCTION OF SETS FOR MUNICIPAL AND STATE POLICE, AND FOR U. S. GOVERNMENT DEPARTMENTS

PAUL A. DE MARS, LEFT, AND JOHN SHEPARD, 3RD, ENJOYED THE EXCITEMENT THEY CREATED AMONG THE ADVERTISING MANAGERS AND AGENCY EXECUTIVES BY THEIR DEMONSTRATION OF FM RECEPTION

FM AMAZES ADVERTISING MEN

Record Attendance at Boston Ad Club Applauds Paxton FM Transmission as Improved Medium of Radio Broadcast Advertising

ON October 22nd, at a Boston Advertising Club luncheon given in honor of John Shepard, 3rd, nearly 400 advertising managers and agency executives listened without moving or speaking during a demonstration of FM from Paxton. Not only that — they burst into applause when Clotilda Zappala, at the other end of the 90-mile FM circuit, finished singing Delibe's Bell Song!

When such a group of hard-boiled radio critics, accustomed to asking, "So what?" in response to the most enthusiastic proponent of a new idea, applaud anything coming from a loudspeaker, it has to be a very extraordinary performance indeed. There is no doubt but that many a consultation has followed this first formal introduction of FM to advertising executives, in which the question has been asked: "What changes will FM bring to the technique of radio broadcasting?" Certainly this demonstration left no doubt in any listener's mind that FM now, having reached the state of commercial perfection, performs a service distinctly superior to that of AM broadcasting.

When the demonstration was over, and John Shepard, 3rd, had modestly accepted the ad men's sincere applause, some of the more technically-minded members went up to see just what kind of special equipment had been used. Expecting that the Yankee Network engineers had gone overboard in setting up some kind of super receiver that would be far beyond the means of the average home listener, they were almost disappointed at its simplicity. The receiver itself was just one of the new G.E. table model tuners, connected to a small amplifier unit, and a big Waite speaker, required to fill the enormous Georgian Room of the Statler Hotel.

As many a radio man knows, this is one of the world's worst spots to demonstrate radio reception, even from the nearby Boston stations. But here was the simplest, most elementary rig, bringing in an actual reproduction of the original studio program with nothing added by way of noise or distortion, and nothing omitted through failure to transmit or receive the full audio range.

The announcement that John Shepard, 3rd, would be the guest of honor, and that he would provide a demonstration of FM reception, brought the largest attendance on record at a Boston Advertising Club luncheon. Many of the executives displayed the curiosity of people seeing television for the first time — but with this significant difference: Those who came to hear FM, went away with the certain knowledge that this was not a scientific curiosity, but a newly perfected service now available to the public, in the form of an important improvement for which an immediate need already exists. Certainly, everyone who attended the luncheon was impressed with the conviction that FM provides a great advancement as a medium of advertising, as well as of home entertainment.

The first speaker was Linus Travers, vice president in charge of sales and production for the Yankee Network. He, in turn, introduced Paul A. de Mars, Yankee's chief engineer, who conducted the demonstration from Paxton. The script followed the lines of the text published in *FM* Magazine for November, 1940, and included the use of the Magic Piano. In this case, a piano was set up at one end of the dining room. A spotlight was put on the floor, so that the shadow of the pianist was thrown up on the wall where it could be seen by those at the opposite end. When he stopped playing, and the music continued without interruption, people began to stand up to see what was taking place. A buzz of conversation went through the room, particularly noticeable because the audience had been so completely silent and attentive throughout the demonstration. Then people were heard to remark: "Why, you can't tell when you're hearing the piano on the stage or the studio piano coming from the loudspeaker!"

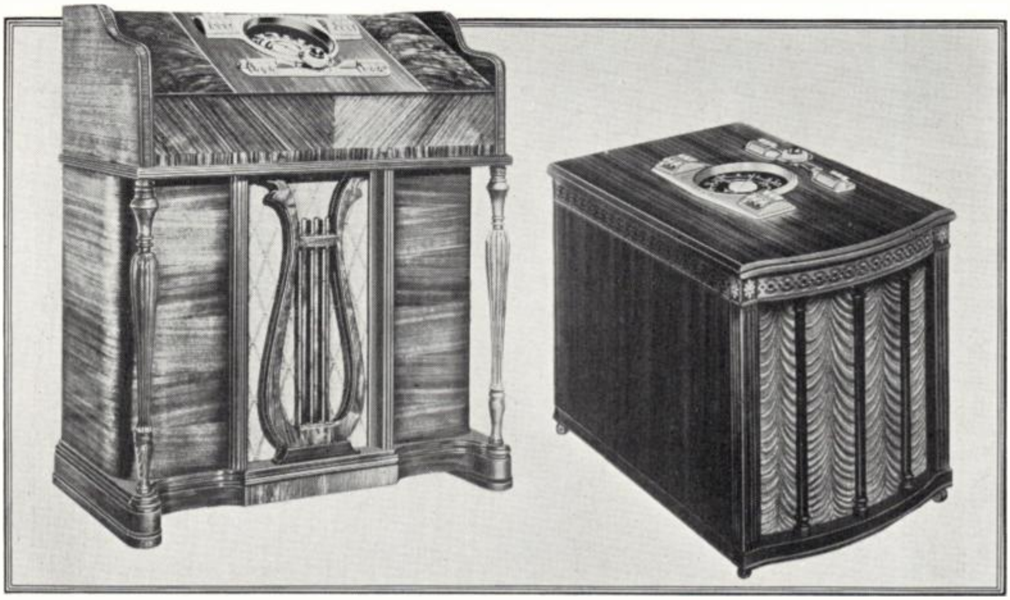
This was indeed, the final and convincing evidence of FM's true and perfect reproduction at the loudspeaker of what goes into the studio microphone.

Then, John Shepard, 3rd, spoke briefly about the possibilities of this new service. It was probably the shortest speech ever made by a guest of honor at such an occasion. It was not necessary for him to say more, because FM had spoken so effectively for itself.

Among those who displayed particular interest in the FM demonstration were Craig Smith of Gillette, Prof. Ross Cunningham head of market research at M.I.T., George Chatfield of Lever Bros., E. C. Favorite of Atlantic Refining, John C. Nicodemus of Kennedy's, Arthur Rogrow of Sears Roebuck, Philip McAtear vice president of the Advertising Federation of America, Herbert C. Claridge of Salada Tea, Ray Ilg of National Shawmut Bank, and Wright of Young and Rubicon.

Unquestionably, this demonstration will have repercussions throughout the entire structure of radio advertising. As another "first" for the Yankee Network, it gave an important impetus to the already fast-growing recognition of FM as a potential answer to many of the problems which have been accumulating in the minds of those who are responsible for the economic and engineering problems of radio broadcasting.

AT THE SPEAKERS' TABLE, L. TO R. JOHN SHEPARD, 3RD, JOHN C. NICODEMUS, V.P. OF THE AD CLUB — LINUS TRAVERS, V.P. OF YANKEE NETWORK — GEORGE CUMMINGS, SOCONY VACUUM — ARTHUR ROGROW, SEARS ROEBUCK — CRAIG SMITH, GILLETTE SAFETY RAZOR



ZENITH IS THE FIRST ARMSTRONG LICENSEE AMONG THE "BIG THREE" RADIO MANUFACTURERS

ZENITH DELIVERS TWO FM MODELS

E. J. McDonald, Jr., Confirms Confidence in FM by Putting Sets into Production

ZENITH dealers who have been non-committal about their FM sales plans now have the green light from Chicago headquarters. Ever since Commander McDonald's FM transmitter, the first to operate in that city, went on the air, there has been much speculation in the trade as to the attitude he would take toward FM.

From his statement in *FM* Magazine for November, it appeared that he is as bullish on FM as he has been bearish about television. Now, Zenith has put two FM-AM models into production and is making deliveries to dealers in areas where the new transmission is available.

Prices ★ The models illustrated here employ two distinct types of cabinet designs, using the same chassis and speaker. Model 10-H-571, with a cabinet suggesting the design of the spinet piano, carries a list price of $139.50. Model 10-H-551, in a chairside cabinet, lists at $129.50.

These models, it should be noted, represent a considerable step up from the list prices of the most popular Zenith AM models, in line with the pronounced tendency to use FM for raising the average unit of sale.

Tuning ★ The chassis used in both cabinets covers the following tuning bands: broadcast 540–1600 kc., short-wave 1.5–5.2 and 5.7—18.5 mc., and FM 41.5 to 50.5 mc. In addition to manual tuning on all four bands, there are 6 automatic buttons for AM and 5 automatic buttons for FM. These are not mechanical controls, but operate tuned electrical circuits. Two-gang condenser tuning is used for manual adjustment.

Tubes ★ There are ten tubes, performing the following functions:

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

The specifications describe the two 7C7 tubes as being used in a "double limiter," designed for extra effectiveness in suppressing noise. No further details are given, however.

Output ★ The power output is rated at 6.5 watts, fed to a 12-in. speaker. A high-frequency diffusing deflector is built into the apex of the speaker, for the purpose of correcting the tendency of the higher audio frequencies to travel in a narrow beam.

QAVC ★ Interstation noise suppression is provided for FM reception. Dealers are finding

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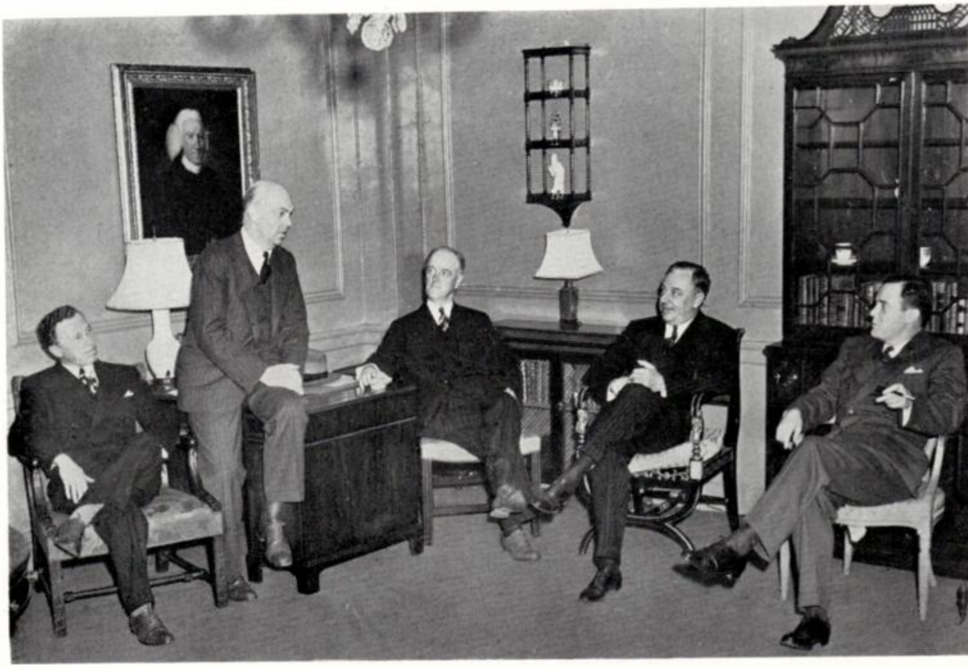


G.E. EXECUTIVES MEET NO. 1 FM SALESMAN AT SHOWING OF MUSAPHONIC MODELS. LEFT TO RIGHT: CARL SNYDER, ASST. TO MANAGER, A & M DEPT. — MAJOR ARMSTRONG — H. H. BARNES, COMMERCIAL V. P. — GEORGE CHAPMAN, ASST. TO MANAGER, A & M DEPT. — AND P. D. REED, CHAIRMAN OF G.E. BOARD

G.E. FM General Electric's New Musaphonic Line Will Go Direct to Appointed Dealers Only—Full Protection—No Sales to Employees

THE first of the significant changes in radio merchandising by the major companies, reflecting the potent influence of frequency modulation, has been announced by the General Electric Company. From Bridgeport, Conn., comes word of the newly created Musaphonic Division of G.E.'s Radio and Television Department, with F. A. Ray as manager.

The Musaphonic Division will handle a special line of concert-quality radios and combinations not available through established G.E. distributors. Instead, Musaphonic instruments will be sold and invoiced directly to a selected group of dealers capable of displaying and selling this class of merchandise.

In the main, these will be specialty music shops, department stores, interior decorators, and stores handling the higher grades of furniture. Both the design and the merchandising of this new line represent a long-planned activity of G.E.'s radio department. The sales staff is a specially-picked group, able to give the necessary cooperation and assistance to these non-radio outlets. In fact, F. A. Ray says that his men are prepared to show Musaphonic dealers how to install chassis in special furniture pieces, or those already owned by customers, when this is necessary.

For the present, promotion efforts will not extend west of the Mississippi. A tentative line-up of dealerships shows, for example, four in New York City, one in Newark and Baltimore, two in Washington, D. C., Detroit, and Cleveland, three in Boston and Chicago. Price competition will not be a factor in this picture, since the dealers who can qualify for Musaphonic will not be of the kind to engage in such practices.

Leading piano and musical houses will be prominent in the line-up of Musaphonic dealers. In the past, many of these houses have shied away from radio because of earlier, unfortunate experiences. They have taken the stand that they can get into so much controversy with a customer over a $24.95 radio as to lose him as a prospect for a $1,000 piano. Human nature being what it is, people impatiently return cheap radios for refund, but when they buy expensive phonograph combinations or pianos they are willing to give the dealer all the time he needs for making adjustments after delivery!

Both as to the radio chassis and the cabinets, G.E. designers worked without the restrictions and limitations imposed by popular price brackets or mass assembly methods. In the first three Musaphonic models, and in others to be released later, the plan is to produce the finest instrument possible for each type of use. Even the small 6-tube set, intended as a personal or bedside radio, is a real precision job electrically and mechanically. The cabinet is a Chippendale chest with doors, and measures 11 ins. high, 17 ins. wide, and 11½ ins. deep, finished in mahogany, walnut, or champagne. The list price is about $50.

Next comes model 60, a 50-watt, 11-tube instrument with a 3-band AM chassis, a record-player carrying 15 records of mixed sizes, and a home-recording device. The output feeds two speakers. The cabinet is authentic Chippendale, manufactured by the Baker Furniture Company, of Grand Rapids, a firm famous for fine reproductions of museum pieces. Dimensions are 37 ins. high, 39 ins. wide, 20 ins. deep. This set is priced at $375 to $475, depending on the finish.

The loveliest of all in the Musaphonic line is the model 80, similar electrically to model 60, but with 20 tubes, and FM tuning. This instrument is illustrated here. The performance of this set on FM is truly startling. Added to the wide audio response are the 50 watts of power to convey full dynamic range from a violin solo up to an orchestral crescendo.

The cabinet is Sheraton at its best. In fact, F. A. Ray pointed out that, because such furniture will be treasured by succeeding generations, the cabinets may well house a succession of radio chassis, and that the Musaphonic Division will make future plans accordingly. The dimensions are 37 ins. high, 43½ ins. wide, 20½ ins. deep. Prices range from $595 to $675.

It is interesting to note that the Musaphonic models fall into the general price classifications predicted for the next year by *FM* Magazine. From $50 for an AM table model there is a jump to $375 to $475 for the AM radio-phonograph, and the next step is the $595 to $695 FM-AM combination.

Because price stability is so essential in handling this class of merchandise, G.E. will not permit its purchase by Company employees. That is an essential restriction, for the whole set-up of appointed dealers could be destroyed if they were not given that protection.

It is expected that the Musaphonic dealerships will be taken up as rapidly as set production can be stepped up. There is a considerable number of radio dealers who can merchandise this type of receivers, and there are many stores, not handling radio at present, who can make a success of such a proposition.

G.E. MUSAPHONIC MODEL 80, COSTING $595 TO $675. 50-WATT OUTPUT DRIVES 2 SPEAKERS. HAS FM TUNING AND ALL-WAVE AM, 15-RECORD MIXED PLAYER AND RECORDER. CABINET IS MAGNIFICENT PIECE PRODUCED BY BAKER FURNITURE COMPANY, OF GRAND RAPIDS

MODEL JFM-165, OF REGULAR G.E. LINE, IS 3-BAND, 7-TUBE AM SET, PLUS 9-TUBE FM TUNER

FM CAUSING PRICE-GROUP SHIFTS

Have-Nots Crowded into Low Brackets—Haves Are Up in Profit Levels—Few Models in Intermediate Price Group

DEALERS in areas where FM transmission is on the air are already feeling that something is going on to influence retail set sales. Those who are smart enough to be realistic, admit that FM publicity, advertising, and broadcast announcements are beginning to have their effect on prospective set purchasers.

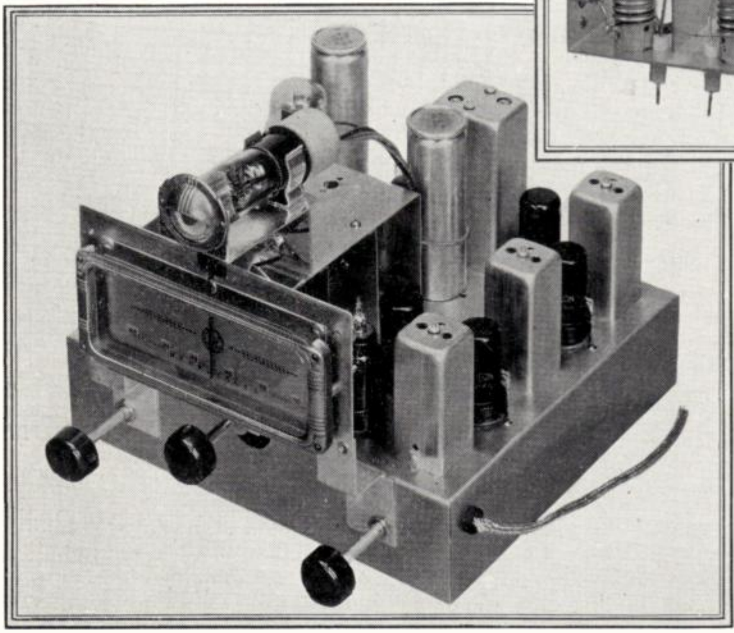
Set manufacturers, ever feeling for the pulse of buying trends, already recognize the advance signs of a change in price-group buying by a now FM-conscious public. It's definitely in the air. Those who can tune in on the signals read the advance dope in these terms:

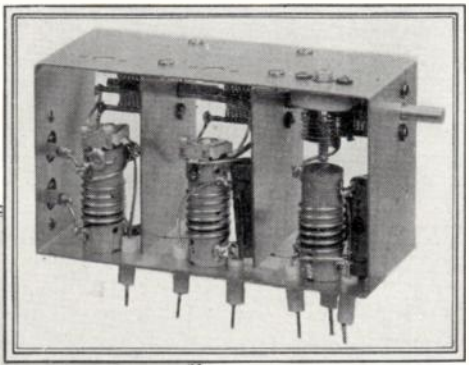
From now until after Christmas, set purchases will be divided in this way: (1) Sales of cheap AM sets, $9.95 to $19.95, will hold their own. These will be bought more for gifts, rather than for personal use, because (2) people buying sets for their own homes are giving very serious consideration to the static-less, squeal-free, tone realism of FM sets. Even though they have not had a chance to investigate FM, they know enough about it to defer investment in more expensive sets until they can get the low-down on FM. Others, a little better informed (3), can be sold high-quality AM receivers, particularly phonograph combinations, if they are assured that the audio end will handle FM quality from an adapter, to be added later. And quite a few (4) will step out and settle their reception problems, once and for all, by purchasing FM-AM sets between now and the end of the year. A substantial part of those sets will have automatic phonographs, also.

Meanwhile, some dealers are holding down their stocks of the more expensive sets, and just treading water until they see what happens. That is conservatism without profit. Others are taking advantage of their slower-moving competitors, and are pushing high-priced FM receivers right now, so as to become well established in this field, and thoroughly experienced with FM's individual sales and installation problems. Many dealers have done much in this direction already.

R. H. MACY DISPLAYS STROMBERG-CARLSON, FREED-EISEMANN, GENERAL ELECTRIC SETS

BELOW: ASSEMBLED CHASSIS OF BROWNING FM CONVERTER, AC-OPERATED, FOR USE IN SPECIAL CABINETS. HIGHLY EFFICIENT AS AN FM TUNER, IT CAN BE USED WITH A STANDARD BROADCAST SET, OR WITH A HIGH QUALITY AMPLIFIER AND SEPARATE SPEAKER





ABOVE: SERVICE MEN AND SKILLED SET-BUILDERS ARE USING THIS TUNING UNIT FOR FM SETS OF THEIR OWN DESIGNS. CONDENSER IS INSULATED TO ELIMINATE CHASSIS CURRENTS, FOR HIGHER STABILITY AND INCREASED GAIN

FOR SET BUILDERS

Active Market For Converters Among Tone-Minded Owners of Combinations

THE fall season is bringing new business to enterprising servicemen and set-builders in the service area of the FM transmitters where, right now, there is a market for converters to be connected to standard broadcast receivers and phonograph combinations. Anyone who has purchased an instrument capable of high-quality reproduction within the last year or two is a prospect and their number is legion.

