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DIRECTED TO BROADCAST ENGINEERS AND EXECUTIVES

Latest White House Comments on American Broadcasting

Wendell L. Willkie's Statement on American Broadcasting

SEPTEMBER » [FM Issue] « 1940

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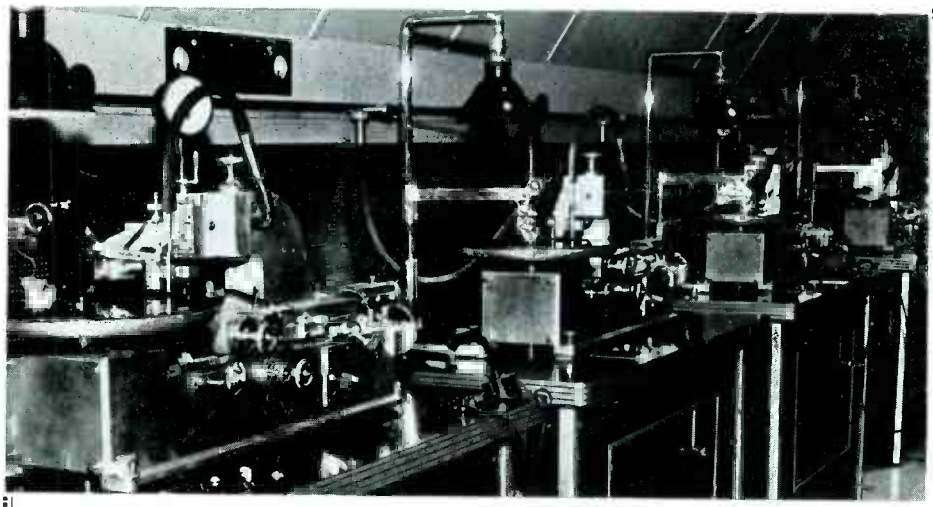
OUR COVER

The Democratic National Convention of 1940, at Chicago, showing the NBC Red Network booth at the left, and the Blue Network booth at the right. Left to right are Engineers A. A. Cooper, H. T. Ashworth, and G. M. Hastings, of New York, and H. F. Abfalter, of Chicago.



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WENDELL L. WILLKIE Gives ATE Journal Exclusive Statement on American Broadcasting!

Wendell L. Willkie
1940 Republican Nominee for the Presidency
of the United States of America

WENDELL L. WILLKIE
109 EAST 42ND STREET
NEW YORK CITY

August 29, 1940.

ATE Journal,
Radio Engineers,
30 Rockefeller Plaza,
New York City.

Gentlemen:

In reply to your request for an expression of my views on radio, keep in mind that American Broadcasting must be kept free of dictatorial censorship, and let us remember that any man who denies speech to someone he hates prepares the way for a denial of speech to someone he loves. At the same time the radio engineer is fully cognizant of the two problems which were presented upon the introduction of radio into our daily life. One was the enjoyment which radio brings to children. Hence it followed that all programs must be confined within the special limits of good taste. The limit to the number of aerial wave lengths made the second problem equally inescapable. It entailed another type of regulation designed primarily to guard the listening public's pleasure.

Further than these, radio must be free from censorship that fresh and unbiased opinions may be continually expressed. Therefore, in addition to the four basic freedoms laid down in the Constitution of the United States of America, it is time for the people of America to pledge themselves to one more freedom — freedom of radio. And it is the responsibility of the radio engineers of America to safeguard this new and vital right.

Sincerely yours,

Wendell L. Willkie

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LATEST WHITE HOUSE INFORMATION ON AMERICAN BROADCASTING

THE WHITE HOUSE
WASHINGTON

August 26, 1940.

Managing Editor,
ATE Journal,
30 Rockefeller Plaza,
New York, N. Y.

Dear Mr. Stolzenberger:

Ever since the President has been in his present position, he has adhered strictly to a course of not giving his views exclusively to any publication.

Deep felt as is the President's appreciation of the cooperation of the Radio Executives and Engineers throughout the Country during the 1940 Democratic Convention, I regret that we cannot single out a specific publication to receive such an expression from the President.

From my speech of August third at the Golden Gate Exposition dedicating plaques at the New York World's Fair and the Golden Gate Exposition symbolic of American Broadcasting, the following excerpts should be of interest to you.

" . . . . To the broadcasters . . . . I bring greetings and best wishes from the President. You broadcasters know the President's views on the relationship of radio to government. Recently, he pointed out that while government long ago had to set up essential controls of radio operation, to prevent complete confusion on the air, in all other respects, radio is as free as the press.

"I bring to you a new expression of hope that this freedom will endure forever. Likewise, I offer congratulations to the radio industry for its great record of progress and service. The American system of free radio . . . . is actually a living symbol of the freedom of us all . . . . "

Very sincerely yours,

STEPHEN EARLY
Secretary to the President

(Photo by U. S. Army Sig. Corps)

President Franklin D. Roosevelt
1940 Democratic Nominee for the Presidency
of the United States of America

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The Why and How of Frequency Modulation

By Raymond F. Guy
N.B.C. Radio Facilities Engineer

THE use of the ultra high frequencies for sound broadcasting offers technical advantages, not only to the broadcaster but to the public, which is much more important. The technical advantages consist of escaping the 10 KC channel limitation, getting away from static and eliminating all except spasmodic long distance interference. We've known this for years, have experimentally operated low power UHF stations since Way Back, and have enjoyed the experience of receiving Clean Stuff from our little UHF transmitters when QRN washed out our temporarily musclebound 50 KW steamrollers, with devastating wallops. Five years ago the FCC had applications for, or had licensed, over 100 UHF transmitting plants and it seemed that a trend was developing toward UHF broadcasting, but this trend was not sustained. Interest has been revived in recent months through the promotion of FM on UHF.