To be more specific: In the state of Wisconsin there are approximately 700,000 homes with one or more radio sets. The FM transmitter operated by the Milwaukee Journal reaches 60% of these homes, or 420,000 families.

Zenith is stepping up the power of their Chicago transmitter so as to cover 25,000 square miles, occupied by 4,500,000 people. In Hartford, Conn., where the per capita income is said to be the highest in the U. S. A., it is possible to receive four FM transmitters easily. These are at Avon Mountain, Meriden Mountain, Springfield, and Paxton. If the antenna is a properly-installed di-pole, Alpine and Worcester come in clearly. The first two of these stations, now operating on 1 kw., will be increased to 50 kw. shortly, and WTHT is preparing to put an FM transmitter on the air. This will give the people of Hartford better FM service than they now have from AM stations!

This is just a sample of the market which the FM broadcasters have created for those who go after the installation and sale of FM converters. The prospects include those who have serious interference on AM channels, those who want to bring their radios up to date, or who are particularly interested in music appreciation. To the last group, the extra enjoyment of the Philharmonic Concerts, transmitted from Alpine on Sunday afternoons, means enough to warrant the expense of a converter!

The first step for the serviceman or set-builder is to assemble or buy one of these instruments, so that he can become thoroughly familiar with its operation and use. First-hand knowledge of the difference between FM and AM reception, both of direct studio broad-

(CONCLUDED ON PAGE 33)

RED LIGHT AHEAD

Tendency to Use Radio for News, Records for Music, Is Threat to Future of Radio As Advertising Medium—By M. B. Sleeper

THERE is a definite and growing tendency toward turning on radio receivers only during news programs, and playing phonograph records for musical entertainment.

Reason ★ There is a specific reason why this is so, and it constitutes a serious threat to the future of the radio broadcast industry. Right now, reflecting the new public listening habits, there are signs which indicate that radio receivers may become mere adjuncts to electric phonographs.

Stated briefly, the reason is just this: By consistently raising program standards, broadcasters have developed a national appreciation of good programs and a public demand for improved quality of reception. Concurrently, radio manufacturers have lowered their standards of performance in order to engage in price competition.

When listeners were brought to the point of enjoying good music, they then became critical of its reception by their radio sets. Oblivious to this, the manufacturers, instead of building better receivers, devoted themselves to building cheaper ones. As a result, probably 90% of the radio sets produced and purchased in 1940 are (1) over-responsive to man-made and natural static, (2) unable to pick up stations, other than powerful locals, with enough strength to knock down the background noise, (3) unable to separate stations, (4) unable to give clear reception of enough stations to give listeners an adequate selection of programs, (5) unable to clear up whistles and squeals, and they are (6) unable to give acceptable reproduction of the original studio programs even from such stations as do come in free of interference.

Result ★ The one thing that radio provides, for which there is no equivalent, is the news programs. Even though the quality of speech is not particularly good, it is probably on a par with the telephone, to the use of which we are all conditioned.

But that is not satisfactory for the other types of programs, dramatic, instrumental, or vocal. Not any more. Such non-critical audience as accepts the accompaniment of buzzing, crackles, squeals, and garbling to its reception isn't important to sponsors.

People who want good musical programs are buying phonograph combinations, turntable attachments, or plain record players. So many people are doing this that, during the past two years, record sales have climbed at an unbelievable rate.

Why? Because they want to buy their music instead of getting it free, by radio? No, it's because they want music of enjoyable quality, free from distracting noises. Thus, millions of listener-hours per day are now lost to radio programs and their sponsors, for the radio goes off when the phonograph is turned on.

Background of Listening Habits ★ Let's go back a few years, and trace the path of listening habits. Before radio broadcasting, most of us heard very little music other than that from the church organ or the home piano, generally played as an accompaniment to singing.

We became acquainted with the phonograph, and enjoyed it because it introduced a new kind of entertainment. Millions of us heard Harry Lauder and Caruso in that way who never could hear them in person. We listened uncritically because we could not compare the reproduction with the original. We even found the very mechanical performance of the player piano entirely acceptable for the same reason.

Then came radio and earphones. It wasn't a very sociable way to listen, but the novelty was enthralling, and the gamble of finding a better spot on the crystal that would bring in a new station made it a sort of game. As soon as we identified one station, we were ready to hunt for another. The call letters were more important than the programs.

Programs were pretty dreadful when loudspeakers made their first appearance. Magnavox was a descriptive but not flattering name in those days! But we were grateful to the stations for whatever they put on the air. No one was trying to sell us things.

The Console Era ★ In the latter part of the Extravagant Twenties, two things happened. Stations began to sell time and to buy talent. We began to refer to radio respectfully as an advertising medium! Simultaneously, table model sets grew up to be consoles with built-in speakers, and their voices changed, for engineers hired away from Western Electric showed the manufacturers how to design amplifiers.

Broadcast advertising began to startle its own proponents with fast-action results, sponsors got into competition for listeners' attention, agents with checks in their hands and contracts in their pockets called on big-name talent. Phonographs were forgotten and the rubber bellows in the player pianos dried out.

School children developed likes and dislikes for orchestras and artists, and ambitions to play musical instruments, or to sing. Courses in music appreciation were created in high schools and colleges. Civic organizations took up the discussion of radio programs, found faults and made suggestions. CBS made a deal to broadcast the New York Philharmonic's Sunday concerts. NBC went overboard and engaged Toscanini for a series of concerts — thus registering the high-water mark of musical entertainment by radio.

Today, the average American is more music-conscious than the citizens of any other nation. This is radio's cultural contribution to our country. Yes, we have become keenly music-conscious, and critically so.

Short-Circuit ★ That is one side of the story, the broadcasting end. It is a most commendable record for the art, the broadcasters, and the sponsors — as far as it goes. But let's look at the other side, the receiving end of the radio circuit.

About the beginning of the Era of the Empty Penthouses, somebody came out of the West with a radio set shrunken to about the same ratio as the average bank balance of that period. It was called the Mantel Radio. Atwater Kent took one look at it, labelled it a threat to the future of the industry, and closed up the finest radio factory in the world.

Today, the original mantel radio would be considered large and expensive, for radios have grown smaller and cheaper in inverse proportion to the national debt. Most of the sets produced in 1940 can share with a reading lamp the top of a bedside table, leaving room to spare for an ashtray. Fine AM receivers are still produced, but they are notable exceptions, and represent a negligible quantity in comparison to the 9,000,000 sets sold last year.

If this account of radio receiver development were a record of improvement in the ability of the sets to reproduce at the loudspeakers the speech and music delivered to the studio microphones, the rest of the story would be quite different. The sad truth is that the introduction of the mantel radio was a short-circuit on the line of radio progress for, since then, what has been sold to the public as improvement has been, in reality, lower prices achieved at the expense of entertainment value.

What the Sponsor Buys ★ How is it possible that such retrogression has been unobserved by sponsors and advertising agencies? Well, let's look at that situation.

You can't see a radio advertisement. You can't take it in your hand and look at it through the eyes of the audience because they can't see it, either. It has to be heard.

The preliminary to sponsoring a radio program is an audition. The larger agencies have audition rooms fitted with comfortable chairs and loudspeakers connected by wires to the local broadcast studios. They have found that it distracts the auditor's attention if he can see the artists, and they want him to hear the proposed program just as if he were listening by radio in his own home.

The sponsor buys what he hears coming in over wires, from equipment probably installed by the broadcast station's engineers. It is as perfect as engineering skill can make it. After the program is put on the air, the company executives who are responsible for its production are very liable to be right at the studio during each performance. They hear the program from the stage or the front row center, or through the control room speaker. What they hear is eminently satisfactory.

What the Sponsor Gets ★ That's a different story. What the sponsor gets is what comes out of the loudspeakers in the millions of homes he wants to reach. If the company executives could hear a composite of their program as it emanates from the radios which comprise the major portion of present-day set production, they would marvel that people listen to their programs at all.

Furthermore, they would stop listening to the program at the studio. Instead, they would buy themselves some sets of average quality, and stay at home to hear their orchestras and artists as they are heard in the homes of the average listeners. If they did, a lot of things would begin to happen in advertising agencies and broadcast stations — fast!

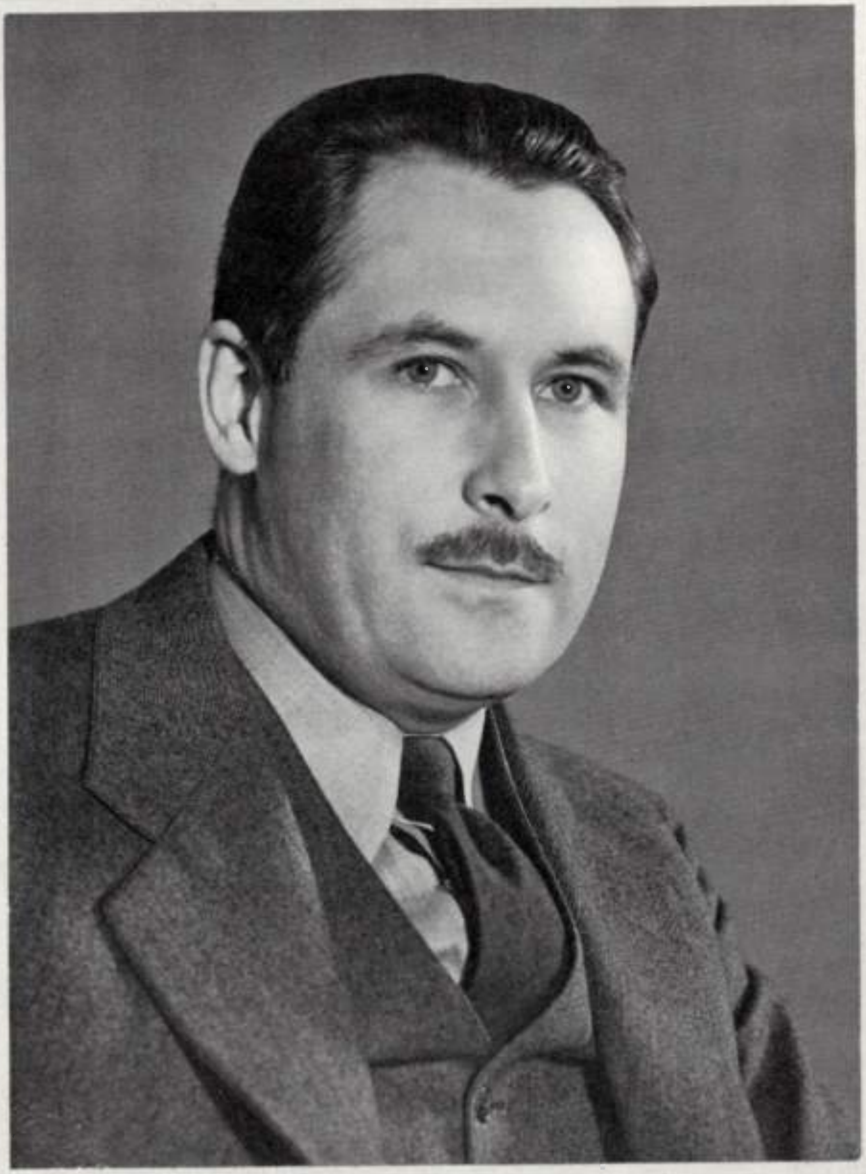
New Competition for Listeners' Time ★ The development of radio broadcasting is now disclosing itself as a sadly lopsided affair. Sponsors, agencies, and stations, concentrating their attention on what they put into the air, lose sight of the fact that no program is better than the radio set that reproduces it.

Thus, over a period of years, while they built a national radio audience, developed its appreciation of fine programs, and encouraged faculties of critical selection, the failure of the set manufacturers to keep pace by improving the quality of home radio reception has opened the door to competition for listeners' time and attention, and for changes in listening habits.

FM Can Reverse the Tide ★ The groundwork for these adverse listening habits has been laid slowly but certainly over a period of years. They might have continued to grow until they reached serious proportions for, if they were recognized, there seemed to be nothing to do about the situation. It was too late to do anything about it with the means at hand.

At least, that was the case until Major Arm-

(CONCLUDED ON PAGE 47)



ARTHUR C. ANSLEY

THE ADVENT OF FREQUENCY MODULATION IS ENABLING ARTHUR ANSLEY TO EXTEND HIS POLICY OF BUILDING RADIO RECEIVERS AND COMBINATIONS AS MUSICAL INSTRUMENTS, TO BE SOLD AS SUCH. HIS IDEAS CONCERNING FM FOR THE IMMEDIATE FUTURE ARE OUTLINED HERE:

THE MANUFACTURERS SAY:

A Statement by Arthur C. Ansley, President of Ansley Radio Corporation, New York City

I HAVE just returned from a trip covering most of the east and middlewest. In all of the cities where frequency modulation is already on the air, or is about to go into operation, I found our dealers enthusiastic about the prospect of sales of FM receivers. They are ready and anxious to do their share toward bringing to the attention of the public the advantages and possibilities of FM reception.

Quality Combinations to Have FM

They seem to feel that at least half of their sales of the larger radios and radio phonograph combinations will be with the FM feature. One even went so far as to say that, in his opinion, all sets above $150 would have to be FM combinations, although he is probably somewhat too optimistic.

Conversations with retail customers on the dealers' floors would lead me to believe that the one-half figure is about right. Although much educational work is yet to be done as far as the general public is concerned, most people know about the new "static-less" broadcasting and are anxious to hear it and quick to appreciate the vastly superior tone and absence of noise.

FM Sets Are Musical Instrument Merchandise

Our particular group of dealers is keenly responsive to the new merchandising features afforded by FM reception, since it is made up of stores patronized largely by people who are genuinely interested in fine music. In fact, the FM set-up is ideal for dealers who handle musical instruments, pianos, and phonograph records. They know how to sell music, and they can discuss this subject interestingly. Moreover, they are accustomed to handling larger units of sales, and prefer to sell more expensive merchandise of fine quality, rather than a greater quantity of cheap merchandise.

Such concerns are generally long-established houses who know, from years of experience, what so many radio dealers have not yet learned: that there is far more profit in a few high-priced sales than in the same dollar-volume of small-unit sales where the price competition is as keen as it is on cheap sets.

Selling Adapters Correctly

One obstacle that the dealer has to overcome is the idea that many people have, to the effect that FM is simply an attachment that can be added to a set, thus bringing about the millennium of perfect reception. Manufacturers can help to overcome this idea by emphasizing the fact that it takes a good audio system and a good speaker to realize the advantages offered by FM. The public will have to be educated away from the idea of $9.95 radios that has been so firmly implanted in their minds by much of the deplorable advertising of the past (or is it past?).

To a person who is not quite ready to spend the money for a good FM set, it is a big inducement if the dealer can assure him that the FM tuner can be built into his set at a reasonable price at a later date. We believe that this is a highly important sales feature, and we are building our sets with audio systems that will do justice to the FM when it is added.

Americans Now Music-Minded

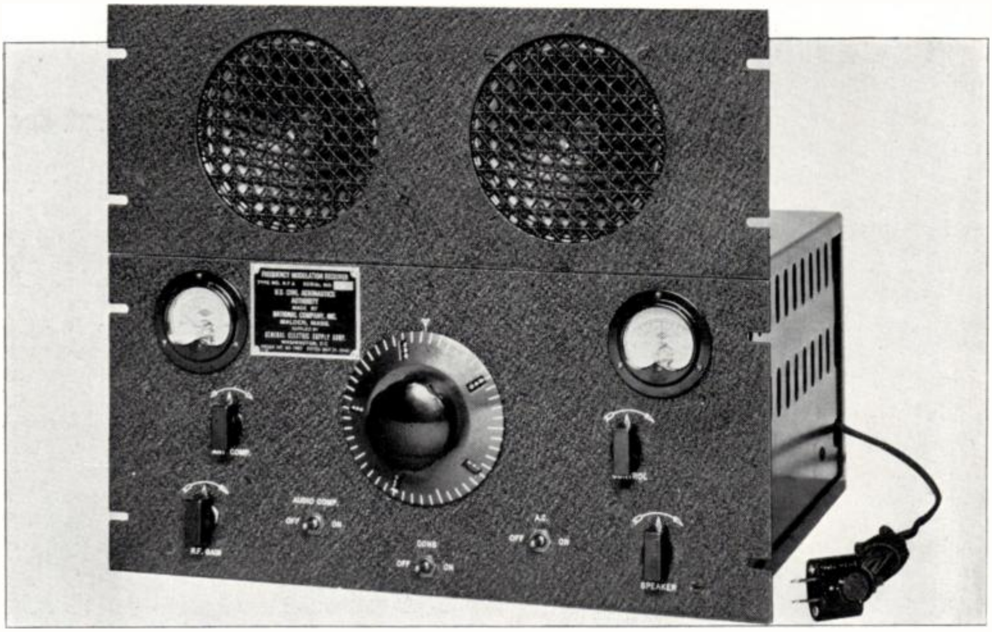
Looking back a few years, we may be able to see signposts which will help to direct the radio industry of the future. The piano business was plowed under by the advent of radio broadcasting. Young people stopped practicing because they could listen to the radio without mental or physical effort. Their elders deserted their pianos for the same reason.

However, as the American people heard more and more of the world's greatest musicians and finest orchestras via radio, they began to take a new interest in music. In the space of a few years, courses in music appreciation have become popular in high schools and colleges. This movement has grown to such an extent that now thousands upon thousands of students are learning to play themselves, with the result that the musical instrument manufacturers have been put back into business on a large scale.

Piano manufacturers, for example, have entered the last quarter of 1940 with the largest backlog of orders in more than twelve years. Unfilled orders on October 1st totalled 7,985 pianos, an increase of 37% over the same date last year. This seems to indicate that the radio manufacturers are not holding their own against a supposedly vanquished rival!

FM May Lead the Way

Frequency modulation offers the radio industry an opportunity to rise out of the depths of poor quality and low prices into which it has sunk. I hope that all of us will take advantage of this opportunity and that we will all work toward this end. Perhaps radio may eventually attain a place as a musical instrument. It can do this, and FM may lead the way.



NATIONAL RACK-MOUNTED RECEIVER UTILIZES FM FOR REMOTE RADIO CONTROL

FM IN COMMUNICATIONS SERVICE

Details of National Company's Precision Type FM Receiver—by Dana Bacon*

THE present system of frequency modulation transmission and reception, in contrast with the accepted amplitude modulation systems, has proven itself capable of high fidelity performance with almost complete freedom from static. Even though this advantage would appear to make frequency modulation primarily applicable to the broadcast of entertainment, it is obvious that such a valuable characteristic is very desirable, if not essential, in a number of specialized communications services.

Special-Purpose FM Receiver ★ One such service brought about the development of the receiver to be described. The basic problem was to set up several reliable communications channels over distances of several miles between a central control station and a number of remotely controlled transmitters. In some cases, wire lines or cables were impracticable since the paths between central and remote stations were over water. Furthermore, the signals required for remote control included voice, keying impulses and tone frequencies of several thousand cycles, all to be transmitted simultaneously, if desired, without mutual interference. The latter requirement, accomplished by means of filters, necessitated the use of a rather wide audio transmission band; in other words, a high fidelity channel. Taken as a whole, these considerations all pointed to the use of a short wave radio system, with frequency modulation definitely preferable over amplitude modulation. An operating frequency of approximately 40 mc. was chosen.

The special receiver employed has several features of interest. These will be discussed briefly, but before doing so, the performance of the receiver will be examined, and it will be seen that in providing the characteristics necessary to the remote control service outlined above, all the requirements of high aural fidelity are more than adequately met.

Tubes ★ The circuit arrangement of the receiver is as follows: The high frequency section includes one stage of RF amplification, followed by the first detector and H.F. oscillator, each circuit employing individual acorn tubes types 956, 954 and 955 respectively. The IF channel has three stages, operating at three megacycles, and using conventional 6SK7 tubes. At the IF amplifier output is the limiter, a 6SJ7, and its associated signal strength

* Chief Electrical Engineer, National Co., Inc., Malden, Mass.