Frequency modulation is a weapon against noise, a sword if you please, with advantages which can be calculated accurately and simply, as we shall see. But unreasonable powers should not be attributed to it. The pen should not be mightier than the sword.

Your scribe bows low and humbly attempts, with these hesitant strokes, to bring to you gentlemen of the ATE Journal what the Lower Classes vulgarly call the Lowdown. A snack of inside dope. So gather around.

Let's get to the point. What advantages does FM really give over AM? Using the frequency deviation approved for the industry by the FCC, FM UNDER THE OPTIMUM CONDITIONS gives an advantage of 20 to 1 in background noise suppression, an advantage of at least 30 to 1 in rejection of shared channel interference, depending on the beat frequency, and some advantage to the broadcaster in capital expenditures and operating costs. There you have it.

One frequently meets laymen who have the mistaken idea that FM is a revolutionary new invention. The justly proud father of your profoundly humble scribe bought him his first lace velvet pants in 1902. Most of you were still unborn during that anteluvian era. It was in that year that a gentleman named Ehret applied for a patent which was issued in 1905 covering the basic method of FM for voice and code transmission and reception. Mr. Ehret proposed to shift the carrier frequency by means of a voice actuated capacitor. He proposed an off tuned circuit in the receiver for converting the frequency modulated waves into waves of varying amplitude. With certain improvements these are the methods now used. For code signalling he proposed to key the transmitter inductance or capacity to change the carrier frequency. Before the No. 1 war this method was very widely used for many years on long wave transmitters. Remember how discombobulated one could become by trying to read the backwave when fatigued?

FM research has been carried on for over 30 years and, except for 1918, 1920 and 1924, patents have been issued on FM methods and devices each year for the last 25 years. They were granted mostly to a number of inventors in the employ of organizations which spend large sums on research, such as GE, Westinghouse, AT&T and RCA, and to a few individuals, particularly Major Edwin H. Armstrong who has promoted use of the feature of "wide swing" in FM.

Other features are important in FM, such as limiting. Gentlemen named Wright and Smith filed a patent application covering it 15 years ago. Fourteen years ago, and subsequently, patent applications were filed and granted to Westinghouse, A.T.&T. and RCA on balanced, or back to back FM demodulators. The most commonly used discriminator today was patented by S. Seeley of RCA. Frequency multiplication of an FM wave to increase the frequency shift is covered in patents issued to Westinghouse, and GE, for which applications were filed in 1926 and subsequent years. High frequency pre-emphasis and de-emphasis circuits were patented by S. Seeley and others of RCA. Its introduction to the industry was due in considerable part to the efforts of R. M. Morris of NBC, who had convictions and followed through.

At the close of 1939 more than 250 patents had been granted on frequency or phase modulation, of which more than 160 covered FM. About 10 years ago RCAC was trying FM on channels between our East and West coasts. About 12 years ago your scribe cooperated with Westinghouse in FM tests between New York and Pittsburgh. So you can see FM isn't new.

There is a popular impression that by use of FM and "wide swing" the public may only now enjoy high fidelity. The facts are that with ultra high frequencies the fidelity can be made as good as anyone wants it to be with either frequency or amplitude modulation. Any improved fidelity is made possible by getting away from the 10 KC channel allocations of the Standard Broadcasting Band and not by using FM, AM or any other M. Furthermore, to get "high fidelity" in AM or FM receivers the listener must pay exactly the same high price for high power, low distortion audio amplifiers, expensive loudspeakers and acoustical systems. However, the time may come when high fidelity will receive the widespread recognition it merits. There is much more interest now in low receiver prices which preclude high fidelity. This is unfortunate but incontestably true regardless of any wishful or idealistic thinking to the contrary.

There is no lack of satisfactory fidelity in present day transmitters because, if for no other reason, the FCC requires it. The loss of fidelity rests in the home receivers. Medium priced receivers satisfy the public demand and high fidelity cannot be obtained in those models. The price paid for so-called high fidelity amplifiers and loudspeakers is in itself more than the cost of most receivers. Possibly one person in six has a receiver of good fidelity. Many of these listeners normally operate with the tone control adjusted for the lowest degree of fidelity possible with such high fidelity receivers. It appears that the public is not suffering any lack of high fidelity because of the present broadcasting system.

We in NBC, and others, have been providing transmission of excellent fidelity for at least 15 years (network lines excepted) and will continue to do so. We believe in it and endorse it. But we have no illusions about the public reaction toward it.

We are told that FM is static-free. FM would under the most favorable

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conditions, but not all conditions, reduce static about 20 to 1. But what static are we talking about? UHF static? All 5 meter hams know that static practically doesn't exist on UHF. Therefore, its absence must be mainly due to the shift to the UHF band? It is.

Despite the foregoing don't think that your humble servant is bearish on FM because that would be incorrect. It is cold professional realism, not bearishness. An FM station will provide noise-free service to a much greater distance than an AM station of equal power because FM can suppress receiver hiss noise, auto ignition noise and other UHF disturbances about 20 to 1, if the carrier is stronger than the noise and if the receivers have enough gain to make the limiters limit at low field intensities. Most FM receivers begin to slack off at about 100 microvolts. To obtain the full benefit of FM out to the "noise threshold" limit they should hold up down to 10 microvolts. This noise threshold is strictly an FM phenomena of which more will be said later. It is not mentioned much but is one of the facts of life you will want to know about.