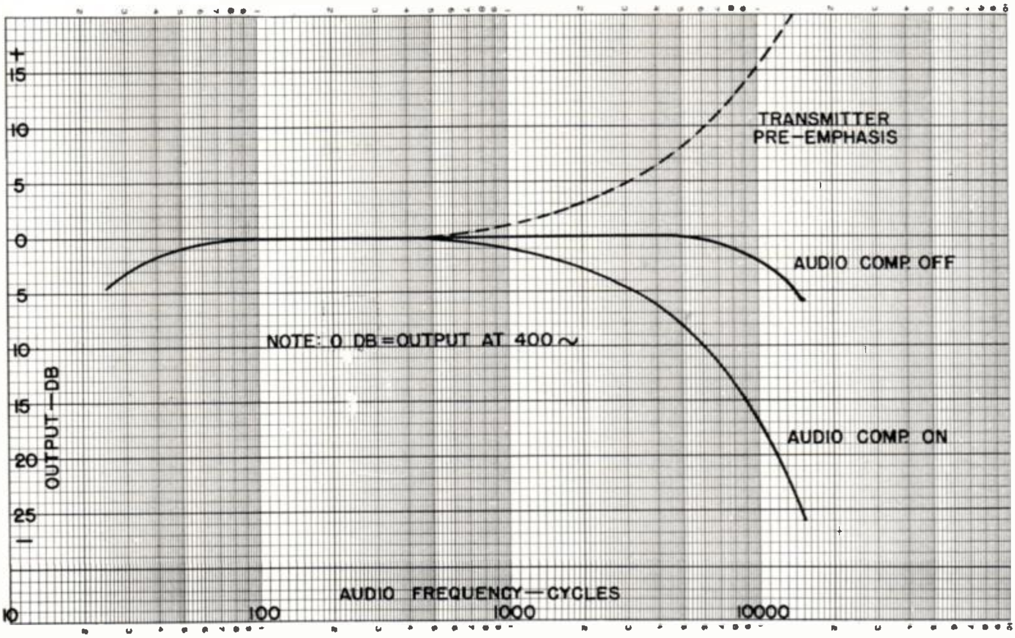


FIG. 1. OVERALL AUDIO RESPONSE OF NATIONAL FM RECEIVER WITH AND WITHOUT COMPENSATOR

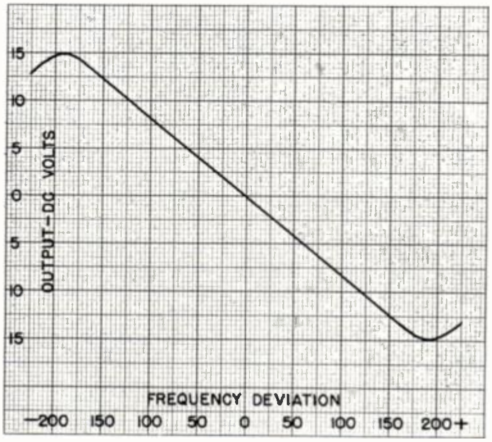
meter. After the limiter comes the discriminator, a 6H6, with a tuning meter of the zero center type connected in the load circuit. Next in line is a 6F8G audio amplifier and phase inverter, which serves also as a squelch tube, and which is resistance coupled to dual audio output stages. One of these stages has two 6F6G's in push-pull and the other utilizes a 6F8G with its elements in push-pull. Auxiliary circuits include an adjustable carrier-off-noise-suppression system using a 6C8G, and the 115 V. AC operated power supply using a 5Y3G.

Performance ★ The performance curves, Figs. 1 to 3 inclusive, require but little explanation. The audio fidelity curve of Fig. 1 shows that overall audio response is flat within plus or minus 1 db. from 40 to 10,000 cycles, a high fidelity characteristic of this type being necessary to provide for uniformly efficient transmission of all portions of the control signals. If the audio response showed a marked falling off in the neighborhood of 10,000 cycles, the tone frequencies mentioned above would not be reproduced equally. As indicated in Fig. 1, the audio characteristic of the receiver may be altered to provide accurate compensation for high frequency pre-emphasis at the transmitting station. With a correctly designed compensating circuit, the overall audio characteristic of the system, when utilizing high frequency pre-emphasis, will be identical with the "Audio Comp. OFF" curve shown. It may be mentioned, in passing, that the audio frequency response of a frequency modulation receiver is dependent almost entirely upon the audio amplifier channel. Too much selectivity in the RF and IF circuits, instead of introducing the side band cutting effects so objectionable in amplitude modulation receivers, tends to produce harmonic distortion or non-linear effects at high modulation levels, although this tendency is usually counteracted by properly designed limiter circuits.

The design of the limiter circuit need not be considered here since no new considerations are involved. It should be noted, however, that the rectified limiter grid current is used to obtain AVC voltage which is applied to the RF pre-selector and the first two IF stages, and this AVC system is entirely separate from the carrier-controlled voltage that is used to actuate the carrier-off-noise-suppression circuits.

The discriminator characteristic is shown in Fig. 2. This curve shows the relationship between discriminator output and variable frequency signal input of constant amplitude. It also shows that any symmetrical amplitude-modulated signal, which may be applied in the discriminator input, will not produce audio output provided carrier frequency is at the central frequency of the discriminator characteristic. This action of the discriminator accounts, to a considerable extent, for the noise rejecting ability of a frequency modulation receiver. A conventional tuning meter is associated with the discriminator circuit.

The selectivity curve of Fig. 3 may be considered practically ideal for reception of frequency modulation signals having a maximum frequency deviation of plus or minus 75 kilocycles from the central channel frequency. The characteristic shows a total variation of less than 1 db. over the 150 kilocycle band and



DISCRIMINATION

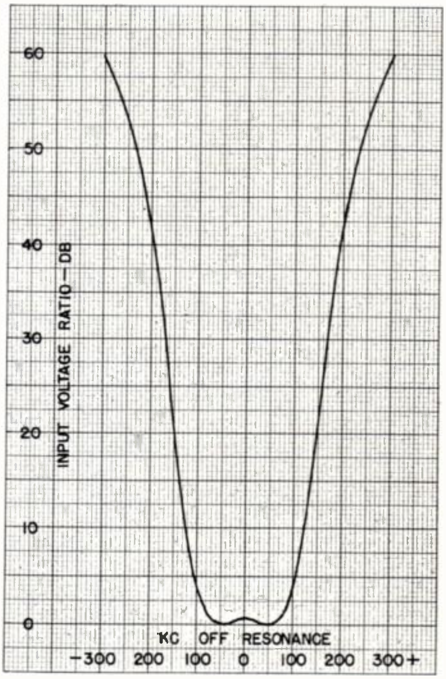
FIG. 2. DISCRIMINATOR CHARACTERISTICS OF THE NATIONAL COMMUNICATIONS RECEIVER

while such an excellent characteristic may not be actually required for satisfactory performance, it reduces the leveling action required of the limiter and, consequently, extends the range of receiver sensitivity to include extremely weak signals which could not otherwise provide adequate limiter action.

Other performance characteristics such as maximum undistorted power output, radio frequency coverage, speaker fidelity, etc., are relatively unimportant as far as this discussion is concerned but it may be mentioned that with the particular circuit shown, about three watts of audio power are available and this has been found ample for monitoring purposes.

Circuit ★ The schematic wiring diagram, Fig. 4, shows that the fundamental circuit is more or less conventional but that a number of auxiliary circuits are provided which make the receiver particularly suitable for the special service requirements previously outlined. Probably the most important of these special features is the carrier-off-noise-suppression circuit having an adjustable threshold level control. This control provides means for adjusting the receiver to respond to any signal input above a definite level, the latter being adjustable at will to any value between 1 and 1000 microvolts. Analysis of the circuit diagram will show that control voltage for the CONS system is obtained from one-half of a dual triode and not from the regular AVC system as might be expected. This is done to provide a very sharp cut-off at the threshold level with a minimum of circuit parts. The output of the discriminator is coupled to a phase-inverter-audio-amplifier of the self-balancing type and it is this tube which serves to squelch the audio circuits when the carrier-off-noise-suppression circuits are in action.

Following the phase-inverter is a dual audio output system comprising two separate output stages with individual gain controls. Such an

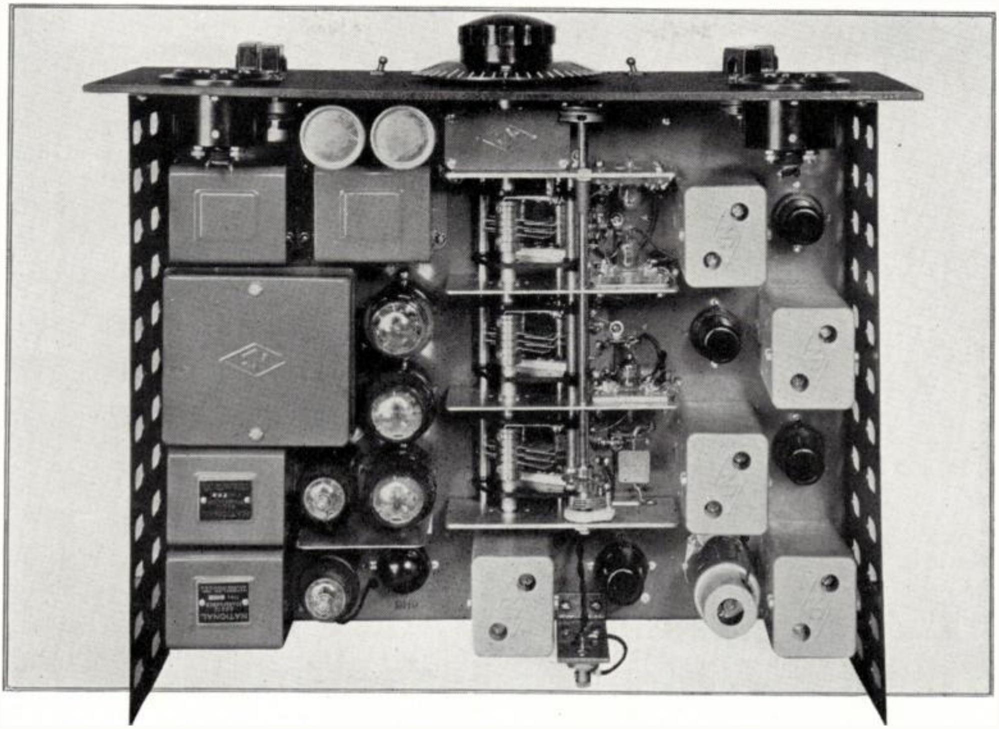


SELECTIVITY

FIG. 3. SELECTIVITY CURVE OF SET DESIGNED FOR FM SIGNALS WITH 75-KC DEVIATION

arrangement permits excellent isolation of the various control signals and output filters. By pure coincidence, a dual output channel of this type is ideal for a composite loud speaker system employing a "woofer" and a "tweeter", particularly since the individual gain controls would allow the system to be easily adjusted to correct balance between highs and lows with the additional possibility of obtaining a variety of tone control effects.

In a control link of the type under consideration, it is important that the stability of the receiver be of an unusually high order as the



TOP VIEW OF NATIONAL FM RECEIVER SHOWS ACORN TUBES MOUNTED ON CONDENSER SHIELDS

equipment must be capable of operating properly for extended periods of time without attention. Rather than resort to crystal control of the high frequency oscillator circuit with the accompanying unavoidable circuit complications, a self-excited oscillator was developed, providing excellent stability. The type 955 triode used in this oscillator is, of course, designed for just such applications and its low interelectrode capacities and high efficiency at the operating frequency render it inherently superior to the more conventional tube types. The actual oscillator circuit is of the tuned-plate-grid-tickler type, a circuit now recognized as having many advantages over the plate-tickler, electron coupled, or Hartley circuits in more common use. On frequencies between 40 and 50 mc., the advantages of the tuned plate oscillator are even more apparent since the electronic loading of the tube grid circuit does not harmfully influence the efficiency of the tuned circuit. The grid loading effect is unimportant in the low impedance grid tickler circuit, and the plate loading effect is not of sufficient magnitude to cause trouble. When it is realized that the stability of the oscillator is directly dependent upon the "Q" of the tuned circuit, the importance of the points just mentioned is apparent. It is, of course, necessary to employ low-loss material throughout the oscillator circuit and to incorporate adequate temperature compensating means.

Acorn tubes are used in the RF and first detector circuits for much the same reasons that dictated the use of the acorn triode in the oscillator circuit. Tubes of the high-Gm type, such as 1852 or 1853, are sometimes to be preferred over the acorn, particularly where price is a predominant factor. Inasmuch as the remote control link must be rendered as free from interference as possible, the acorn RF tubes were chosen since they provided a vastly better signal-to-image ratio with no sacrifice in RF gain or signal-to-noise ratio.

The mechanical construction of the receiver is best explained by the accompanying photographs. The receiver, primarily designed for relay rack mounting, is fitted with a dust cover of the U-shaped, slide-on type which, when removed, completely exposes the top, rear, and bottom of the receiver chassis. Particular attention is called to the three-gang tuning condenser assembly with acorn tube sockets, mounted directly on the condenser section shielding partitions. Cathode and screen by-pass capacity is obtained through alternate sheets of brass and mica, assembled condenser

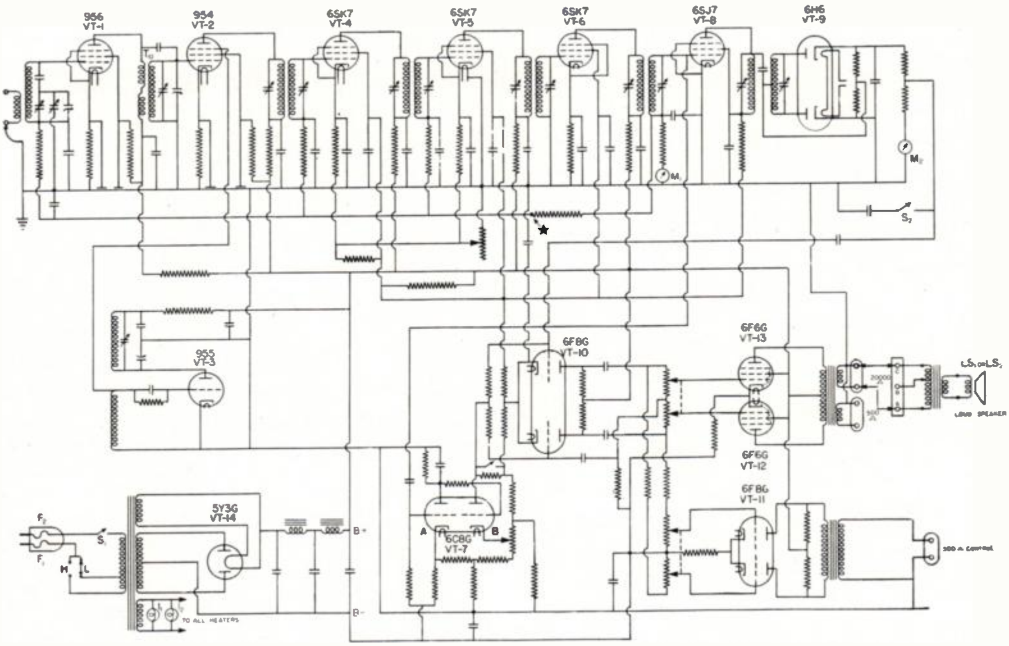


FIG. 4 COMPLETE SCHEMATIC WIRING DIAGRAM DISCLOSES INTERESTING CIRCUIT FEATURES

fashion, and mounted between the acorn sockets and the supporting shield partitions. Through such condenser assemblies, it is possible to build up capacities required having negligible inductance.

This National FM receiver can be described as a truly universal type for the reason that its design makes it suitable to a wide range of applications in addition to the conventional service of voice reception. In fact, this receiver was designed to permit the use of the many kinds of special equipment now made practical and dependable by the reduction of interference provided by FM transmission.

ZENITH DELIVERS TWO FM MODELS

(CONTINUED FROM PAGE 7)

this to be an essential feature for FM demonstrations, for it is not enough to suppress noise on the signal and leave it in between stations. Because FM has been announced to the public as being static-less, listeners expect quiet operation throughout the tuning range.

Antenna ★ Zenith provides two loop antennas, one for AM and one for FM. They are mounted so that they can be rotated after installation. Connections are provided for an outside antenna, to be used if the field strength of the FM signals is found to be insufficient for quiet operation.

Cabinet Size ★ Chairside model 10-H-551 is 21½ inches high, 28¾ inches wide, and 18¼ inches deep. The spinet cabinet, model 10-H-571, is 38¼ inches high, 32½ inches wide, and 17½ inches deep.

Circuit ★ The schematic diagram is not available at this time of writing. However, it is planned to present the complete service data on these models in the forthcoming issue of *FM* Magazine.

SORRY — NOVEMBER SOLD OUT!

WE WOULD like to comply with the great number of requests to have subscriptions to *FM* Magazine start with the November. This is impossible, however, because the only copies of that issue remaining are the 50 which have been set aside for bound volumes.

Since *FM* Magazine is sold by subscription only, we have no unsold copies coming back from the news stands.

Only 500 extra copies are being printed of the December issue. If you have friends who want to subscribe to FM, we shall appreciate your telling them that, unless they act at once, we shall have to start them off with the January number.

SYNCHRONIZED FM TRANSMITTER

How Western Electric Obtains FM Carrier Stability — by W. H. Doherty*

IMPORTANT new developments in communication, as in other sciences, are often retarded in their commercial application by the lack of apparatus and techniques that are suitable for actual use in the field, where exacting standards of performance have to be met over long periods of time with complete reliability. Wide band frequency modulation presents its share of these practical problems, but through the coordination of a number of new and distinct laboratory developments, the approaching expansion in FM broadcasting finds equipment ready for use that meets the most rigorous requirements. These new developments are embodied in Synchronized Frequency Modulation, which makes its appearance for the first time in the 1000 watt Western Electric 503A-1 Radio Transmitting Equipment.

Probably foremost among the practical problems is that of frequency stability — a term which in FM must of course have a new

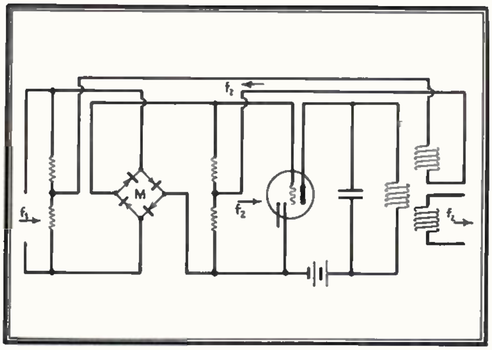


FIG. 1. SCHEMATIC OF 2-TO-1 FREQUENCY DIVIDER

meaning, since it can refer only to the average frequency. In amplitude modulation systems the crystal oscillator has provided all that could be desired in the way of frequency stability; but in a mode of transmission employing deliberate variation of frequency over a wide range, the direct use of the crystal as the source of the oscillations would necessarily give rise to a conflict between the factors which stabilize the frequency and those which are to produce the desired variation. Yet the mean frequency in FM transmission is subject to the same strict regulation prevailing for the carrier frequency in amplitude modulation, requiring that in some manner the virtues of the crystal oscillator be made use of.

Now the mean frequency in a frequency modulated signal may be defined as the *total number of cycles* occurring in a second, whatever their distribution in time over this interval may be; so that a logical and direct procedure in maintaining the mean frequency at the assigned carrier value, would be to count continuously the number of cycles per second, comparing this with the number generated by a precise fixed-frequency standard, and adjust-

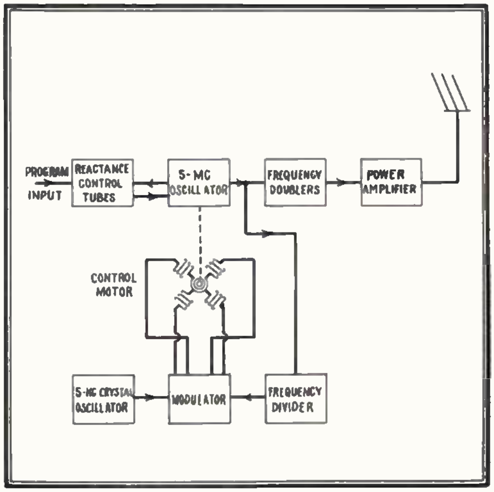


FIG. 2. BLOCK DIAGRAM OF W.E. FM TRANSMITTER

ing the source of the oscillations to keep the two always exactly the same. This is in effect what is accomplished in Synchronized Frequency Modulation. The procedure has a close parallel in electric power system practice, where cycle counting by means of synchronous motor clocks permits accurate control of the average frequency.

It is not necessary, however, to count millions of cycles each second, for the frequency may be reduced to any desired degree through the new technique of *frequency division*, whereby a low frequency is obtained which is an exact submultiple derived directly from the original frequency and having its variations reduced in proportion. The frequency divider, a tool of considerable promise in the communication field, consists basically of a modulator (M. Fig. 1) and a vacuum tube amplifier. The frequency f_2 appearing in the output of the modulator is the difference between the fre-

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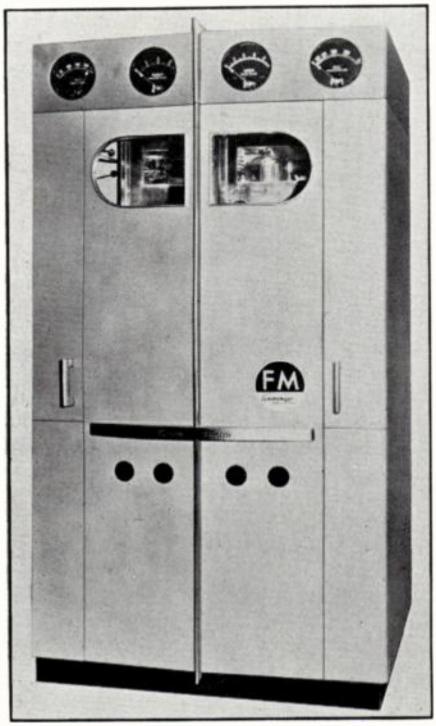
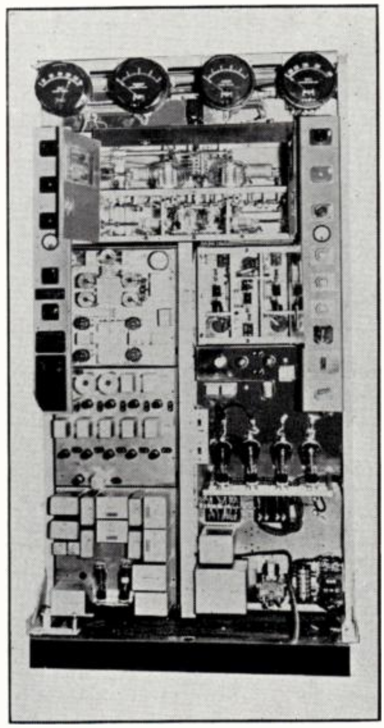
* Commercial Products Development, Bell Telephone Laboratories, New York City.