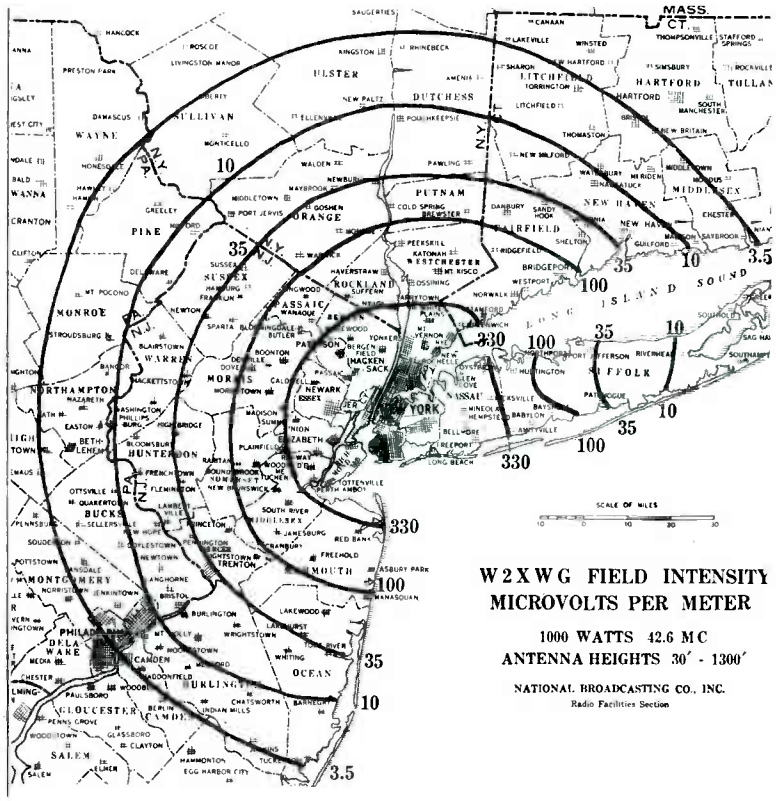
We are all confident that television has a most brilliant future. We are not entirely clear on the position that UHF sound broadcasting will have with respect to it. Those of us who have lived with television for many years feel that sound is supplemental to sight but definitely second in importance. When television hits its stride, sound broadcasting may assume the status of silent pictures. Who knows? Nobody does. In any event, sound broadcasting will be with us for many more years and we must give full opportunity to improved methods and devices. FM is one of them. NBC has one FM station and will build more. FM is being given its chance to prove itself.

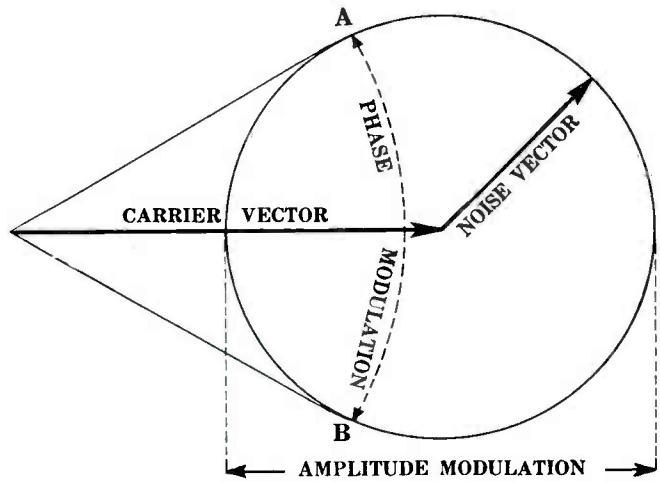
The NBC has for many years viewed realistically the advantages of the ultra high frequencies and has been confident that the industry would, in time, do likewise. Four years ago Mr. Hanson and your profoundly humble scribe wrote a long report on the subject forecasting the growth of UHF Sound Broadcasting by 6 month intervals and hitting very close. FM had such promising theoretical advantages that we undertook a full scale field test to determine the extent to which they could be realized in practice.

As a result we recently completed, at a cost of over $30,000, the most thorough field test of FM ever undertaken and we have the information we sought. It was obtained, not by laboratory work, which had been done before by others, including RCAC, nor merely by operating an FM station, but by building special transmitters, receivers, measuring instruments, etc., and then painstakingly making thousands of measurements at distant points over many months and under a variety of conditions.

A special 1,000 watt transmitter was ordered from the RCAM Company. It had facilities for both AM and any degree of FM deviation or "swing" desired, with remote control facilities for instantaneously switching to either system. Since the FM deviation varies directly with the audio input level, remote controlled pads could be and were used to select the deviation desired.

W2XWG was installed in the Empire State Building. Special authority was obtained from the FCC to use amplitude modulation as well as FM on 42.6 MC for the term of the project. The television video antenna, having a pass band extending from 30 to 60 megacycles, was used for most of the W2XWG transmissions although a special folded dipole was used when the





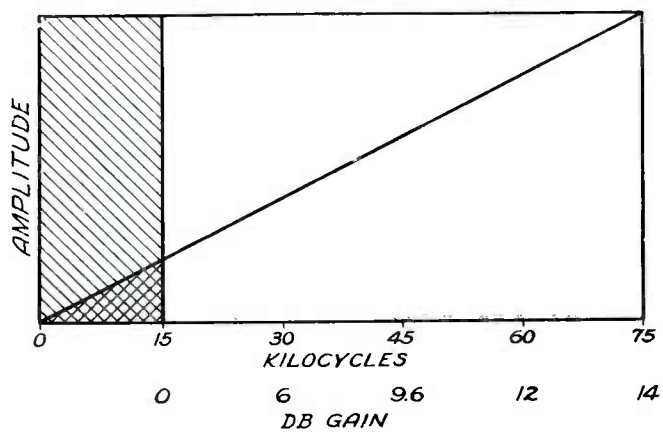


Fig. 1, above

Fig. 2, top right

Fig. 3, bottom right

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video antenna was transmitting pictures.

W2XWG was equipped with means for continuous variation of power between 1/10 watt and 1,000 watts, and a vacuum tube voltmeter for accurately measuring the power.

The modulation conditions selected were AM, FM 15 (deviation of 15 KC, or total swing of 30 KC), and FM 75 (deviation of 75 KC or total swing of 150 KC). Tone modulation was used for most measurements. For measuring distortion, or noise levels with modulation present, the tone output of the receivers was cleaned up by passing it through filters and then impressed upon RCA noise and distortion meters.