LEFT: WESTERN ELECTRIC 1KW. SYNCHRONIZED FM TRANSMITTER. RIGHT: TRANSMITTER WITH CABINET REMOVED. SPECIAL FEATURE IS METHOD OF MAINTAINING CONSTANT FREQUENCY

quency fed back from the output, which is f_2 itself, and the frequency f_1 applied to the device; that is, $f_2 = f_1 - f_2$. This requires that $f_2 = f_1/2$, so that we have an exact halving of the frequency; and the output wave, although produced by a regenerative action, is under complete control of the input by virtue of the modulation process through which it originates.

Using a modulator of the copper oxide type, which recent refinements have rendered suitable for use at frequencies of several megacycles, the frequency divider becomes a very compact and simple device. By cascading a series of such dividers, we obtain for synchronizing purposes a frequency as low as desired, in exact submultiple relationship to the carrier frequency. In Synchronized Frequency Modulation the dividing process ends up with a frequency of about 5000 cycles, or 1/8000 of the carrier frequency.

Referring now to the block diagram of the system, Fig. 2, the role of the frequency divider becomes apparent. The divider is energized from the output of a frequency modulated oscillator operating at about five megacycles, and its function as a part of the synchronizing system is to insure the constancy of the mean frequency of this oscillator, and hence of the final output frequency (42 to 50 megacycles) to be obtained by doublers following the oscillator.

There has been in use for some years a method of synchronizing two frequencies wherein the frequencies are combined in a modulator to produce a rotating magnetic field whose speed and direction of rotation correspond to the amount and sense of the frequency difference. As a small armature, geared to the tuning condenser of one oscillating source, brings the frequency back toward synchronism, the speed of rotation of the field decreases and the armature slows down, coming to rest when exact synchronism is attained.

At first thought, one would not expect such a device to be applicable in an ultra-high frequency system because the departures in frequency are so great as to be beyond the capacity of a mechanical system to follow; but when the frequency is reduced by our dividing process to the order of 5000 cycles, or 1/8000th of the output frequency, we find that variations of hundreds of kilocycles in the output frequency are represented by variations of only tens of cycles, so that with a low-frequency crystal oscillator as the comparison standard we obtain a rotating magnetic field readily followed by the armature. So effective and immediate is the control that if the output frequency through some cause were to depart suddenly by as much as *four hundred kilocycles* from its assigned value, it would be returned to exact synchronism in two to three seconds; while gradual changes in frequency of as much as several megacycles will also be corrected because the change is followed continuously.

It is well known in frequency modulation theory that the phase deviations are directly proportional to the frequency swing and inversely proportional to the audio rate at which the swing is produced. The frequency swings employed in wide band frequency modulation are so great as to entail phase deviations of thousands of degrees; that is, the frequency modulated wave is alternately advanced and retarded by many complete cycles with respect to an unmodulated comparison wave. When a high order of frequency division is introduced, however, the frequency swing becomes small while the audio rate is unchanged, so that the phase departures due to modulation are then only a few degrees.

The magnetic field in the control device therefore oscillates only slightly at audio frequencies about its mean position, and the oscillation is not followed by the motor because of its inertia; the slightest change in *mean* frequency, however, produces a continuous rotation of the field and is corrected at once. The frequency divider, then, serves two important purposes: to reduce the whole phenomenon to a time scale suited to electromechanical operations, and to obscure the effects of modulation so that only changes in the mean frequency, or total number of cycles per second, can influence the frequency control mechanism.

Not long ago 50 kilocycles was regarded as an extremely low frequency for quartz crystals. The appearance of a 5-kilocycle crystal oscillator in the block diagram of Fig. 2 is a reminder that advances in the frequency range of radio equipment are not being confined to the high-frequency end of the spectrum. This is a low temperature co-efficient crystal oscillator giving the same per cent stability as obtained in the best broadcast crystals. The stability is well under one part in a million per degree centigrade, making temperature control entirely unnecessary.

The system of frequency control described above is so unique in a number of important characteristics as to bring to light immediately certain limitations of other methods that might not otherwise be obvious. For one thing, the stability is identically that of a single crystal oscillator, unaffected by any beating process with other oscillators, or by changes in gain or frequency characteristics of associated circuits. There are no temperature-controlled networks for converting frequency changes into amplitude changes, opening the door to errors due to gain fluctuations; everything in the control system is kept in terms of frequency. In the second place, the actual control exercised on the oscillator to maintain its mean frequency is mechanical, involving a variable condenser;

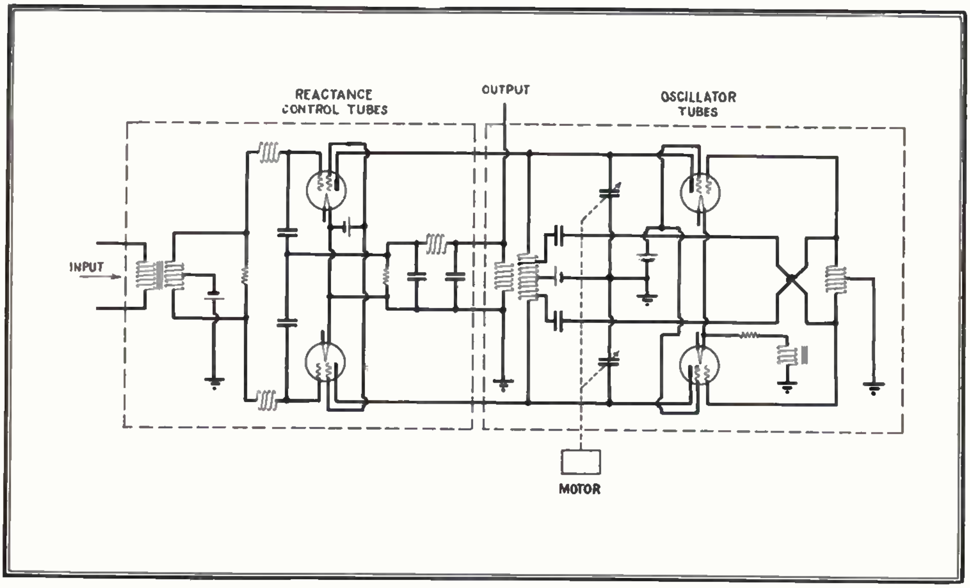
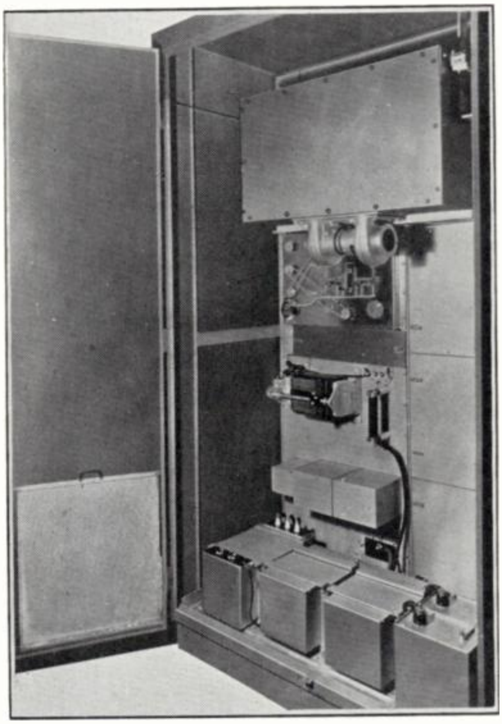
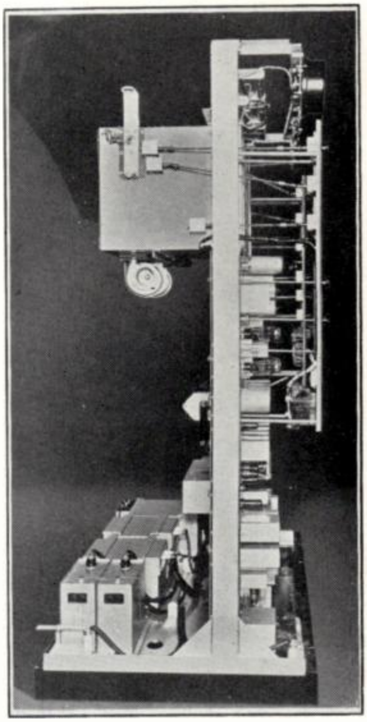


FIG. 3. SCHEMATIC DIAGRAM OF SYNCHRONIZED FREQUENCY MODULATION TRANSMITTER





LEFT: REAR VIEW OF TRANSMITTER WITH DOOR OPEN. RIGHT, SIDE VIEW WITH CABINET REMOVED. THIS TYPE OF TRANSMITTER IS USED BY WOR'S FM STATION, W2XOR, IN NEW YORK CITY

and being mechanical, when the oscillator is brought to the correct frequency it is *left* there, without the necessity of any sustaining voltage such as must be supplied when slope-circuit control is used, and therefore without the danger of a sudden wide departure in the frequency should the control voltage fail.

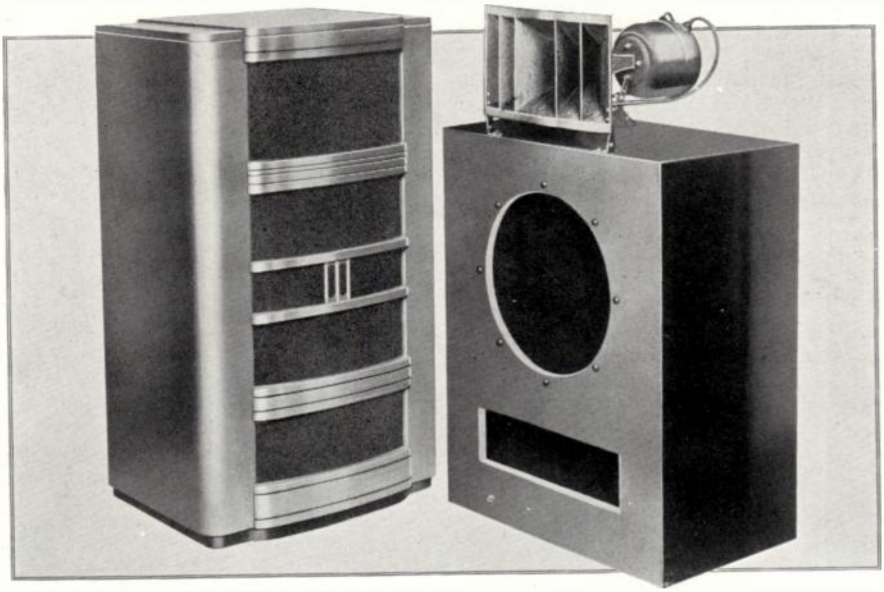
Mechanical control, moreover, completely relieves the frequency modulating elements of any connection with the stabilization of the mean frequency, so that these elements may always be operated at the optimum point for linear modulation and the frequency swing obtainable is not limited by the necessity for correcting frequency drifts in the oscillator. Finally, the entire synchronizing system, including the crystal oscillator, is completely external to the program-carrying part of the transmitter and no failure or misadjustment within it can have any influence on either the quality or the continuity of the transmission.

Frequency modulation holds such promise as a vehicle for high-quality noise-free broadcast service that no pains have been spared in producing a transmitting circuit design of extremely low distortion and background noise level. By modulating at a carrier frequency of five or six megacycles, where the phase deviations are large, the difficulty encountered at low initial frequencies from phase modulation due to power supply hum and microphonics is removed. In Synchronized Frequency Modulation, moreover, the complete separation of the two functions of modulation and frequency stabilization permits the use of push-pull reactance control tubes for modulating the oscillator, so that ripples in bias or plate voltage supplies do not modulate the frequency. The balanced circuit (Fig. 3) employed for these tubes and for the oscillator, together with other refinements in design, permit a frequency excursion of hundreds of kilocycles on either side with very low distortion.

Following the modulated oscillator in the 503A-1 equipment are four pentode stages, three of them being doublers, and all extremely simple in design. At the final output frequency two triode stages increase the power to 1000 watts for transmission to the antenna. These triode stages use the 356A and 357A, stemless and baseless ultra-high frequency tubes in the molded hard glass type envelope. The 357A is rated at 350 watts plate dissipation, with full voltage rating up to 100 megacycles. Two of these in the 40-50 megacycle range deliver 1000 watts for FM with great ease.

The 1-kilowatt broadcast transmitter in which the 357A tube made its debut a year ago introduced a new mechanical construction and an exceptionally attractive modern cabinet design. These features have been received so favorably for broadcasting and high quality police service that the same lines have been followed in this first commercial Western Electric frequency modulation transmitter. All apparatus is mounted independently of the cabinet; every part is immediately accessible for inspection or maintenance; all controls are protected by narrow side doors flanking the main door. The apparatus has been designed to give long and trouble-free life.

The new techniques and apparatus refinements that are made use of in Synchronized Frequency Modulation have been contributed by various departments of the Bell Laboratories. The co-ordination of these contributions into a practical and reliable system of frequency modulation generation and control is the work of J. F. Morrison. His associates at the Whippany Laboratory, in designing the 503A-1, have applied to their first FM product the results of long experience in the regular broadcast band.



LEFT, BASS-REFLEX SPEAKER FOR FM RECEPTION. RIGHT, LESS EXPENSIVE CLOSURE

Jensen Announces FM Speaker Line

DEMAND for new speakers, capable of handling the wide audio range delivered by FM receivers, is responsible for special types recently announced by Jensen Radio Manufacturing Company of Chicago. Most interesting are the two-speaker models illustrated above. Identical in design except for the cabinets, each has a direct-radiator unit, mounted in a Bass-Reflex enclosure for extending the low-frequency response, an 800-cycle dividing network with an adjustable cut-off and a high-frequency level control, and a high-frequency unit with a diffusing horn. This combination is described as giving excellent response up to 12,000 with relatively wide-angle distribution of the upper register.

The type shown at the left is indicative of a trend in radio receiver design which has been given considerable impetus since the introduction of FM sets. This refers to the plan of mounting the speaker in a cabinet separate from the radio itself, with the audio amplifier located in the speaker element rather than in the radio cabinet.

Two methods of installation are then possible: One is to place the receiver directly on top of the speaker. The other method, giving superior acoustic effects, is to locate the radio where it can be reached most easily for adjustment, with the speaker installed at some distant point in the room. In this way, reception can be heard to best advantage without any sacrifice of convenience of operation.

The other speaker shown is intended for monitoring purposes, or to be built into special custom-made cabinets or into the permanent furnishings of homes or broadcast studio rooms.

LINK DESIGNS FM FOR POLICE

F. M. Link Has Portable Transmitter and Receiver for Police, Fire, Other Emergency Service

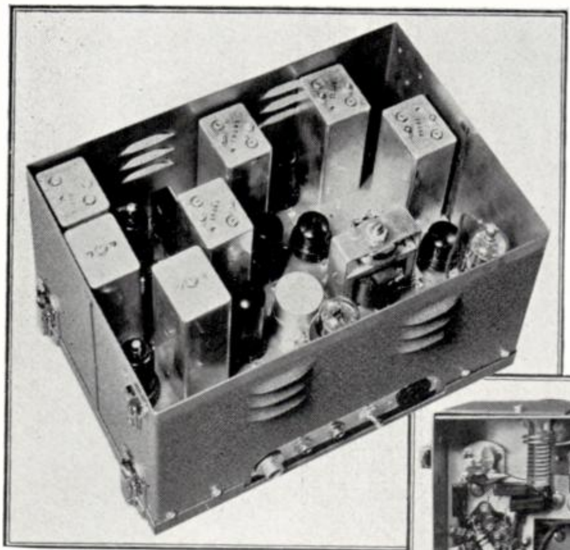
11-UF FM MOBILE RECEIVER FOR EMERGENCY USE

FEW radio engineers not intimately concerned with mobile equipment for police and other emergency service realize the present degree of FM development in this field, and the extent to which FM equipment is now being used for such purposes.[1]

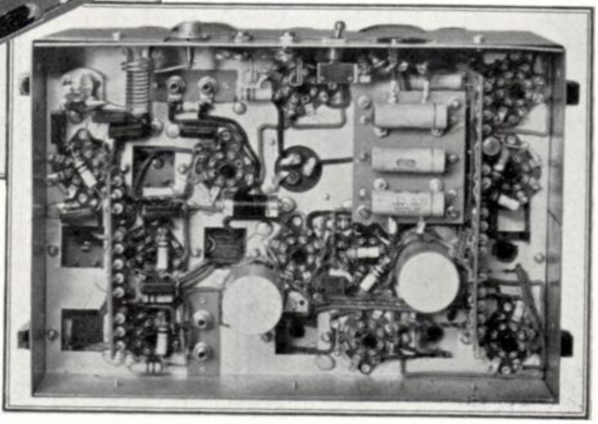
The accompanying photographs show many interesting details of mobile apparatus developed and manufactured under Armstrong license by Fred M. Link, of 125 West 17th Street, New York City.

These units have given remarkable results in delivering optimum speech intelligibility over maximum service areas. As a result of pre-emphasis in the transmitter, with corresponding compensation in the receiver, it is practical to obtain usable signals below the RF noise level. Utilizing fundamental FM design principles, distortion due to excessive audio input to the transmitter is virtually eliminated, and excellent AVC action is obtained in the receiver. In fact, by using two limiters and ample

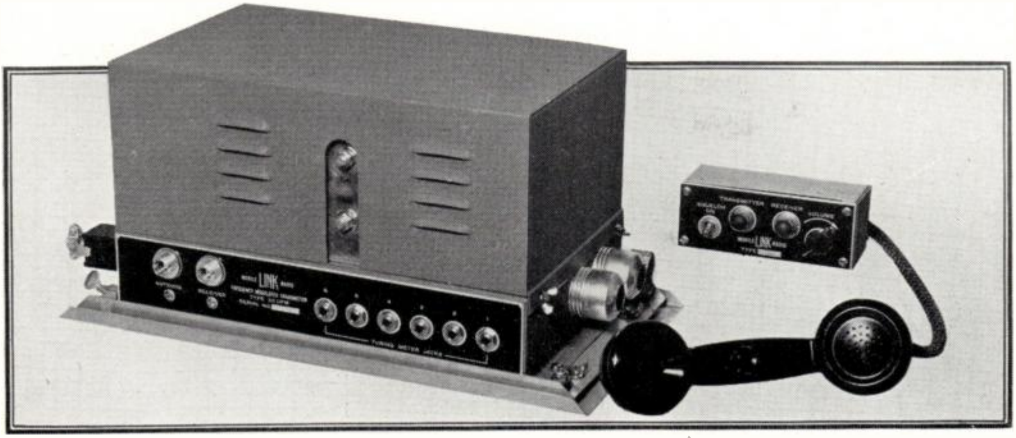
[1] Considerable space will be devoted to this subject in the January *FM* Magazine, including complete data on the Connecticut State Police system, comprising 10 fixed stations and 225 car installations.



THIS FM RECEIVER IS SUITED FOR AC OR DC OPERATION. IT CAN BE MOUNTED IN THE REAR COMPARTMENT OF A PROWL CAR, OR SET UP FOR RACK MOUNTING, WITH A BUILT-IN POWER SUPPLY, FOR MAIN STATION INSTALLATIONS



UNDER SIDE OF THE RECEIVER CHASSIS. SERVICE TIME HAS BEEN REDUCED TO A MINIMUM BY COMPLETE ACCESSIBILITY AND UNIT CONSTRUCTION



TYPE 25-UFM MOBILE TRANSMITTER, WITH DASH-BOARD CONTROL AND HAND TELEPHONE SET

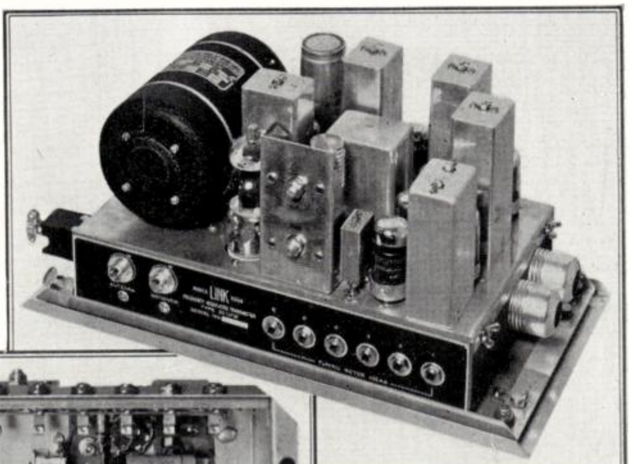
RF gain, it is possible to receive intelligible signals in the region of .1 to .2 mv.