Four special receivers were built by the RCAM Company for this project. Each was equipped for instantaneous selection of AM, FM 15 or FM 75. Two complete IF systems were built in, one 150 KC wide and one 30 KC wide, each having 5 stages, with both AM and FM detectors. All receivers contained meters, controls, de-emphasis circuits with keys, 8 KC cutoff filters with keys, separate high quality amplifiers and speakers, cathode ray oscillographs, etc. Each receiver had sufficient RF gain to give full output with limiting at input levels much lower than required, theoretically doing so with only 1/10 microvolt input. These receivers were made as good as receivers can be built in order that our conclusions on FM would not be clouded by apparatus shortcomings. Sacrificing good receiver design to price will not permit the full gain of FM, as reported herein, to be realized.

As a part of the project, a field intensity survey was made of the W2XWG transmissions. The map is included herein for 1,000 watts, 1,300 feet antenna height and .7 antenna gain. It is Fig. 1.

Measurements and electrical transcriptions were made under a variety of conditions at the following locations:

	Miles
Collingswood, N. J.	85
Hollis, L. I.	12
Floral Park, L. I.	15
Port Jefferson, L. I.	50
Commack, L. I.	36
Riverhead, L. I.	70
Hampton Bays, L. I.	78
Bridgehampton, L. I.	89
Eastport, L. I.	65
NBC Laboratory	1
Bellmore, L. I.	23

All above stations are temporary, with the exception of the last two, which are permanent.

Most of the measurements were made at the Bellmore station. For the temporary stations, two automobiles were equipped and used, one a Radio Facilities Group measuring car, the other a borrowed RCAC truck full of recording gear. The receiving stations represented a cross section of rural and suburban Americana.

Let's next see what theoretical advantage FM has in noise suppression and how it is obtained. Later we will see what we measured.

In FM the deviation of the carrier frequency can be made as great as desired. If it is 15 KC and the audio band width is 15 KC the deviation ratio is 1, corresponding to the deviation divided by the audio band width. If the deviation is 30 KC the deviation ratio is 2, etc.

The advantages of FM over AM in noise suppression are contributed by three factors:

1. The triangular noise spectrum of FM.
2. Wide swings, or large deviation ratios.
3. The greater effect of de-emphasis in FM compared to AM.

Let us consider them in order.

THE TRIANGULAR NOISE SPECTRUM

An FM system with a deviation ratio of 1 has an advantage in signal to noise ratio of 1.73 or 4.75 db for hiss or other types of fluctuating noise.

Since the figure 1.73 applies to such noises as tube hiss, which is comparatively steady in amplitude, we will consider this type of noise. It differs from impulse noise such as is produced by automobile ignition systems.

Tube hiss consists of a great many closely overlapping impulses or peaks. There are so many of them at all audio frequencies, we are concerned with, that the noise has a steady characteristic. When combined with a steady carrier of fixed frequency, the noise peaks beat with the carrier. The noise peaks also beat with each other. When the carrier is considerably stronger than the noise peaks, beats between the noise peaks become negligible in amplitude and the predominating noise is due to the combination of carrier and noise peaks.

Since a combination of two carriers differing in frequency produces a similar phenomenon, we will treat both cases at the same time. The effect is most easily shown and understood by means of a simple vector diagram.

The strongest carrier vector continuously rotates through 360 degrees and is indicated on Fig. 2. The weaker carrier, or the noise voltage, rotates around the carrier vector at a frequency which is equal to the difference between the desired carrier and undesired frequency. It will be seen that amplitude modulation is produced. If the undesired frequency is 50% as strong as the desired frequency, 50% amplitude modulation results. As the undesired vector rotates around the desired vector, phase modulation also is produced between the limits A and B. The faster the undesired vector rotates, or the faster the rate of phase change becomes, the greater becomes the momentary change in frequency and, therefore, the greater the frequency modulation becomes, because Frequency Modulation is a function of the first differential of phase modulation. Therefore, the amplitude of the frequency modulation noise or beat note varies directly with beat frequency. With both frequencies exactly the same there is no amplitude modulation nor is there any frequency modulation.

Such being the case, the noise frequencies close to the carrier produce little frequency modulation noise but as the noise components further from the carrier combine with it they produce more frequency modulation. Therefore, the higher the noise beat frequency the higher its amplitude. This results in a frequency modulation noise spectrum in which the noise amplitude rises directly with its frequency. In other words, it is a triangular spectrum.

In amplitude modulation there is no such effect as this. All noise components combine with the carrier equally. Therefore in amplitude modulation there is a rectangular noise spectrum. The ratio of noise voltages in FM and AM is therefore the ratio between the square root of the squared ordinates of a triangle and a rectangle. This ratio is 1.73 or 4.75 DB.

THE DEVIATION RATIO

For an FM System the suppression of fluctuation noise is directly proportional to the deviation ratio. On Fig. 3 the AM noise spectrum corresponds to the total hatched area below 15 KC because the IF system would cut off there. The FM 75 receiver IF system actually accepts noise out to 75 KC and it has the usual FM triangular characteristic. However, the receiver output and the ear responds only to noise frequencies within the range of audibility, around 15 KC, and rejects everything else. Therefore, the

(Continued on Page Eighteen)

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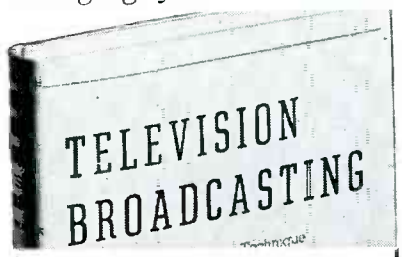

BY LENOX R. LOHR

Formerly President, National Broadcasting Company, Inc.

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National Political Conventions---1940

By G. M. Hastings
Audio Facilities Engineer

THIS year it was decided that the three broadcasting systems, NBC, CBS, and Mutual, would get together on the installation of circuits and equipment for the Republican and Democratic National Conventions in Philadelphia and Chicago, respectively. This meant that one contract was to be issued to the electrical contractor for miscellaneous microphone circuits, and a separate one for the delegation floor microphone system, each company to pay an equal share of the billings. Mr. McElrath of NBC, Mr. Grossman of CBS, and Mr. Poppele of Mutual, who were the guiding geniuses for their respective companies, held several meetings to determine the architectural layout of the booths and what facilities would be required.

It was decided that the NBC system used at the Republican National Convention four years ago would be the best to use this time. This system required the use of fifty-five microphones, one in front of the chairman of each state delegation, which was connected through by means of a relay system. Inasmuch as we still had the relays and the control panel available we were given the job of building and installing the delegation microphone floor system with feeds to the other two companies.

This time our installation was to be bigger than usual because separate commentators and announcers were to be used for the Red and Blue networks. This meant that the architectural layout required two booths and each had to be equipped as though it were a separate field job by itself. The racks of equipment also had to have individual amplifiers for each network, and the number of microphones was doubled, except for the floor system, due to the fact that both Red and Blue microphones were required at all positions.

The booths in Philadelphia were wide but not very deep so the engineers, announcers, commentators, and program directors sat alongside of each other at a long table in the front. This was fine for good vision but poor from the traffic angle. In contrast to this, the layout in Chicago was narrower but deeper, so the announcers, commentators, and program directors sat in front, and the engineers sat on a raised platform just in back of them. This was a better arrangement because anyone wishing to confer with the program department could do so without disturbing the engineers and vice versa.

The floor system was installed by laying a DT-20 cable (20 copper shielded pairs) along each of four aisles and fanning out the individual pairs to each chairman's position. These pairs were pulled up through the microphone stands, the stands were screwed to the floor, and the plugs were connected and fastened to the stands with clamps. Identification of pairs was made by inserting a short circuited plug in a microphone position, finding the pair among the eighty pairs which were at the rack, and tagging it with the name of the state.

One of the big problems of this floor system was to cover the cables for protection and still not have an obstruction on the floor that people would trip over. This was solved by placing a 7/8 inch board four inches wide each side of the cable, bevelling the edges right down to the floor and nailing a strip of sheet metal along the top. This kept the height down to one inch or less, with each edge bevelled off so there was no abrupt change in level.

In Chicago at the Chicago Stadium the problem was more difficult because the floor was terrazzo with freezing pipes underneath. This meant that nothing could be screwed to the floor, so another way of fastening the microphone stands and cable covering was designed. This was done by seating all chairmen on the aisle and putting down a wooden aisle with a projection in front of each chairman's chair for the microphone stand. This platform was raised from the floor by means of narrow strips running lengthwise along the aisle so that the cable pairs could be run underneath it and be protected. These details can be seen in the photographs of the two different systems.

When all of the wiring (27,000 feet of wire and 1,000 connections) was completed, we started testing. That was when the fun began. We had been left pretty much alone up till this time, but now everyone else was on the job too and we would just be in the middle of a test, trying to eliminate some noise or other from the circuit when a movie sound man would hand us a pair and say, "This is a feed to ————". Then an engineer from one of the Philadelphia stations would hand us a pair with the same statement. We would say "O.K." and then holler, "Archie, put a plug on it". All twelve of the outputs from our multi-unit amplifier were in use by the time we went on the air. Also, right in the middle of our testing all of the lights would go out. The electrician would inform us (after he was located) that some movies were being taken and our lights were spoiling the picture. There was nothing to do about it but wait until the lights came back on again.

The block diagram shows what facilities were available and they were all put to good use. The first three days of each convention were just routine meetings with speeches and announcements, the floor relays only being used once at each session to adjourn the meeting. On the fourth day the roll call of the states started. Then our relays really went to work. The control board was arranged

Everyone, including our NBC executives and the listening public, was greatly impressed and pleased with the broadcasting of the two political conventions. The operations of our technical set up were particularly gratifying to me, and I know that without the fine spirit, 100% cooperation, and tireless efforts of all the boys who worked on the job, we could not have obtained such successful results. I would like to take this opportunity, through the medium of the ATE Journal, to extend my appreciation and sincere thanks to each and every engineer who participated in the broadcasts of the political conventions. It is a real pleasure to work with them.—George McElrath.