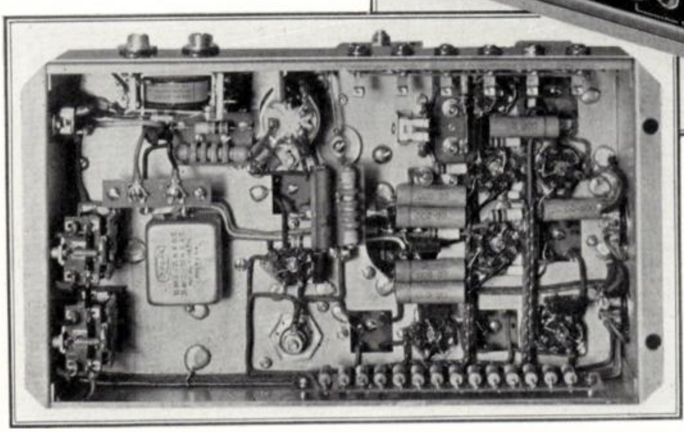
Transmitter efficiency is high compared to similar AM equipment, giving nearly twice the carrier output for the same battery current. Crystals used in these sets are of the low-drift type, with a coefficient not greater than 2 cycles per mc. per degree C.

With constant amplitude audio input to the transmitter, the frequency deviation increases linearly to 3,000 cycles, representing an increase of 15 db over the frequency deviation at 500 cycles. A low-pass filter network attenuates modulation components above 3,000 cycles, to prevent excessive high-frequency side-bands.

The audio characteristics of the receiver, designed in coordination with the pre-emphasis in the transmitter, provide a sharp cut-off through a low-pass filter which attenuates all frequencies above 2,800 cycles.

THIS FM TRANSMITTER COMPARES WITH AM UNITS IN FIRST COST AND UPKEEP, AND DELIVERS MUCH GREATER TALK-BACK RANGE PER DOLLAR OF INVESTMENT AND PER WATT OF POWER INPUT





AS THIS VIEW SHOWS, THE FM TRANSMITTER IS SIMPLE IN DESIGN, ASSURING LONG LIFE UNDER CONDITIONS OF HARDEST USE

SERVICE MANUALS

The Complete and Authoritative Source of Information on the Latest Frequency Modulation Receivers

STROMBERG-CARLSON 505 CONVERTER

CONVERTER-RECEIVER FOR FM ONLY

IDENTIFICATION TABLE

Model	*Input Power Frequency*	*Chassis*	*Cabinet*	*Speaker*
505-H	50–60 Cycles	32674	31422	31451
505-HB	25–60 Cycles	32675	31422	31451

SPECIFICATIONS

Voltage Rating............105 to 125 Volts
Type of Circuit...........Frequency Modulation — Superheterodyne
Tuning Range.............42 to 50 Megacycles (42,000 to 50,000 Kilocycles)
Number and Type of Tubes — 9
1 — 6AC7 RF Amplifier
1 — 6SA7 Modulator and Oscillator
1 — 6AB7 IF Amplifier
1 — 6AC7 IF Amplifier
1 — 6SJ7 Limiter
1 — 6H6 Demodulator (Discriminator)
1 — 6SF5 Audio Amplifier
1 — 6F6G Output
1 — 80 Rectifier
Input Power Rating (120 Volt line)..79 Watts
Intermediate Frequency...........4.3 Megacycles (4300 Kilocycles)
Speaker Voice Coil Impedance at 400 Cycles Approximately 5 Ohms
Speaker Field Coil Resistance......Approximately 550 Ohms

FEATURES

General ★ This receiver is designed for the reception of frequency modulated broadcast stations only. The Armstrong Wide-Swing Frequency Modulation System used in this receiver is an outstanding development in radio. It makes possible:

1. Static-free reception: Both natural and man-made static is virtually eliminated.

2. Noise-free reception: The tube and set noises present in ordinary amplitude modulation receivers are virtually eliminated.

BEST REPRODUCTION IS OBTAINED WHEN THIS SET IS CONNECTED TO HIGH QUALITY CONSOLE

3. Extreme high fidelity reception: Noise free reproduction of an audio range limited only by the capacity of the human ear or the audio system of the receiver is possible without interference.

4. Interference-free reception: Two stations cannot be received at the same time.

This system is patented and Stromberg-Carlson manufactures these receivers under an Armstrong license. The Federal Communications Commission has established forty channels between 42 and 50 megacycles for frequency modulated transmitting stations. Since this is a comparatively high frequency, the distance over which reception is possible is limited. It should also be noted that the fidelity may be limited by telephone lines, or by program transcriptions, although this condition will, undoubtedly, be improved as time goes on.

Using the 505 Receiver as a Converter ★ This receiver may be used as a converter so that the audio system of a good high fidelity receiver of the ordinary amplitude modulation type may be utilized to provide the type of high fidelity reception only possible with frequency modulation.

It is only necessary to connect the single pin jack on the back of the chassis (labeled Frequency Modulation Sound Output Jack) to the Phono Input of any other receiver or sound system by means of the cord provided.

In this way, the speaker of the 505 Receiver will act as a "tweeter" or treble speaker and the speaker system of the amplitude modulation receiver will serve as the bass speaker. The balance between the two speakers can be controlled by operating the two volume controls.

ACCESSORIES

Antenna ★ The proper antenna for frequency modulation reception will depend upon the distance from the stations which it is desired to receive. In some locations, a simple single wire antenna will be suitable, but for best results the Stromberg-Carlson No. 6 Antenna is recommended. This antenna is designed to provide improved pick-up in the frequency modulation range. It may be necessary to utilize a di-pole type of antenna in some locations.

Playing Records ★ To obtain the best quality of phonograph reproduction, a Stromberg-Carlson record player is recommended. If this set is used as a converter, the phonograph should be attached to the amplitude modulation receiver in the regular way. The installation of a simple switch will eliminate plugging and unplugging.

If this set is used as a receiver, the sound output jack may be readily converted to a phonograph input jack by removing the black-white wire which comes from this jack from the terminal block to which it is connected and connecting it to the hi-h side of the volume control. This is the terminal on the volume control to which resistor R-11 is attached.

After this has been done, it is only necessary to plug in a record player, tune to a quiet place on the dial and proceed to operate.

Adjusting Dial Lamp ★ One dial lamp is used to illuminate the dial on the No. 505 Receiver. To adjust the dial lamp for proper illumination of the dial, slide the lamp socket back and forth on its mounting bracket until maximum illumination is obtained.

ALIGNING INFORMATION

General ★ Never realign unless absolutely necessary. All aligning adjustments are carefully made at the factory with special equipment, which is designed for aligning frequency modulation receivers. The limitations of commercial oscillographs and other ordinary test equipment are such that alignment should not be attempted in the field unless absolutely necessary.

If alignment is attempted, it will not be successful unless the instructions which follow are adhered to exactly.

The following equipment will be required:

1. A good signal generator with variable output voltage. (All adjustments are made using an unmodulated signal.)

2. A good center "O" microammeter with 100 divisions on each side of "O." Always have receiver volume control full on.

See location chart, page 31, for location aligning adjustment screws.

I. Discriminator Adjustment ★

1. Tune the set to the extreme low frequency end of the dial.

2. Connect the center "O" microammeter with a one-megohm resistor in series across the whole discriminator load from the high side of R-13 to ground.

3. Connect the ground terminal of the signal generator to the ground terminal of the chassis.

4. Introduce an unmodulated signal of 4.3 megacycles to the grid (terminal No. 4) of the 6SJ7 limiter tube using a 0.1 microfarad capacitor in series with the output lead of the signal generator. Approximately one volt signal is necessary.

5. Adjust the secondary of the discriminator transformer for "O" reading of the microammeter.

6. Remove the microammeter and one-megohm resistor from the high side of R-13 Resistor and connect them across one-half of

the discriminator load (from ground to the junction of the two 100,000-ohm resistors R-12 and R-13).

7. Adjust the primary of the discriminator transformer for a maximum reading of the microammeter.

NOTE: To check for correct adjustment of discriminator circuit, connect the center "O" microammeter across the whole discriminator load, noting that the microammeter reads "O". If a discrepancy exists it may be corrected by readjusting the secondary trimmer for "O" reading of the microammeter, then tune the receiver on either side of 4.3 megacycles, noting that the reading of the microammeter is approximately the same on either side of "O." If a discrepancy exists it may be corrected by adjusting the primary trimmer for maximum swing of the microammeter on either side of "O."

II. Intermediate Frequency Adjustments ★

IMPORTANT: All intermediate frequency adjustments are made using the same unmodulated signal of 4.3 megacycles. Each IF stage must be adjusted independently and in the order given. Do not make any overall adjustments after the previous stage is aligned.

1. Disconnect the jumper wire from the low side of the limiter grid resistor (R-10) and connect the microammeter directly to this wire without using the one-megohm resistor.

2. Correct the output lead from the signal generator with the 0.1 microfarad capacitor in series to the grid of the 6AC7 second IF tube (Terminal No. 4).

3. Adjust the secondary of the third IF transformer for maximum reading of the microammeter.

4. Adjust the primary of the third IF transformer for maximum reading of the microammeter.

5. Connect the output lead from the signal generator with the 0.1 microfarad capacitor in series to the grid of the 6AB7 first IF tube (Terminal No. 4).

6. Adjust the secondary of the second IF transformer for maximum reading of the microammeter.

7. Adjust the primary of the second IF transformer for maximum reading of the microammeter.

8. Disconnect the green wire to the RF coil from the grid terminal of the 6SA7 modulator tube (Terminal No. 8), connect a 150,000-ohm resistor from Terminal No. 8 to ground, and connect the output lead from the signal with the 0.1 microfarad capacitor in series to this terminal.

TERMINALS OF SOCKETS

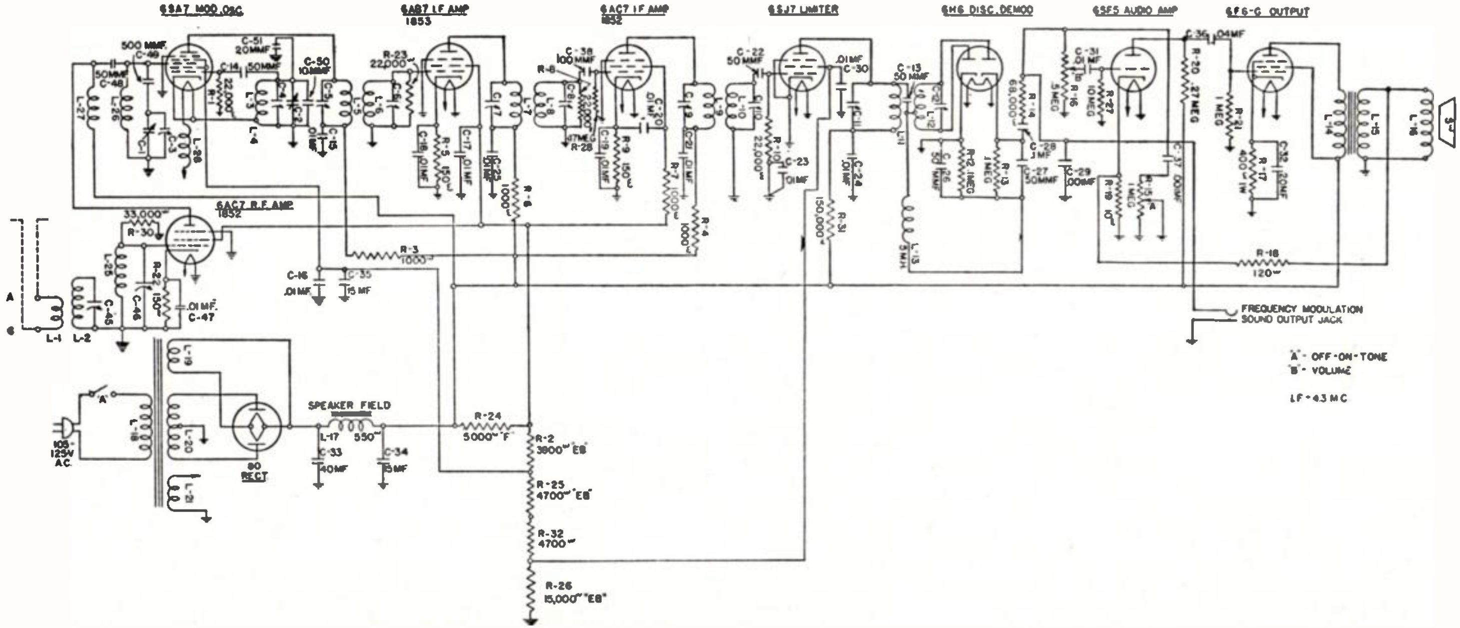
Tube	*Circuit*	*Cap*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*
6AC7	RF Amp.	—	0	0	0	0	+2*	+75	6.3	+220
6SA7	Osc. and Mod.	—	0	0	+240	+90	0	0	6.3	0
6AB7	1st IF Amp.	—	0	0	0	0	+2*	+75	6.3	+230
6AC7	2nd IF Amp.	—	0	0	0	0	+2*	+145	6.3	+230
6SJ7	Limiter	—	0	0	0	0	0	+50	6.3	+57
6H6	Demod. (Discr.)	—	0	0	0	0	—10*	0	6.3	0
6SF5	Audio Amp.	—	0	0	0	0	+90	+245	6.3	0
6F6G	Output	—	0	0	+230	+245	0	0	6.3	+15*
80	Rectifier	—	+300	310	310	+300	—	—	—	—

* Read on lowest possible scale of voltmeter.

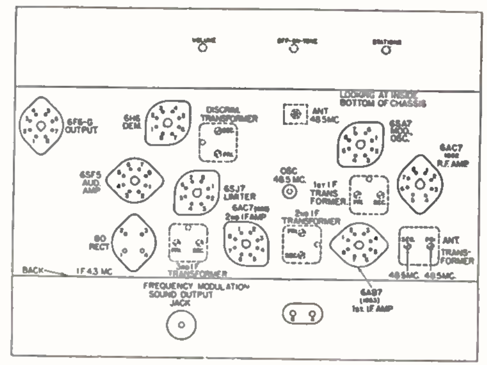
TERMINALS OF SOCKETS

Tube	*Circuit*	*Cap*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*
6AC7	RF Amp.	—	S	S	S	S	150¶	15000¶	S	15000¶
6SA7	Osc. and Mod.	—	S	S	30000¶	20000¶	20000¶	S	S	S
6AB7	1st IF Amp.	—	S	S	S	2¶	150¶	15000¶	S	15000¶
6AC7	2nd IF Amp.	—	S	S	S	500000¶	150¶	30000¶	S	30000¶
6SJ7	Limiter	—	S	S	S	20000¶	S	18000¶	S	18000¶
6H6	Demod. (Discr.)	—	S	S	90000¶	S	90000¶	O	S	180000¶
6SF5	Audio Amp.	—	S	10¶	10M	S	300000¶	30000¶	S	S
6F6G	Output	—	S	S	30000¶	30000¶	1M	O	S	400¶
80	Rectifier	—	100¶	30000¶	30000¶	100¶	—	—	—	—

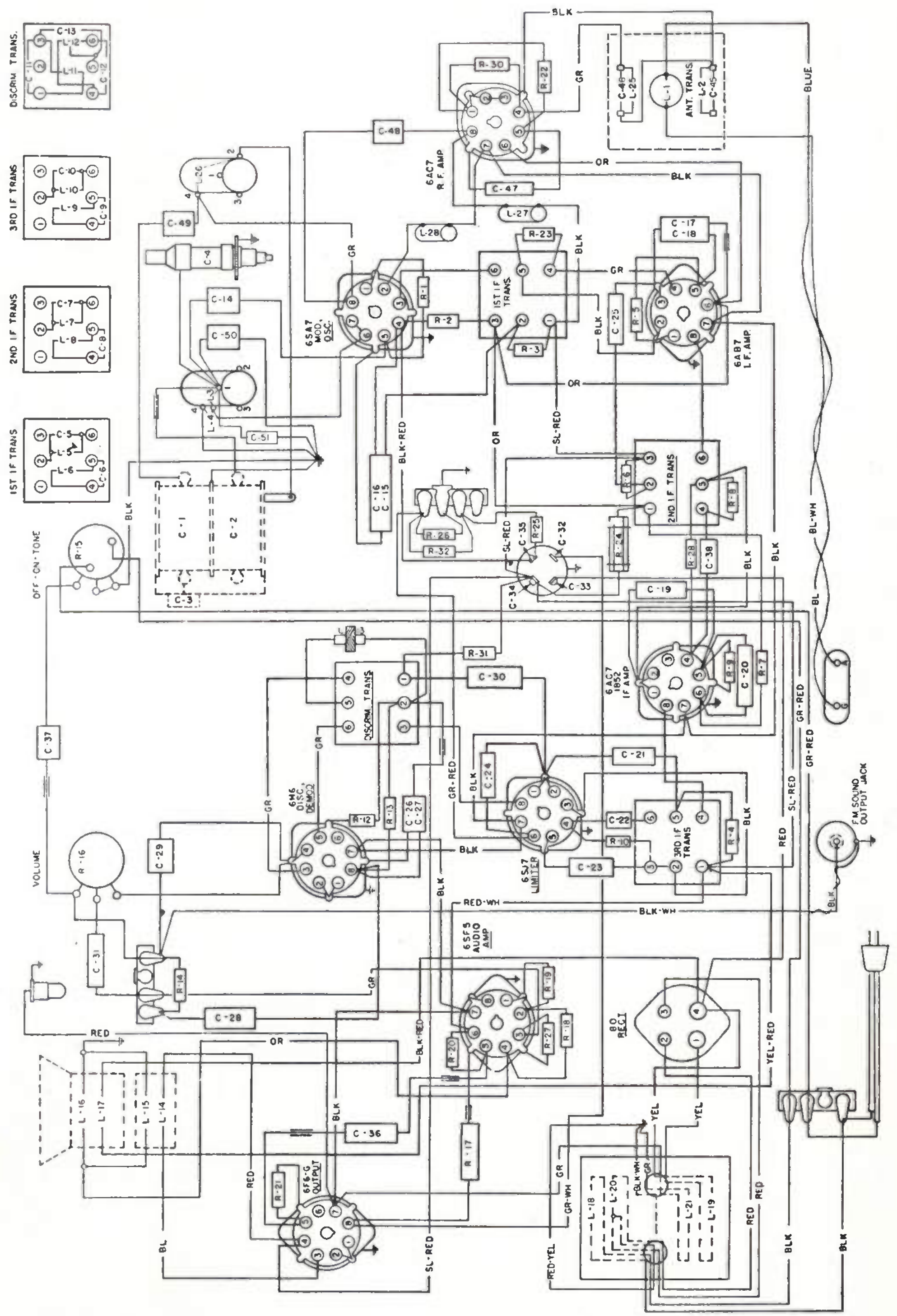
Symbols used are as follows: ¶—ohms; M—megohms; S—short; O—open.



ABOVE, SCHEMATIC WIRING DIAGRAM OF THE STROMBERG-CARLSON 505 CONVERTER-RECEIVER. CORRESPONDING REFERENCE NUMBERS FOR THE COILS, CONDENSERS, AND RESISTORS WILL BE FOUND IN THE PICTURE WIRING DIAGRAM OF THE CONVERTER CHASSIS



RIGHT, THE UNDER SIDE OF THE CHASSIS, AS IT APPEARS WHEN THE CONTROLS ARE AWAY FROM YOU. NOTE THE MANUFACTURER'S WARNING THAT REALIGNMENT SHOULD NOT BE ATTEMPTED WITHOUT THE SPECIAL INSTRUMENTS NEEDED FOR FM SERVICE



PICTURE WIRING DIAGRAM OF THE STROMBERG-CARLSON FM CONVERTER-RECEIVER, MODEL 505

9. Adjust the secondary of the first IF transformer for maximum reading of the microammeter.

10. Adjust the primary of the first IF transformer for maximum reading of the microammeter.

III. Radio Frequency Adjustments ★

Leave the signal generator connected to the grid of the 6SA7 tube in the same manner as when adjusting the first IF transformer.

1. Set the signal generator frequency and the receiver tuning dial to exactly 48.5 megacycles.

2. Adjust the oscillator aligning capacitor (air trimmer) for maximum reading of the microammeter.

3. Remove the output lead and the 0.1 microfarad capacitor in series with it from the grid of the 6SA7 tube and resolder in its original position the green wire which was removed from this terminal. Remove the 150,000-ohm resistor.

4. Remove the green wire from the grid of the 6AC7 RF tube (Terminal No. 4) and connect the output lead from the signal generator with a 0.1 microfarad capacitor in series with it to this terminal. Adjust the RF aligning capacitor for maximum reading of the microammeter. A slight adjustment of the oscillator (air trimmer) may also be made at this point to obtain maximum reading of the microammeter. Resolder the green wire in its original position.

5. Replace the 0.1 microfarad capacitor in series with the output lead from the signal generator with a 100 ohm carbon type resistor and connect it to the antenna terminal of the receiver.

6. Adjust the antenna aligning capacitors for maximum reading of the microammeter.

7. Check for correct antenna circuit adjustment by setting the signal generator and tuning the receiver to 42 megacycles, noting that the sensitivity is approximately the same as at 48.5 megacycles. If a discrepancy exists the secondary of the antenna transformer may be adjusted to obtain maximum reading of the microammeter. Set the signal generator frequency and the receiver tuning dial to 48.5 megacycles and readjust both the primary and secondary of the antenna transformer for maximum reading of the microammeter.

8. Resolder the jumper wire to the low side of the limiter grid resistor (R-10).

NORMAL VOLTAGE READINGS

Take all readings with chassis operating and tuned to approximately 47 megacycles — no signal. Use a line voltage of 120 volts, or make allowance for any slight difference.

Use a good high resistance voltmeter having a resistance of at least 1,000 ohms per volt. Take all DC readings on the 500 volt scale except when an asterisk appears. Read from indicated terminals to chassis base. See location chart for position of terminals.

AC voltages are indicated by italics.

CONTINUITY TEST

Caution: Remove all tubes and disconnect the receiver from the power supply before making continuity test.

Use a good ohmmeter capable of measuring accurately up to several megohms.

The resistances given are often approximate, owing to electrolytic capacitors in the circuit. When this is the case, be sure to reverse the test leads and read the highest resistance.

Read from indicated terminals to chassis base.

Other Tests Not Shown on Chart:

Antenna terminal to chassis base . . . "short"
Ground terminal to chassis base . . . . "short"
FM sound output jack to chassis base 1 megohm
Terminals of AC plug to chassis base . . "open"
Between terminals of AC plug:
AC switch open . . . . "open"
AC switch closed . . . . 6 ohms

(CONTINUED FROM PAGE 11)

casts and network programs, is essential to effective and successful sales efforts.

The Browning Laboratories are making available both semi-finished and completed converters. Equipped with a stage of tuned RF, their performance with respect to sensitivity and noise elimination, should equal that of much more expensive, complete receiving sets. As to tone quality, that depends upon the audio amplifier and speaker to which the converter is connected. In comparing the performance of converters, or FM receivers for that matter, the RF stage will be found even more important than in AM equipment. That is not only because of the greater sensitivity due to the tuned RF circuit, but to the fact that, delivering a stronger signal to the noise limiter, interference is suppressed more effectively.

In addition to the complete and semi-finished converters, the Browning Laboratories are furnishing tuning units, illustrated above, calibrated dials, detection and IF transformers, and punched steel chassis, for those who want to experiment with FM circuits and designs.

W1XPW BUILDS FM AUDIENCE

Pioneer Connecticut Station Has 12 Hours of Special FM Programs Daily

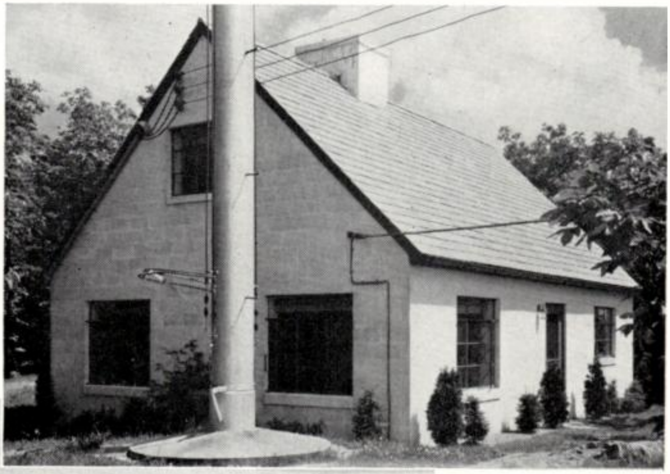
FM STATION W1XPW, under the management of Franklin M. Doolittle, who also operates WDRC, is doing an aggressive job of selling the advantages of the new broadcasting to one of the richest markets in America. Franklin Doolittle believes in FM as a superior medium of radio entertainment and advertising.

He has been active in broadcasting since its inception. Photographs in the offices of WDRC, at Hartford, portray his series of transmitters, going back to the time when he himself performed all the functions which now require an extensive and highly specialized organization.

He has brought the same enthusiastic and progressive spirit to his plans to improve further the service to radio listeners through FM transmission. Taking advantage of Meriden Mountain's 1,000-ft. elevation, located at the geographical center of Connecticut, he has erected there station W1XPW, views of which are shown in the accompanying illustrations.

Although this station has been used for various experimental and test purposes, notably in conjunction with Major Armstrong's relay transmissions originating at Alpine, the purpose of its installation was entirely commercial. To that end, a 12-hour daily schedule

HERE IS W1XPW'S TRANSMITTER HOUSE, ATOP MERIDEN MOUNTAIN. THIS VIEW ALSO SHOWS THE CONCRETE FOUNDATION OF THE 90-FT. STEEL MAST. A DETAILED VIEW OF THE ANTENNA TERMINATION IS SHOWN ON PAGE 39 OF THIS ISSUE



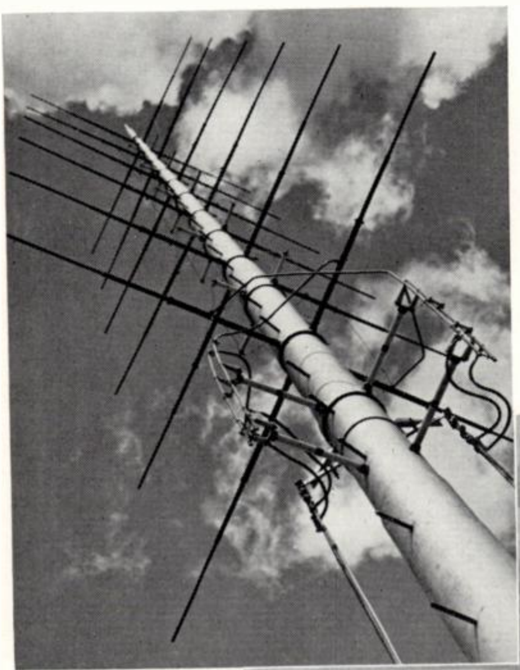
U. S. COAST GUARDSMEN SHOT A LINE FROM A LYLE GUN OVER THE FACE OF THE STEEP CLIFF, SO THAT TELEPHONE AND POWER CABLES COULD BE PULLED UP TO THE TRANSMITTER HOUSE, A UNIQUE FEAT IN TELEPHONE PRACTICE of special FM programs was inaugurated last September. At that time, Mr. Doolittle announced in the Connecticut newspapers that "W1XPW is starting this new schedule so that high fidelity programs will be available for demonstration purposes, and for reception by purchasers of FM sets."

In other words, instead of waiting until enough sets had been sold to constitute an FM audience, he very wisely took the position that programs, and plenty of them, must be on the air before the public would start to buy receivers. Then, to encourage the dealers in their efforts to merchandise FM, he set up a separate FM promotion and production department, headed by Robert M. Provan, Jr., laid out schedules a week in advance, and started a weekly program mailing to all radio dealers within the station's service area.

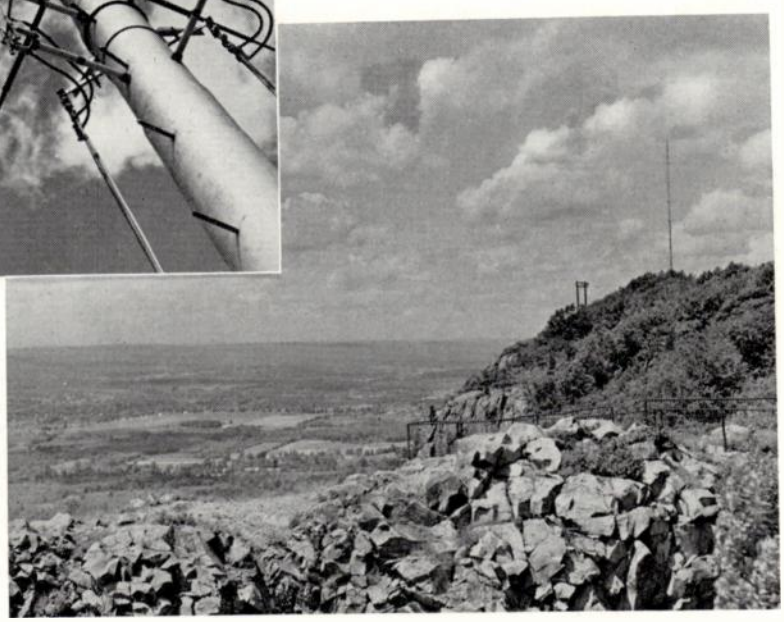
At the same time, he enlisted the coöperation of the newspapers in a publicity campaign to tell listeners about the greater enjoyment offered by FM reception. It must be admitted that the dealers were slow, at first, to take advantage of the efforts to open the market for FM receivers. Investigation showed that this was largely due to misunderstanding of announcements from the FCC that FM transmitters would not operate on a commercial basis until January 1st, 1941.

Salesmen representing radio manufacturers not in a position to deliver FM receivers also urged this point in their efforts to discourage dealers from undertaking FM sales, so that they would continue to concentrate their efforts on AM sets. Resulting confusion in the dealers' minds, and the all-too-clear recollec-

(CONTINUED ON PAGE 39)



ARRANGEMENT OF THE DI-POLES AS SEEN LOOKING UP THE 90-FT. MAST AT STATION W1XPW. ALTHOUGH THE OUTPUT OF THE TRANSMITTER IS ONLY 1 KW., THIS STATION HAS REMARKABLY FINE COVERAGE OF ALL THE INDUSTRIAL CENTERS IN THE STATE OF CONNECTICUT, DUE TO ITS ADVANTAGEOUS LOCATION



AT THE LEFT OF THE ANTENNA ARE TERMINALS FOR THE TELEPHONE AND POWER LINES WHICH DROP SHARPLY INTO THE VALLEY BELOW

FCC Rules and Regulations Amended to Permit Most Effective Coverage of Entire Nation by FM Stations—Industry Pleased by Fast Action

PREPARING to put FM broadcasting on the same commercial footing as the AM stations on January 1, 1941, the FCC has moved to simplify and clarify the Rules and Regulations already established governing high frequency [1] broadcasting transmitters.

Only a few months ago, it appeared that several years might elapse before the advantages of FM reception would be available to listeners throughout the nation. Now, it is not unreasonable to expect that probably 90% of the radio audience in the USA will be within range of FM stations by the end of 1941!

National Defense May Speed FM ★ While there has been no public discussion of preference for FM over AM broadcasting in connection with plans for national defense, it is quite likely that this may prove to be an important reason for speeding the erection of FM transmitters in cities within two or three hundred miles of the coastline.

Experience in Europe has shown that the dissemination of information by radio broadcasting stations is essential under war conditions. At the same time, such transmission is helpful to enemy ships and planes, since the transmitters serve as direction-finding points.

AM stations, even of moderate power, can be picked up several hundred miles out at sea. In contrast to that, FM signals have a definitely limited service area, beyond which they cannot be heard. From the military point of view, therefore, it would be advantageous to have all broadcast stations near the coast on FM rather than on AM transmission.

This may explain, at least in part, the efforts being made by the FCC to straighten out, as rapidly as possible, the remaining details for FM broadcasting on a national basis.

Purpose of the Revisions ★ The FCC has issued a bulletin explaining the purpose of the revisions. This is given in full here, together with the text of the revisions to the Rules and Regulations Governing High Frequency Broadcast Stations.

The full text of the original Rules and Regulations, comprising Subpart B from Part 3 of the FCC Rules appeared in *FM* Magazine, November 1940 issue.

Service Areas Revised ★ For the purpose of providing more effective use of the channels available for FM broadcast stations, the Commission has amended the Rules and Regulations Governing High Frequency Broadcast Stations so as to clarify the requirements as to the areas to be served. Under the amendment, the 35 channels are divided in three groups as previously. However, the extent of the service area of stations operating on these frequencies is defined more specifically.

The terms "basic trade area" and "limited trade area" are coined for the purpose of defining and establishing the area to be served by high frequency broadcast stations. In addition to these two areas, rural areas are also recognized as service areas. The meaning of rural area as used for this purpose is substantially the same as that defined by the Census Bureau except for certain modifications for radio purposes. Trade areas, both basic and limited, are selected as the best means of establishing the service of high frequency stations.

This basis has been selected because the limitation of the trade areas as established corresponds in general with the social and cultural interests of the community and also the area which a high frequency broadcast station can serve with good technical service both day and night corresponds in a large measure with the majority of such areas. The aggregate of all the basic trade areas includes the entire area of the United States and thus the entire population will receive service under the plan except where technically and economically it is not possible to render service throughout some areas.

Trade Areas ★ There will be approximately 625 basic trade areas. The Commission will establish the boundaries of these areas on the basis of a showing made by applicants and other Government economic radio coverage data. Special consideration will be given to the radio coverage limitations, but as far as possible, the retail trading area will be followed. Each area will have one or more stations designed to serve the entire area, but since the area may vary widely in size, the effective radiation (determined by antenna height, antenna gain and power) from stations in different areas will vary widely. To permit the stations in the large cities to extend their areas beyond the trade area would necessarily result in a situation where some areas which could otherwise support a station would not be able to do so, and as a result, the plan for uniform distribution of service where technically and economically feasible would be impaired.

Limited trade areas are established for the purpose of permitting service to cities and their trade areas so that the many cities which are not listed as principal cities of basic trade areas may have stations to cover the sphere of economic influence of such city. These areas

[1] All high frequency broadcast stations are now required to use frequency modulation.

in general are much smaller than basic trade areas and do not follow a uniform pattern throughout the United States but are determined by location of cities in their respective spheres of economic influence.

Twenty-two channels are assigned to be used by stations serving basic and limited trade areas in which the city in which the station is located has a population of over 25,000. Six channels are reserved for the basic and limited trade areas in which the city in which the station is located has population less than 25,000.

Recognized Maps ★ In case an application is submitted for a station to serve an area which has not been established and recognized by the Commission as a service area for high frequency broadcast stations, the applicant must submit the necessary data to permit the establishment of the area as a service area. In case of basic trade areas, a composite map should be made from the several sources on retail trading areas. The following are recognized sources of information: J. Walter Thompson (Retail Shopping Areas),[1] Hearst Magazines, Inc. (Consumer Trading Areas),[1] Rand McNally Map Company (Trading Areas),[2] and Hagstrom Map Company's Four Color Retail Trading Area Map.[3] If other reliable sources of information are available, they may also be drawn on the composite trade area map. This map may best be made on copy drawing paper with the area boundaries from various sources in different colors.

Stations designed to cover a limited trade area must also have an established service area. The Hagstrom Map Company's Four Color Retail Trading Area Map may best be used to assist in determining the service area.

Area Coverage ★ In covering a trade area, the transmitter must be so located that good service is delivered to the trade center of such area and the field intensity contour bounding the service area of the station should conform generally with established boundary of the trade area. In rugged terrain or sparse population, special consideration must be given to the service area in light of the engineering and economic factors involved. A station designed to serve a basic trade area in which the principal city constitutes one of the metropolitan districts, as determined by the Census Bureau, must deliver a signal of at least 1 mv/m throughout the business district of each city in the metropolitan district with population over 10,000.

Seven channels are assigned for stations designed to serve primarily large rural areas which cannot be served satisfactorily by stations serving basic and limited trade areas due to technical or economic limitations. These stations are permitted to serve principal cities or other cities provided that in giving this service, they do not sacrifice their rural service which the station is designated to serve. These stations cannot be located so that their service area coincides with limited or basic area station. The location ordinarily would utilize high topographical locations to permit of the coverage of large rural areas which must be at least 15,000 square miles except in special cases provided in the rules. The purpose of these stations is to round out the service to the rural area which these stations can supply, but could not be supplied by the stations designated to serve trade areas. The key to these stations is large rural coverage without competitive advantages over trade area stations.

By Section 3.223 (d), an area of unusual characteristics is recognized as a service area which does not fall under the pattern as outlined above. Such an area will be recognized as the service area of a station only in special cases where a definite need can be shown and where unfair competition will not arise. The general plan as outlined for the areas in Section 3.223 (a), (b) and (c) is necessary to give a well rounded out technical service and create a sound economic basis for allocation. This special service area is established only for the very unusual case which may arise but which must not result in a substantial departure from the purpose and plan in rendering service to the public by means of high frequency broadcast stations.

EFFECTIVE IMMEDIATELY

The Commission today adopted the following proposed amendments to its Rules and Regulations, effective October 2, 1940.

Section 3.222, subsection (f) of Section 3.224 and Section 3.225 of the Commission's existing rules are repealed.

New Sections 3.222 and 3.223 are added.

Sections 3.223 and 3.224 are renumbered as 3.224 and 3.225, respectively.

Subsections (g) to (l) inclusive of renumbered Section 3.225 are renumbered as subsections (f) to (k) respectively.

New Sections 3.226 and 3.227 are added.

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[1] Maps prepared by J. W. Thompson and Hearst Magazines, Inc., are contained in the Market Data Handbook of U. S. Domestic Commerce Service, No. 30, obtainable from Superintendent of Documents, Government Printing Office, Washington, D. C. Price $2.50 per copy. Also available from American Map Co., Inc., 16 East 42nd Street, New York City, and Hearst Magazines, Inc., Marketing Division, 57th and 8th Avenue, New York City.

[2] Available from Rand McNally Map Company, 536 South Clark Street, Chicago, Ill., at a cost of $11.00 in the paper edition.

[3] Available from Hagstrom Map Company, 20 Vesey Street, New York City, at a cost of $10.00 in the paper edition.

Existing Sections 3.226 to 3.229 inclusive are renumbered as 3.228 to 3.231, respectively.

New Section 3.225 is hereby amended to read as follows:

"(a) That the area which the applicant proposes to serve has the characteristics of an area described in Section 3.223 hereof."

HIGH FREQUENCY BROADCAST RULES

Sec. 3.222. Service Areas—Definitions ★ For the purpose of determining the areas to be served by high frequency broadcast stations, the following definitions apply:

(a) "Basic trade areas" and "limited trade areas" consist of areas the boundaries of which are determined by the Commission on the basis of showings made in applications as to retail trading areas or consumer trading areas and from government data.[1] Each basic trade area includes one "principal city." The boundaries of the basic trade areas are adjoining and the aggregate of all such areas is the total area of the United States. Each "limited trade area" includes one city. The boundaries of limited trade areas are not necessarily adjoining. Such areas may include portions of other limited trade areas and may extend into more than one basic trade area.

(b) "Principal city" means the largest city or the city or cities designated as "principal city" by the Commission, within a basic trade area. "City" means any city, town, or borough in a basic trade area except the principal city. Each "city" has a limited trade area.

(c) "Rural area" means all land area outside incorporated towns or cities with population greater than 2500 and where the density of population is less than 150 per square mile. Incorporated towns or cities with population from 2500 to 5000 without a high frequency broadcast station and not adjacent to larger cities may be considered rural area.

Sec. 3.223. Service Areas—Established ★ The Commission in considering applications for high frequency broadcast stations will establish service areas. Such stations will be licensed to serve areas having the following characteristics:

(a) An area comprising a limited trade area and a city. The station shall render good service to the city and its service area shall conform generally with the limited trade area.

(b) An area comprising a basic trade area and a principal city. The station shall render good service to the principal city and its service area shall conform generally with the basic trade area.

(c) An area of at least 15,000 square miles comprising primarily a large rural area, and particularly that part of basic trade areas which cannot be served by stations assigned basic trade areas due to economic and technical limitations. The service area may include one or more principal city or cities, provided that in rendering service to such cities, the service to rural areas which the station is designated to serve is not impaired. The transmitter of such a station shall be located in such a manner that the service area, (1) shall extend into two or more basic trade areas, (2) shall not conform generally with a basic trade area, and (3) shall not merely extend beyond a basic trade area.

(d) An area having substantially different characteristics (social, cultural, or economic) from those areas specified in subsections (a), (b) and (c) of this section where, by reason of special conditions, it is shown that a need (which cannot be supplied by a station serving areas under subsections (a), (b) or (c) of this section) for the proposed service both program and technical exists which makes the establishment of the service area in the public interest, convenience or necessity. The Commission will give particular consideration in this connection to competitive advantages which such stations would have over other stations established under other provisions.

(e) In case it is not economically and technically feasible for a station assigned a basic or limited trade area to serve substantially all such area, the Commission will establish the service area on the basis of conditions which obtain in the trade area.

(f) In case an applicant proposes a change in an established service area, the applicant shall make a full showing as to need for such change and the effect on other stations serving the area.