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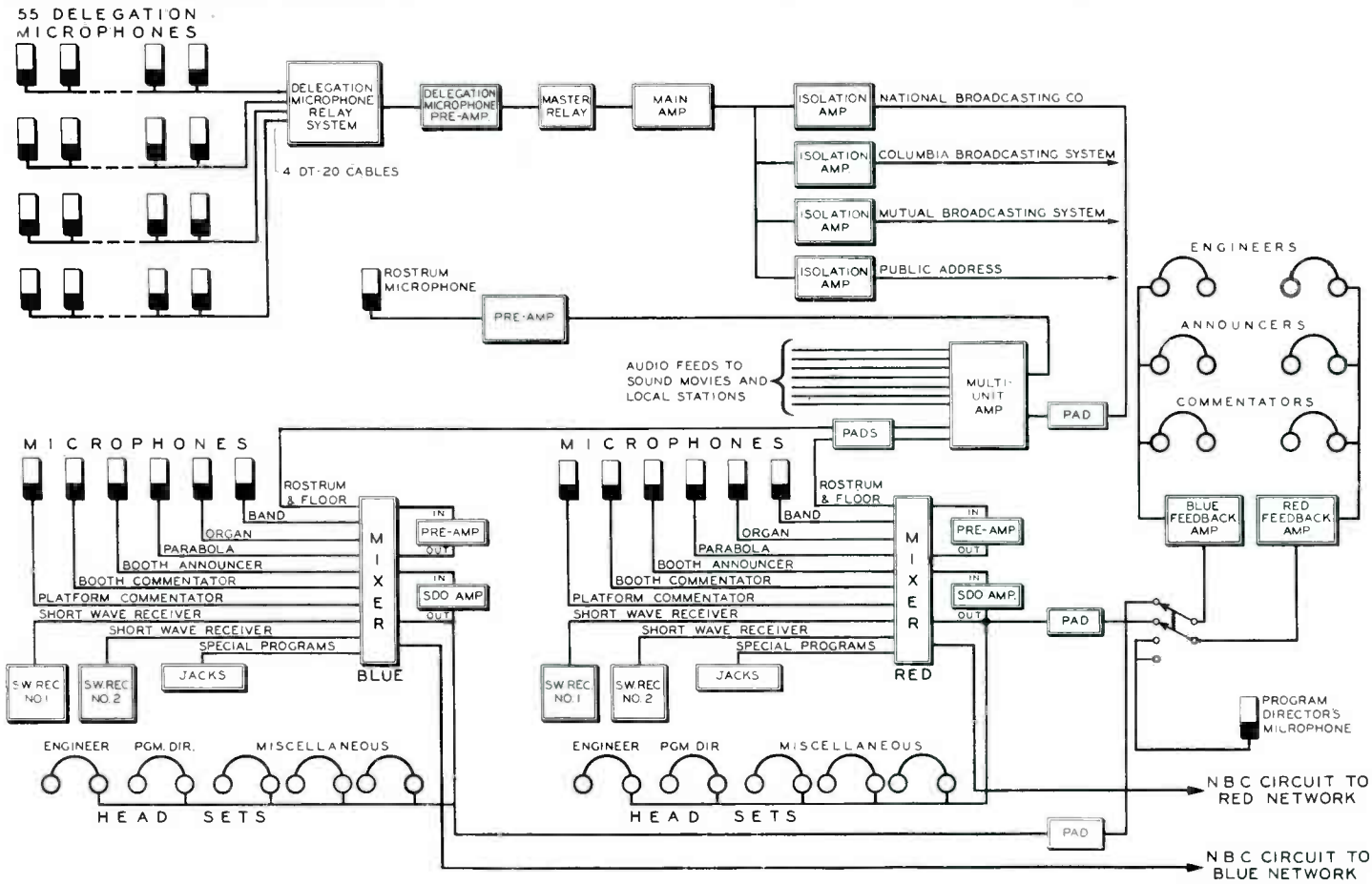
CONVENTION FLOOR PROBLEMS — PHILADELPHIA LEFT, CHICAGO RIGHT

alphabetically so we knew which to operate next except when a state would pass to another. In this case we had to set up a relay for the other state which might be anywhere on the board. The polling of the individual delegates in any state where the vote was questioned was taken care of by having the floor microphone maintenance men plug in a microphone with a 30-foot lead on it and pass it to each delegate as he voted.

Our short wave facilities consisted of two beer mug transmitters with their associated receivers, one pack set cue transmitter, and two cue receivers. One evening when Carleton Smith was interviewing people with a beer mug transmitter and one of the engineers was following him around with the cue receiver, the aisles were all jammed up so Carleton got up on a railing to walk to another section. The engineer followed bravely but not wisely and fell right into the lap of a dowager. He quickly muttered something like "Sorry, but the show must go on" and dashed off to catch up with Carleton.



PROGRAM FACILITIES FOR NATIONAL POLITICAL CONVENTION 1940
NATIONAL BROADCASTING CO. INC - ENGINEERING DEPT

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Frequency Modulation Notes

By R. F. Bigwood, NYME

Part I

BEFORE examining some of the transmitting equipment suitable for getting an FM signal on the air, let us first briefly compare our almost universally used AM system with the proposed FM methods.

From our book learning we will recall for analysis the equation of a wave of carrier frequency F_c, amplitude modulated by a single sine-wave of audio frequency F_m as:

$$i = Io \sin W_c t \; [mIo/2] \cos (W_c - W_m)t - mIo/2 \cos (W_c + W_m)t$$

i = Instantaneous amplitude of the modulated wave.

Io = Peak amplitude of unmodulated carrier or average amplitude of modulated carrier.

$W = 2Pi \times F_c$ or F_m, whichever the subscript indicates.

t = Time.

m = Modulation factor, variable from zero to one.

$= \frac{1}{2} (Imax - Imin) / I_o$

Imax = Maximum peak amplitude of wave under modulation.

Imin = Minimum peak amplitude of wave under modulation.

The wave contains three frequencies, and the first term of the above equation represents the carrier; its average value I_o remains constant, it carries no intelligence, and its frequency is constant. The second term indicates a frequency F_m cycles below the carrier and is the lowest side frequency. The remaining third term represents the upper side frequency F_m cycles above the carrier. These two side frequencies carry all the intelligence, and their sum total power varies as the square of the modulation factor m. For m=1, or 100% modulation, 1/3 of the total power represented will be divided between these two side frequencies, and 2/3 will be allotted to the carrier. This accounts for all the power contained in our AM wave. Furthermore, at m=1, the total transmitted power is 1.5 times the carrier alone power. Please remember this is under sine-wave conditions only. With program material, there may be simultaneous side frequencies called side bands, and the combinations encountered may cause the modulated wave power to exceed this factor 1.5 in certain instances, but, on the average, it is considerably below this value. Also, since the power in the intelligence carrying side frequencies varies as the square of the modulation factor, this should explain the desirability of maintaining as high a modulation percentage as possible, consistent with satisfactory dynamic range of the program material being transmitted.

Assuming, under double side band transmission practice, we have an audio system capable of amplitude modulating our carrier at a rate of 30 to 15,000 cps., we will theoretically require for perfect reception an interference-free allotment of space in the radio frequency spectrum for our carrier frequency, plus a band 15,000 cps. above and below our assigned carrier, or a total band width of twice the top audio frequency to be transmitted. Note that when we have defined our top modulating frequency, we will by the nature of the AM system occupy no more of a band width than twice that top audio frequency. The discussion of least permissible band-width for so-called "satisfactory" reception and the interference phenomena which beset AM due to allocation, propagation, and static, will not be undertaken herein.

Now for FM.

If you will cull the choice gems of technical information in your texts, you will probably find a page or two devoted to frequency modulation. Of course in the light of "wide swing" developments, some of the disparaging remarks about the use of FM in broadcasting must be disregarded. At the time most available texts were made up, they based their comments on the experimental results of narrow swing FM, and these showed high quality broadcasting and narrow swing FM did not get along well together. However, FM waves had been studied and mathematical analysis made which indicated their nature. Let's review and bring things up to date.

Frequency modulation is a system of transmission wherein the following conditions are imposed:

(1) The peak amplitude of the carrier remains constant at the assigned center frequency.

(2) The frequency of the carrier is varied up and down across the center frequency, at a rate dependent upon the frequency of the signal to be transmitted.

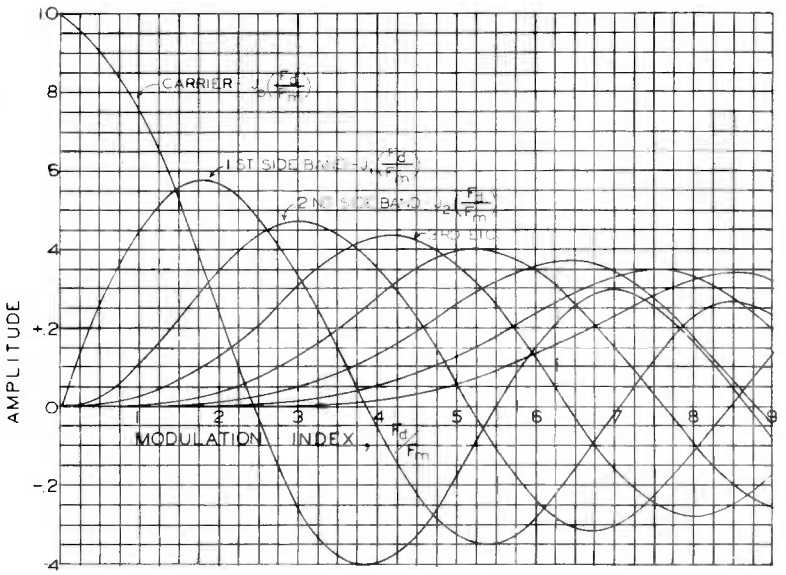
(3) The amount of deviation of the carrier above and below the center frequency is made proportional to the amplitude of the signal to be transmitted, with a practical amount of deviation determined from experiment and definite maximum defined by law.

Considering condition (1): While the peak value of the carrier remains constant at the center frequency, under modulating conditions it becomes less than this value, even zero, when the modulating index assumes certain values. This will be shown later by graphical analysis. In AM, the average carrier amplitude was constant, but the peak value went from zero to two times the carrier peak when 100% modulation was applied.

Condition (2): By this operation of varying, or modulating, the frequency

(Continued on Page Sixteen)

Fig. 1



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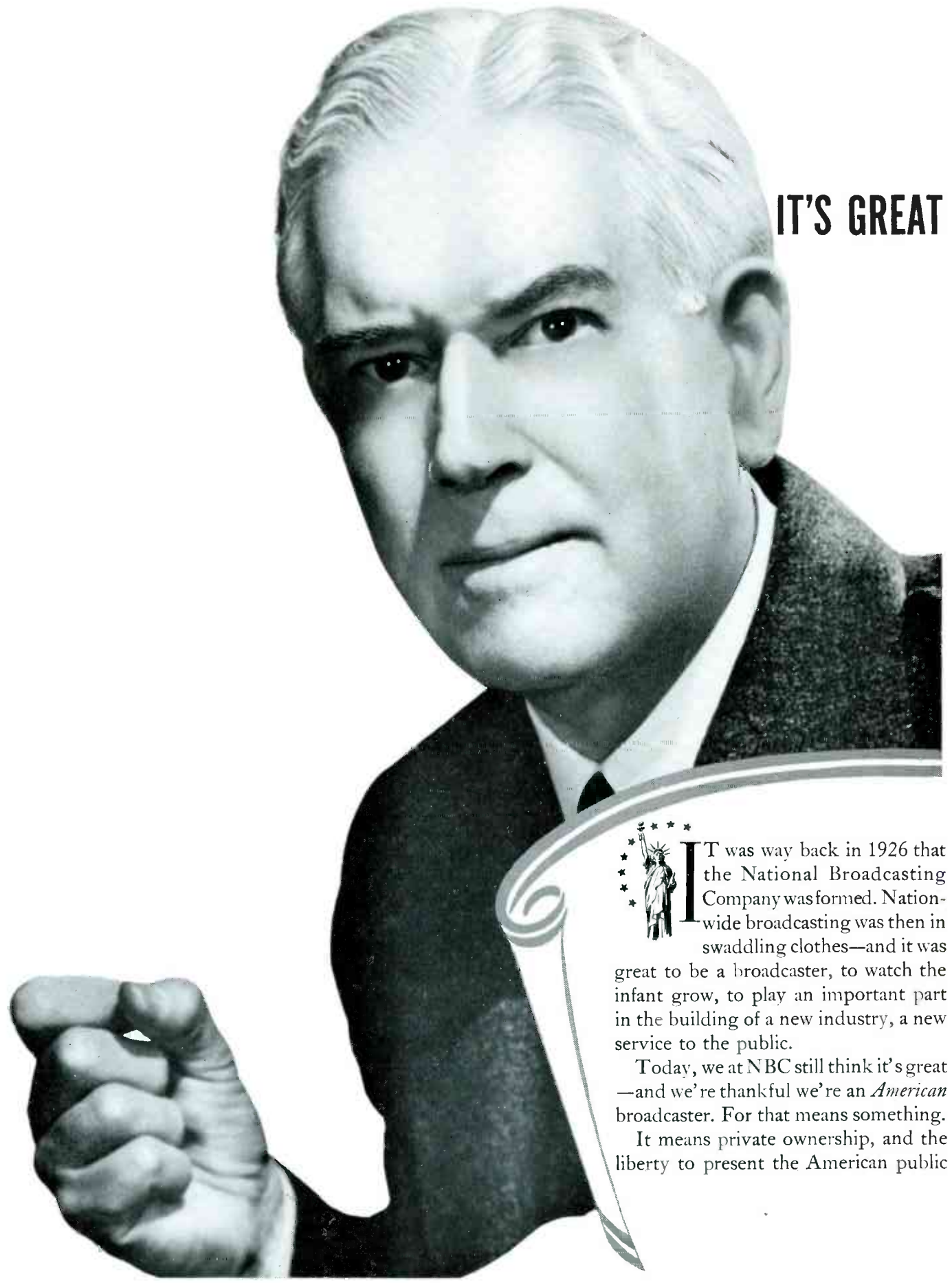