Sec. 3.226. Channel Assignments ★ The channels set forth below with the indicated center frequencies are available for assignment to high frequency broadcast stations to serve the areas provided in Sec. 3.223:

(a) An applicant for a station to serve an area specified in Sec. 3.223 (a) or (b), to be located in a principal city or city which has a

[1] There are several current and recognized authorities on retail trading areas or consumer trading areas from which the applicant may prepare its showing and to which the Commission will give consideration in making its determination. Among these recognized authorities are the following. J. Walter Thompson (Retail Shopping Areas), Hearst Magazines, Inc. (Consumer Trading Areas), Rand McNally Map Company (Trading Areas), and Hagstrom Map Company's Four Color Retail Trading Area Map. Although the foregoing sources of data are expressly recognized, the Commission will also give consideration to data furnished from other sources which may have probative value on which the applicant may desire to prepare its showing. See separate release of the Commission on "Concerning Application For High Frequency Broadcast Stations."

population less than 25,000 (city only) shall apply for one of the following channels:

48900	49500
49100	49700
49300	49900

(b) An applicant for a station to serve an area specified in Sec. 3.223 (a) or (b), to be located in a principal city or city which has a population greater than 25,000 (city only) shall apply for one of the following channels:

44500	45900	47500
44700	46100	47700
44900	46300	47900
45100	46500	48100
45300	46700	48300
45500	46900	48500
45700	47100	48700
	47300	

(c) An applicant for a station to serve primarily a large rural area, specified in Sec. 3.223 (c) or an area specified in Sec. 3.223 (d) shall apply for one of the following channels:

43100	43900
43300	44100
43500	44300
43700	

Sec. 3.227. Special Provisions Concerning Assignments ★

(a) Stations located in the same city shall have substantially the same service area.

(b) High frequency broadcast stations shall use frequency modulation exclusively.

(c) Stations serving a substantial part of the same area shall not be assigned adjacent channels.

(d) One channel only will be assigned to a station.

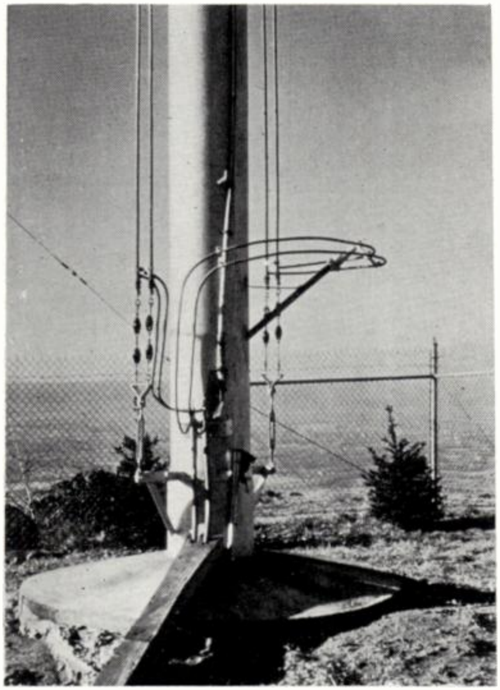
W1XPW BUILDS FM AUDIENCE

(CONTINUED FROM PAGE 35)

tion of television promises unfulfilled, unquestionably caused many dealers to think that FM, too, might be still in the experimental stage, something of the indefinite future.

Slowly, however, the idea of FM as a demonstrated success and an accomplished fact became a conviction in the minds of the Connecticut radio dealers. This was further confirmed when the newspapers started to print the daily FM programs on their radio pages. Some, of course, with heavy commitments already made on the purchase of higher-priced AM sets in anticipation of the Christmas trade, simply could not undertake to merchandise FM-AM models for fear of jeopardizing their AM sales. These stores, however, are watching their stocks carefully, in preparation for swinging over to FM-AM receivers as soon as they are out from under.

Receiving conditions in Connecticut are not favorable to AM reception. Local interference is extremely bad in many of the busy industrial centers. This is generally attributed to leaking power lines, and equipment which has long needed replacement. In those sections, FM shows up to great advantage. Waterbury, like other Connecticut cities, is located in a river valley, where surrounding hills make AM reception difficult, yet W1XPW gets in with a signal strong enough to give absolutely perfect reception during severe summer thunderstorms. A very large part of the credit for FM's rapid progress in this state is due to the aggressive efforts of W1XPW. As Mr. Doolittle said in a recent article published by the Hartford Times: "Very shortly, the first question asked about a radio receiver will be: Has it a frequency modulation band?"



ANTENNA TERMINATION AT STATION W1XPW

Under Commission rules and regulations FM stations are available to every community. They are not subject to the same interference as standard broadcast stations and, therefore, can operate on the same channel with less mileage separation. However, FM stations serving the same area are not assigned adjacent channels.

TECHNICAL DATA ON SCOTT MODELS

Part 1—Information on FM Tuner and FM-AM Sets—by Marvin Hobbs*

THE Scott FM tuner and combinations are superheterodyne receivers covering a tuning range of 41 to 50 megacycles for wide band frequency modulation reception. The same basic FM circuit is used in all models and the RF sections are identical, except in the Philharmonic where two RF stages are used to provide exceptionally high image and spurious signal rejection ratios. Hence the FM performance characteristics do not differ appreciably and the same alignment procedure may be followed for any of the models.

Special circuit developments include a voltage and temperature stabilized oscillator system, a high frequency IF for maximum image signal rejection ratio, high sensitivity level for limiting at low signal levels, cascaded limiting stages for maximum range of flat limiter action, cathode ray tuning indication, eight tuned circuits at the intermediate frequency for high adjacent channel signal attenuation, an RF gain control to prevent overloading at high signal levels, and an air-tuned discriminator circuit of high sensitivity.

The receiver chassis of the FM tuner is shown in Fig. 1. The Phantom DeLuxe (28 tubes FM-AM), and the Philharmonic (33 tubes FM-AM) are shown in Figs. 3 and 4 of Part 2. In the FM-AM models the FM section is a completely separate receiver from the antenna to the detector output terminals and none of its tubes or components is used in common with the AM section with the exception of the voltage regulator and sensitivity control.

TECHNICAL FEATURES

Antenna Input Circuit ★ The coupling between the primary and secondary of the antenna transformer is such that a di-pole or lead-in impedance of 75 to 100 ohms is suitably matched for optimum results. By disconnecting the jumper wire from one side of the primary wind-

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

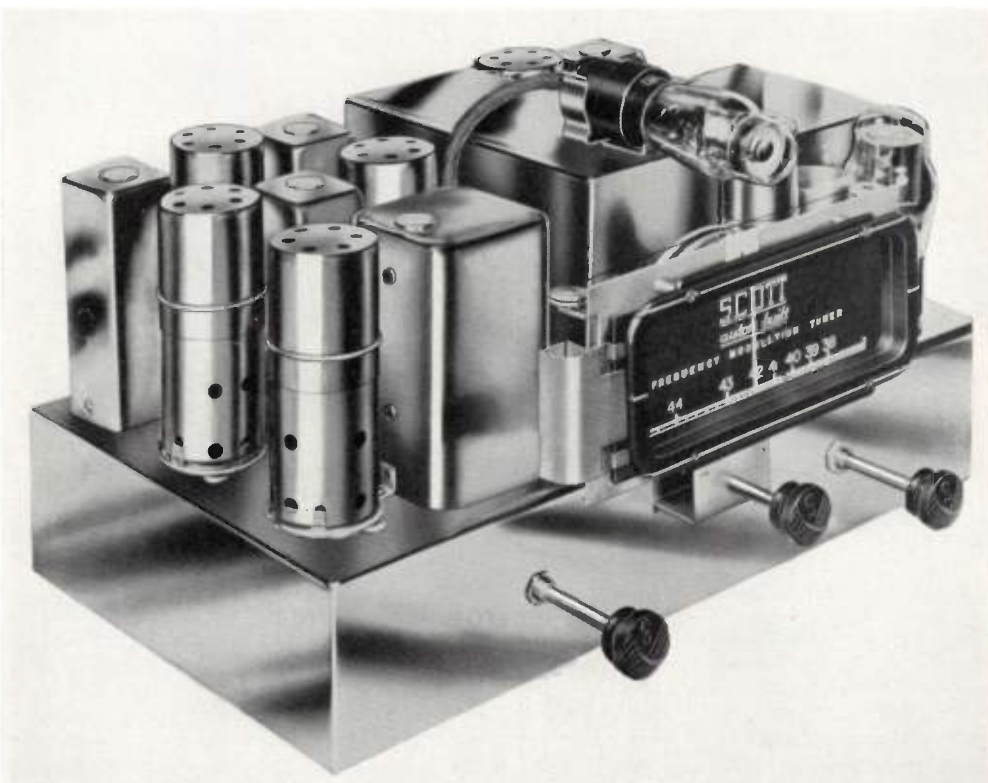


FIG. 1. CHASSIS OF THE SCOTT FM TUNER IS COMPLETE UNIT, WITH BUILT-IN AC SUPPLY

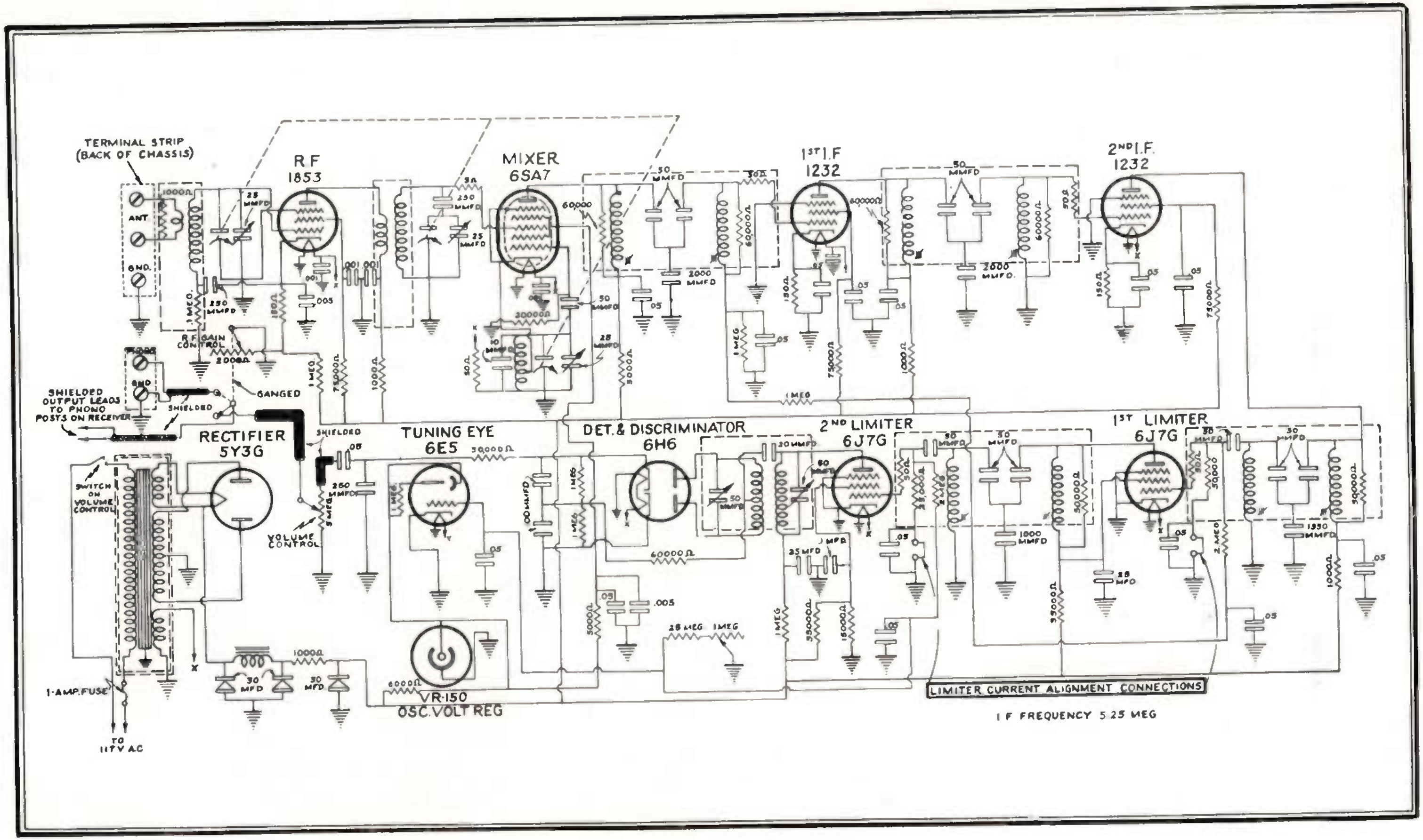


FIG. 2. SCOTT FM TUNER

THIS FM TUNER WAS DESIGNED PRIMARILY FOR USE WITH SCOTT AM RECEIVERS, ALTHOUGH IT CAN BE EMPLOYED TO OPERATE ANY HIGH QUALITY AUDIO AMPLIFIER AND SPEAKER SYSTEM. THE CIRCUIT OF THE TUNER IS ESSENTIALLY THE SAME AS THE FM END OF THE SCOTT FM-AM PHANTOM DE LUXE AND PHILHARMONIC RECEIVERS ing to the chassis a floating di-pole or doublet connection is provided to minimize capacitive coupling for noise picked up in the lead-in. If a single-wire horizontal or vertical antenna is used, the antenna input is connected to the terminal remote from ground and the one adjacent to ground is connected to that point by means of the jumper wire. However, the balanced di-pole connection is recommended for maximum signal-to-noise ratio.

In the FM Tuner, the input conductance of the 1853 tube is neutralized to a certain extent by connecting the grid return condenser of the antenna transformer secondary to the cathode terminal of that tube. This circuit is not used in the combination receivers, because the leads required for it are too long to avoid instability in production sets. Input conductance neutralization increases the effective shunt resistance across the input circuit and allows it to function with higher gain and selectivity. The result is more sensitivity and a better image ratio.

The RF Stage ★ In all models an 1853 high Gm. tube is used for RF. amplification. Its output impedance operates into a bifilar winding tightly coupled to the secondary circuit feeding the mixer tube. The variable mu characteristic of the 1853 is employed to advantage in the control of the RF gain by a variable bias resistor. Ultra high frequency circuits are much broader for a given frequency deviation from resonance than low frequency circuits and strong signals are more likely to produce spurious responses. Hence, in the presence of strong FM signals it is advisable to reduce the RF gain to avoid repeat signals on the dial. This function is accomplished by the left hand control on the Tuner and the conventional sensitivity control on all of the FM-AM combinations, except the Philharmonic. In this receiver two RF stages using 1853 tubes are employed and a somewhat higher attenuation of unwanted signals is present, with the result that spurious responses are not serious and an RF gain control is not necessary there.

Mixer and Oscillator ★ A 6SA7 tube is used as a mixer and oscillator because of its relatively good behavior in the ultra high frequency band when compared with other composite tubes. Loading of the input circuit is to be avoided and in this respect the 6SA7 is good.

The triode section can be made to oscillate readily and with good stability at 41 to 50 megacycles. By providing temperature compensation of an element of the oscillator circuit capacity, a high degree of stability of the oscillator frequency with respect to time can be maintained. A rapid type of compensation is provided by placing a small heating resistor in close proximity with the compensating condenser. (See 50 ohm resistor and 10 mmfd. condenser in the oscillator circuit.) It is also important that the oscillator frequency shall not shift with variations in the strength of the received signal. The 6SA7 oscillator-mixer combination is excellent in this respect.

The oscillator frequency is below the frequency of the incoming signal to avoid image signals from television transmitters and to maintain greater stability.

Stability with respect to line voltage is insured by supplying the oscillator plate voltage through a VR150 voltage regulator tube.

IF Amplifier ★ The intermediate frequency used in all Scott FM sets is 5.25 megacycles.

The first two IF stages employ high Gm 1232 type tubes and provide a large share of the gain and selectivity at this frequency. Each circuit is inductively tuned by low-loss powdered iron cores and primary and secondary fixed silvercap tuning condensers are capacitively coupled by common fixed condensers to reduce the effects of tuning upon the coupling of each transformer. While there is a small amount of inductive coupling between the primary and secondary windings, the larger percentage of the coupling is derived from the common capacity between each grid and plate tuning condenser.

Each circuit is loaded with the correct amount of resistance to obtain the proper selectivity and to avoid transient distortion possible with a frequency modulated signal.

The third and fourth IF stages are somewhat similar to the first two, but differ by the fact that they act as limiting amplifiers, thus performing a function peculiar only to frequency modulation receivers.

Limiting Stages ★ The third and fourth IF stages, or the first and second limiters respectively, employ 6J7G tubes, whose characteristics are most suitable for providing a flat limiting action once the signal has reached sufficient amplitude to cause this characteristic to come into play. By using a cascade arrangement of these tubes, weak signals can produce limiting action at the second limiter and stronger signals cause both limiters to act on various impulse noises, such as ignition and arcs.

A factor of considerable importance in the limiting of ignition and other fast types of impulse noise is the time constant of the limiter grid leak-condenser combination. The first limiter has a grid circuit time constant of 2.5 microseconds and the second has a constant of 1.25 microseconds, thus insuring a fast action on noises possessing a steep wavefront.

A perfect degree of limiter flatness, once the action begins, is obtained by the proper choice of limiter plate and screen grid voltages.

(TO BE CONCLUDED IN FORTHCOMING ISSUE)

FM HANDBOOK

Chapter 2: The Transmission of FM Signals

BY GLENN H. BROWNING

THE fundamental concepts of frequency modulation and the advantages thereof have been discussed. The next step in the study of FM concerns the actual production of frequency-modulated signals, the apparatus and principles involved.

Reactance Tube Method ★ Probably the simplest method of frequency-modulating a carrier is the reactance tube method. The principle on which the reactance tube operates is well known to many servicemen as well as others, for it was used in radio receivers employing automatic frequency control. The circuit of an oscillator, frequency-modulated in the above manner, is shown in Figure 1.

The function of the reactance tube circuit is to change the frequency of the oscillator when an audio voltage is impressed between grid No. 3 and ground of the 6L7 tube. The frequency change will depend upon the amplitude of the audio signal, not upon the audio frequency. The circuit is so designed that the tube acts as a variable inductance connected across the oscillator. That is, the current taken by the tube lags the oscillatory voltage by substantially 90 electrical degrees. The amount of current taken depends upon voltage impressed on grid No. 3, and thus the effective inductance is varied by the audio signal. (The only difference between a large and a small inductance with the same Q is the amount of current which would flow due to a given impressed voltage). This result is accomplished by developing a voltage E_1 across C, which lags the oscillator voltage E by approximately 90° and placing this voltage E_1 on the control grid of the 6L7 tube which in turn changes the plate resistance so that the tube draws a lagging current.

Frequency Stability ★ The simple transmission system explained above could readily be used for broadcast transmitters (the RF frequency-modulated signal of course would have to be amplified to the required power) were it not for one fundamental difficulty, that of frequency stability. This is probably the foremost practical problem which is encountered in the design of FM broadcast transmitters. This term "frequency stability" has a slightly different meaning in the case of frequency-modulated transmitters, for in this case it refers to the average or center frequency about which the frequency deviation occurs which, of course, should be the carrier frequency when there is no modulation.

Since the advent of widespread use of frequency modulation for broadcast service, several types of transmission systems have been devised to fulfill the requirements of frequency stability. The end result of each of the systems is to produce a frequency-modulated wave. The frequency deviation in each system depends upon the amplitude of the audio modulation, and the rate at which the frequency deviation occurs depends on the audio frequency. The carrier deviation so produced is

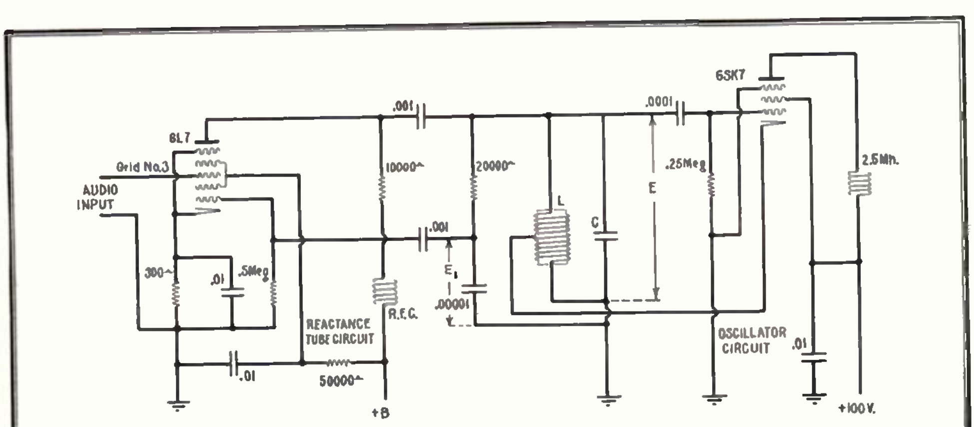


FIG. 1. ELEMENTARY CIRCUIT FOR FREQUENCY MODULATION OF AN OSCILLATOR CIRCUIT

illustrated in Fig. 2, which shows the relationship between the audio modulation voltage and the radio frequency of the transmitter. This figure illustrates the characteristics of the transmitted wave for the case of pure frequency modulation. In actual practice the high frequencies of the audio spectrum are pre-emphasized in order to obtain a better signal-to-noise ratio. In other words, the higher audio frequencies are amplified to a greater extent than lower audio frequencies by some predetermined amount. This allows de-emphasis of highs by a suitable network in the receiver, whereupon

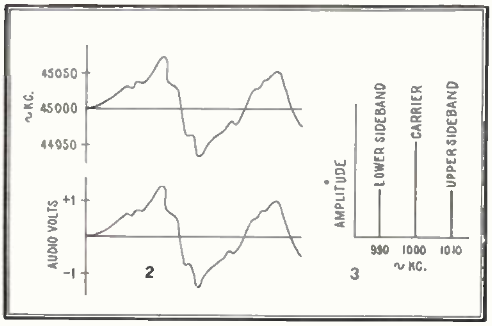


FIG. 2, LEFT. AUDIO MODULATION OF CARRIER
FIG. 3, RIGHT. 100% AMPLITUDE MODULATION

natural reproduction is obtained with less hissing noise.

Transmitter Characteristics ★ The characteristics which a FM transmitter must possess to give satisfactory broadcast performance are as follows:

First the modulator must be capable of producing a frequency deviation of the carrier frequency corresponding to 100% modulation. In the case of FM the term 100% modulation has an entirely different meaning than in the case of amplitude modulation. For AM transmission, 100% modulation represents a very definite limit which cannot be exceeded without producing objectionable poor quality. In the case of FM, however, 100% modulation is an arbitrary limit of frequency deviation specified by the FCC in order to have some standard so that all transmitters and receivers can be designed to definite specifications. Should a FM transmitter be modulated by a greater amount than that specified as 100% modulation, there would be no loss of audio fidelity, and the increase in required band-width is not as serious. The necessity of a transmitter possessing a capability of 100% modulation for FM is due to the requirement of a large frequency swing if the signal-to-noise ratio is to be kept high. The FCC has allowed a maximum deviation of 75 kc., and this value constitutes 100% modulation in the systems used at present.

The second characteristic which must be present in a FM modulation system is stability of the mean carrier frequency, or center frequency. This has been discussed already.

The other necessary characteristics are those of minimum distortion of the audio signal and low hum level. Inasmuch as the FM transmissions are inherently capable of greater fidelity and dynamic range than those of amplitude modulation broadcasts, it is essential that distortion and hum be kept to an absolute minimum.

The FM Spectrum ★ The method of analyzing an *amplitude-modulated* signal into a carrier and side bands is well known. The results of such an analysis show that if the audio modulation is a single frequency sine wave, three frequencies are required for faithful transmission. These three frequencies consist of the carrier, and the upper and lower side bands respectively. Each side band frequency is displaced from the carrier by a number of cycles equal to the audio frequency being used to modulate the transmitter. The maximum value which the side bands can have is one-half that of the carrier. Regardless of the amount of modulation, up to 100%, the amplitude of the radiated carrier is constant and equal to the amplitude of the carrier when unmodulated. The side bands may have any amplitude between zero and one-half the carrier, depending upon the percentage modulation. The case of 100% amplitude modulated wave is illustrated in Fig. 3, which shows the carrier and the two side bands which result when a 1,000-kc. carrier is 100% modulated by a 10,000-cycle sine wave.

If a similar analysis is applied to a *frequency-modulated* wave a much more complicated spectrum is found to exist.[1] It is found that instead of only two side bands as in the case of amplitude modulation an infinite number of side bands are produced. This characteristic has been known for many years and probably tended to discourage any interest in FM, as its noise-free properties were not recognized, and it was generally believed that it would be impossible to employ FM for broadcasting due to the large number of side band frequencies required. As we shall see presently, however, such is not the case.

Not only does the FM spectrum possess an infinite number of side bands but the carrier does not have a constant value as in the case of AM transmissions. Instead, the value of the carrier depends on the modulation index which is defined as the ratio of the frequency deviation to the audio frequency. Thus, if the fre-

[1] Amplitude, Phase, and Frequency Modulation, Hans Roder, *IRE*, Dec. 1931.

quency deviation is represented by Δf and the audio frequency is fa the modulation index m is defined by $m = \frac{\Delta f}{fa}$. For instance, if a carrier is modulated with an audio frequency of 10 kc. and caused to deviate 75 kc. either side of its average value, the modulation index m is 7.5.

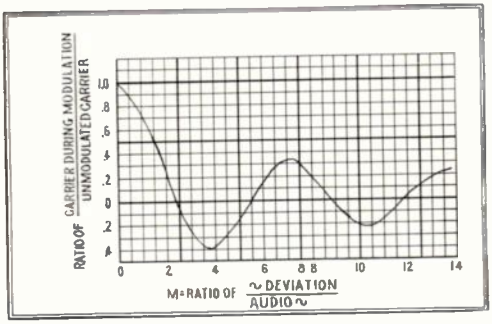


FIG. 4. CARRIER AMPLITUDE PLOTTED AGAINST MODULATION INDEX

Fig. 4 shows a plot of the carrier amplitude against the modulation index. Negative values on the plot merely indicate a phase reversal. It can be seen that the carrier fluctuates and that for certain values of the modulation index the carrier is actually zero. A few of the values for the modulation index at which the carrier is zero are 2.405; 5.520; 8.654; 11.792. Theoretically, it is true that an infinite number of side bands are broadcast by a FM transmitter, but this does not necessarily mean that a large amount of energy will be radiated in the higher side bands. The amplitude of the side bands greater than a certain frequency deviation from the carrier will be negligible in comparison with the unmodulated carrier amplitude. Thus, a FM transmitter may be said to require a certain band width in the ether just as does an AM transmitter. The band width actually required depends on whether the frequency deviation of the carrier is greater or less than the audio modulating frequency.

That is, whether m is greater or less than unity. If the frequency deviation of the carrier is less than the highest audio frequency employed, the band width required is equal to twice the highest audio frequency. If the frequency deviation of the carrier is greater than the highest audio frequency, the band width required is equal to twice the carrier deviation. With wide-band FM as used in present day broadcasting, the latter case is the one which applies. The band width required is thus twice the carrier deviation.

When it is said, however, that the side bands beyond the so-called "necessary band width" are reduced to a negligible value the question immediately arises as to what constitutes a negligible value. For instance, if a 75-kc. deviation is employed for broadcasting a 15-kc. audio frequency, the amplitude of the side bands at the edge of the "required frequency band" is .261 that of the unmodulated carrier.[2] This is certainly not negligible if another carrier is operating 150 kc. away. In the allocation of channels by the FCC, carriers of stations in the same service area are not placed closer than 400 kc. Full modulation, 75-kc. deviation, is then permissible for all audio frequencies up to 15 kc. without any possibility of interference.

Types of Transmission Systems. ★ It has already been pointed out that regardless of the type of transmission system employed, the end results must be the same. There are, however, various methods by which a frequency-modulated wave can be produced. The first of these is that developed by Major Armstrong.[3] This system is shown in block diagram form in Fig. 5. It consists of a crystal-controlled oscillator, the output of which is fed to complementary grids of a balanced modulator. The audio frequency

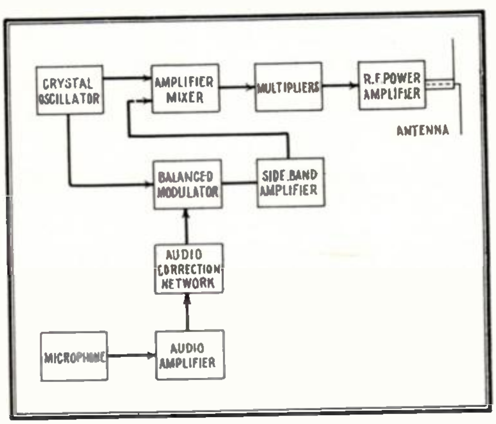


FIG. 5. BLOCK DIAGRAM OF PHASE MODULATION TYPE OF FM TRANSMITTER

is fed in push-pull to the second set of grids. In the output of the modulator, the carrier is absent and only the side bands exist. These side bands are then mixed with the carrier of the crystal oscillator in an amplifier. Such a system results in phase modulation of the carrier rather than in frequency modulation. Mathematically, phase modulation is similar to frequency modulation except that the devia-

[2] Modulation Limits in FM, L. J. Black and H. I. Scott, Electronics, Sept. 1940.

[3] A Method of Reducing Disturbances in Radio Signaling By a System of Frequency Modulation, E. A. Armstrong, *IRE*, May 1936.

tion of the carrier for constant audio amplitude is proportional to the audio frequency. Thus a 10-kc. audio frequency of a given amplitude will produce 10 times the carrier frequency deviation as that produced by a 1-kc. audio frequency of same amplitude. It is apparent that if the audio input to the modulator is first passed through a network whose output is inversely proportional to the audio frequency, the resulting signal will be of the true frequency modulation type.

With this system a phase shift of only about 30 degrees can be tolerated in the initial modulator if the audio fidelity is to be good. Inasmuch as a phase shift of 360 degrees is required for a frequency deviation of one cycle, and a 75-kc. deviation is required for full modulation, it is obvious that the output of the modulator must be multiplied many times. In actual practice this is usually accomplished by starting with an oscillator of relatively low frequency and multiplying to a high frequency, beating with a fixed oscillator down to a low frequency again, and then repeating the multiplication process.

The Armstrong system possesses the advantage of having a crystal controlled oscillator as the frequency standard. The frequency stability therefore is as good as that of the crystal used. The large number of multiplications required result in some complexity of design, but this has not proved a great problem in production once the design details have been worked out. Receiving tubes can be used for all of the multiplier stages except the last few, which develop excitation for the final amplifier.

A second method of transmission was proposed by M. G. Crosby of RCA. This method, illustrated in block form in Fig. 6, is simpler than the Armstrong system. It employs a reactance tube and is essentially the same as the method first described, but includes means for obtaining frequency stability. This is accomplished by mixing the output of the modulated oscillator with the output of a crystal oscillator and feeding the beat frequency obtained to a discriminator circuit which is similar to those employed for automatic frequency control purposes. The output of this discriminator is fed through a network having a relatively large time constant, so that it will not respond to audio frequencies, to a grid of the reactance tube modulator. This provides a bias which tends to correct any frequency drift of the modulated oscillator. A relatively large frequency deviation can be produced in this way resulting in a smaller number of multiplications being required. The disadvantages in the system lie in the difficulty of maintaining the required frequency stability and in difficulties in eliminating hum which can quite easily affect such a system.

A third system[4] of frequency modulation has recently been proposed by the Bell Telephone Laboratories. If the amplitude of the side-band frequencies is small compared to the carrier, the carrier deviation is small compared to the audio frequency. This can be used to advantage to provide a means of stabilizing the output frequency of the reactance tube modulator. The resultant frequency modulated signal is beat down by means of a series of frequency dividers. The final frequency is made relatively low so that the carrier frequency is large compared to the side frequencies. The low frequency carrier thus obtained is fed to one set of windings of a motor. The other set

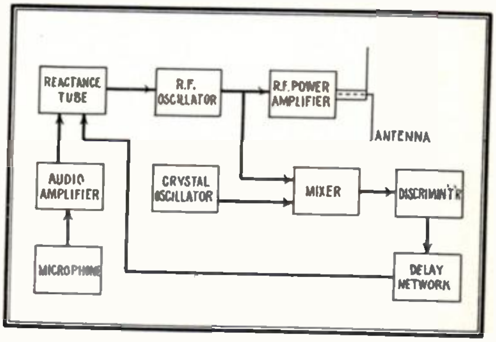


FIG. 6. ANOTHER TYPE OF FM TRANSMITTER

of windings is fed by the output of a crystal oscillator. The motor is mechanically coupled to the shaft of the original modulated oscillator. By this means if the carrier frequency deviates in phase or frequency from the output of the crystal, the motor will rotate in such a direction as to bring the two voltages again into phase. This system results in a stability which is the same as that of the controlling crystal. The advantages of the reactance tube modulator are thus realized and a large frequency deviation with low distortion can be obtained in the original modulator.

All FM transmitters regardless of their type have certain advantages which are inherent in the transmission system itself. These advantages all accrue from the fact that the radio frequency amplitude does not vary and that the power output has the same instantaneous value whether the carrier is modulated or unmodulated. This means that the final amplifier can be run straight class C with the resulting high efficiency of operation. As no bulky or costly high-powered audio modulating stages are required, a material saving results.

Wide-band frequency modulation has the advantage of a better signal-to-noise ratio than narrow-band frequency modulation. It will be

[4] Synchronized FM, by W. H. Doherty, *FM* Magazine, Dec. 1940.

recalled that the frequency deviation is directly proportional to the sound intensity striking the microphone. If there is any noise which is not eliminated by the limiter and the detection circuits in the receiver, this same amount of noise will be present regardless of the audio signal. Consequently the greater the audio signal (greater the carrier deviation), the better signal-to-noise ratio. Statements have been made that there is actually less noise in wide-band frequency modulation than there is in narrow-band frequency modulation. Such is not the case, as the amount of noise received is the same with equal signal strengths. However, the signal-to-noise ratio is improved, as the frequency swing is increased.

APOLOGIES TO FREED RADIO

THE name of Freed Radio Corporation was inadvertently omitted from the list of Armstrong licensees published in the November issue of *FM* Magazine. We apologize sincerely for this error, and for any embarrassment it may have caused Freed Radio.

As a matter of fact, this Company was one of the first FM licensees, and has been active in marketing two FM-AM sets — one a table model, and the other a console, both using a 14-tube AC-DC chassis. The former model is shown in the picture of R. H. Macy's FM display, at the right, on page 10 of this issue of *FM* Magazine.

Freed Radio is publishing an FM News Bulletin containing much information for dealers, who are planning to handle or are now carrying FM receivers. Such dealers should send a postcard request to have their names put on the mailing list. There is no charge for this very useful news service. The Freed Radio Corporation plant is located at 39 West 19th Street, New York City.

RED LIGHT AHEAD

(CONTINUED FROM PAGE 13)

strong completed his development of frequency modulation. Let us see what influence it will have toward counteracting the substitution of phonograph records for radio programs. (1) FM not only eliminates natural and man-made static noises during reception of local stations but from stations at distances too great for acceptable reception of regular AM transmission. (2) There is no irritation from background noise since FM eliminates all such interference on reception within the normal receiving radius. Under such conditions, FM receivers give essentially complete and perfect reproduction of the original music. (3) FM particularly preserves the original character of women's voices, without loss or alteration. (4) A greater number of FM stations can operate without interference within a given area, and deliver perfect reception to listeners within that area, than is possible with AM broadcasting. (5) Since all types of programs are reproduced accurately by FM receivers, there is no tendency toward using FM for news reception only. (6) With FM reception, it is not necessary to use records in order to get enjoyable musical programs, free of interference.

Opportunity for Revision ★ Can't something be done about correcting conditions now prevailing without a change so drastic as to require the use of new transmitters and receivers? Yes, some things could be done, but the time and effort required at this stage make the outcome uncertain. Moreover, the fundamental limitations of AM broadcasting would remain.

Radio manufacturers have convinced the public that sets priced at $9.95 to $29.95 deliver the best there is in broadcast reception, and listeners are adjusting their habits accordingly. Since they cannot get their entertainment by radio, they are using records. Most of these records are produced, incidentally, by companies affiliated with the two largest broadcasting chains.

No, nothing less than a drastic change in the whole radio set-up will work fast enough to be effective. Such a change must, above all, meet the competition of phonograph records. Frequency modulation broadcasting not only affords all the means for correcting adverse conditions which now prevail, but offers the only method for furnishing home musical entertainment superior to that obtained from records!

Closer cooperation between broadcasters and set manufacturers in years past would have headed off the progressive degeneration of radio reception. It is essential to the future of both broadcasting and set manufacturing that these two forces work together in using FM to maintain radio's preeminent place as a source of entertainment in American homes.

FCC ISSUES 15 FM PERMITS

Nation-Wide Spread of FM Started by FCC's Action on October 31st

MORE than 27,000,000 people are included in the service areas of 15 FM broadcast stations authorized by the FCC on October 31st. Thus, in 10 states, from New England to the Pacific Coast, and from the Great Lakes to the Gulf, high-quality, static-less radio entertainment will become available to listeners. These stations, authorized to operate "on a commercial basis as soon as they are ready to do so," are:

The Evening News Association
Detroit, Michigan
44.5 megacycles; 6,820 square miles; population, 2,498,000

Don Lee Broadcasting System
Los Angeles, Calif.
44.5 megacycles; 6,944 square miles; population, 2,600,000

Baton Rouge Broadcasting Co.
Baton Rouge, La.
44.5 megacycles; 8,100 square miles; population, 361,400

Radio Service Corp. of Utah
Salt Lake City, Utah
44.7 megacycles; 6,230 square miles; population, 194,000

Zenith Radio Corp.
Chicago, Illinois
45.1 megacycles, 10,760 square miles; population, 4,500,000

The Yankee Network
Atop Mt. Washington, N. H.
43.9 megacycles; 31,000 square miles; population, 2,000,000

The Journal Company
Milwaukee, Wisconsin
45.5 megacycles; 8,540 square miles; population, 1,522,000

National Broadcasting Co.
New York City, N. Y.
45.0 megacycles; 8,500 square miles; population, 12,000,000

William G. H. Finch
New York, N. Y.
45.5 megacycles; 8,500 square miles; population, 12,000,000

Marcus Loew Booking Agency
New York, N. Y.
46.3 megacycles; 8,500 square miles; population, 12,000,000

Frequency Broadcasting Corp.
Brooklyn, N. Y.
45.9 megacycles; 8,000 square miles; population, 11,000,000

Evansville On the Air, Inc.
Evansville, Ind.
44.5 megacycles; 8,397 square miles; population, 465,000

Howitt-Wood Radio Co., Inc.
Binghamton, N. Y.
44.9 megacycles; 6,500 square miles; population, 256,300

WBNS, Inc.
Columbus, Ohio
44.5 megacycles; 12,400 square miles; population, 1,100,000

Capitol Broadcasting Co., Inc.
Schenectady, N. Y.
44.7 megacycles; 6,589 square miles; population, 967,700

Concerning this action, Chairman James Lawrence Fly said, "The granting of these licenses marks an important milestone in the continued advance of the radio industry." This emphasizes the statement of the FCC that: "On the basis of testimony by engineers of both the radio manufacturing and broadcast industries, the Commission heralds the business debut of FM as inviting the public demand for service and sets, which will have a stimulating effect on programming as well as on the purchase and maintenance of new equipment."

With these 15 applications granted, there are still 36 awaiting action. These, according to an FCC spokesman, "will be acted upon at the earliest opportunity." Some of the 36 pending applications have been returned for changes, a number are awaiting clearance by the Civil Aeronautics Board which must pass upon the location of antenna towers, and others are in process of routine examination by various FCC departments.

It should be noted that, in this list, the new stations are not rated by power but by the area into which they will put a signal "not subject to objectionable interference or objectionable fading." Owing to topographical conditions, the service area may not be exactly circular, but for rough approximations it can be considered so. Thus, a service area of 6,820 square miles represents a transmitting radius of about 46 miles; 8,500 square miles indicates a radius of about 52 miles; 31,000 square miles indicates a radius of about 100 miles.

The other significant figure given is the population within each service area, as that indicates the potential market to be reached by FM program sponsors, and for the sale of the new receivers. The total population included in the service areas of these 15 stations is 27,000,000 or one-fifth of the population of the entire Country.

An official Bulletin from the FCC states: "To obviate possible monopoly, and to encourage local initiative, no person or group is permitted to control more than one FM station in the same area, and not more than six in the country as a whole."

May We Suggest to the

AM BROADCASTERS:

In the November 1st issue of "Broadcasting," a four-page advertisement of the Columbia Broadcasting System starts with the statement: "There is a word that has become lost in the world of radio." What is that word? It is then disclosed in the question: "How long since you've heard anybody use the word SMALLER about radio?"

Of course, we know that the man who wrote this copy was thinking about broadcasting, for that is what CBS sells. And we know that the copy was directed to advertising managers and agency executives, for they buy broadcasting.

It is undoubtedly true that those who sell, and those who buy broadcasting haven't used the word SMALLER for a long time.

But there are some other people in this radio business to whom SMALLER is no lost word. These people may be forgotten men to those who sell and buy programs, but they are the ones upon whom both broadcasters and sponsors depend for getting radio reception into American homes.

They are the dealers and the servicemen. SMALLER is no lost word to them! They use it dozens of times a day. They use it to refer to the size of radio sets, to the prices of radio sets, to the profits realized from the sale of these sets, to the ability of these sets to give satisfactory service to listeners, and to afford an adequate choice of programs.

Most important of all to those who sell and buy broadcasting, they use the word SMALLER in referring to the ability of radio sets to reproduce in the homes of listeners the programs delivered to the studio microphones!

Dr. Ray H. Manson, vice president of Stromberg-Carlson, meant just that when, discussing the performance of home radio sets before a convention of telephone engineers, he stated: ". . . the cost of the receiver is in proportion to the audio capabilities provided."

To this we add: To advertisers, the value of any listener is in proportion to the audio capabilities (price) of his radio receiver. SMALLER should not have become a lost word to sellers and buyers of radio programs for two reasons.

(1) In homes where good reception is appreciated, current radio models are now bought and used mainly for getting news flashes.

(2) With $9.95 sets sold at 25c per week, families supported by Federal relief and WPA can and do relieve the monotony of their leisure hours by listening to radios they can all afford now.

MAY WE SUGGEST to AM broadcasters that, with radio set prices and audio capabilities at their present low level, audience surveys, if they are to measure markets significantly, must take into account the quality of reception in listeners' homes, for in that respect SMALLER is rapidly becoming a bigger word!

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

RUMFORD PRESS
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