IT'S GREAT TO BE A BROADCASTER—

AN *American* BROADCASTER!

IT was way back in 1926 that the National Broadcasting Company was formed. Nationwide broadcasting was then in swaddling clothes—and it was great to be a broadcaster, to watch the infant grow, to play an important part in the building of a new industry, a new service to the public.

Today, we at NBC still think it's great—and we're thankful we're an *American* broadcaster. For that means something.

It means private ownership, and the liberty to present the American public with facts—pro and con—about any and all issues.

It means we can give them the news of the world unvarnished, untarnished and true.

It means we can give our listeners the kind of entertainment *they* want to hear, entertainment that heightens their spirit and morale.

It means we can contribute to their fullness of life with fine educational programs that will broaden their minds.

It means that we can offer this great force to our country in the aid of national defense. In short, it means freedom of speech and action on our part—freedom of listening for those we serve . . . No wonder American broadcasting is without equal anywhere else in the world! And no wonder we're proud of the contributions and accomplishments of NBC in making it the finest.

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Whither Frequency Modulation

By Dick Dorrance

FM Broadcasters, Inc.

ODDLY enough, as any oldtimer will sagely inform you, frequency modulation is nothing new. It was the first method of radiotelephony back in the days when a frequency check meant anything within plus or minus 5,000 kilocycles. Then a man named Heising came along and amplitude modulation took the spotlight.

But the FM of today is as different from frequency modulation of yore as the brontosaurus is from a Seeing Eye dog. The difference, of course, comes in the method used to secure frequency modulation and, even more important, control it within precise channels.

As with everything new that is a departure from accepted precedent, there are many folk on both sides of the fence. The FM proponents speak loudly in favor of their protege. The advocates of the existing AM broadcast system feel that there is such a thing as gilding the lily, that present fidelity standards are quite good enough and that $75,000,000 in transmitting equipment, not to mention 45,000,000 American radio receivers, are not to be pushed aside like milady's last year's hat.

To review the situation briefly, if you haven't all the facts at your fingertips, the FM people went to Washington last March. The FCC listened to much that was said by Major Edwin H. Armstrong (the Armstrong circuit man . . . remember?) who is FM's developer and most rabid booster, and FM Broadcasters, Inc., a non-profit group comprising the top layer of FM station owners in the nation, plus a lot of qualified experts and radio executives.

The FCC mulled the matter over for a few weeks, then burst forth with a glowing report that called FM "one of the most significant contributions to radio in recent years."

The Commission's enthusiasm was rather significant too. It flashed a green light to FM's dreams of a commercial status on a par with regular broadcast stations. It opened a nice new band from 42 to 50 megacycles, neatly marked off like a new real estate development into 40 channels of 200 kilocycles each. Unfortunate at the same time was the fact that the new band deprived television of its No. 1 channel.

At the time the FCC crashed through with its glad news for FM-ites, there were about 22 experimental stations licensed and some 140 others that had applications in for experimental licenses. All these latter were sent home for refiling.

They're coming back to Washington these days on the new 42-page application blanks that ask for about everything except the name of the studio cat. By January 1, 1941, when the new commercial life starts for FM, it is estimated there will be about 50 stations in operation, many more under construction.

It's all a new line of endeavor for the radio industry, and anybody's guess is a good one as to where it will lead. We can't, however, overlook the fact that there are now 14 manufacturers turning out the new FM receivers (most of which have an AM band on them as well).

There are quite a few interesting FM installations going up around these United States. One of the latest is W2XOR, the new skyscraper station inaugurated by WOR on August 1.

W2XOR is a 1 kw. FM station, complete from microphone to the coaxial vertical skyhook that stands 650 feet above New York's streets. The wire line that links the special FM studio at Broadway and 40th Street to the transmitter at Madison Avenue and 49th Street (better than a couple of good stone's throws) is a triumph of telephone engineering — flat from 20 to 20,000 cycles without the use of yogism or mirrors.

WOR has taken its Studio 1, largest in the Mutual New York outlet, and installed completely new input equipment that can handle 30 to 15,000 cycles without distortion. Special mikes—a new model that has been dubbed the "ostrich egg"—are used to secure as nearly perfect full-range pick-up as possible.

But W2XOR is only one of a great many such organizations that are giving the radio business much to think about. Take, for example, NBC's new application to the FCC for an FM station atop the Empire State Building.

New York's highest building already harbors W2XWG, a 1 kw. outfit that relays NBC Red and Blue programs. The new outfit requested in NBC's application for a CP would be a 50 kw. rig on 43.9 mc., some 1,230 feet above the streets of New York. Within its 16,880 square miles of area to be served live 15,524,000 people.

Let's take a look at the Middle West. Chicago already has four separate applications in for FM stations. WGN wants a 50 kw. outfit, and so does WMBI. Detroit broadcasters are seeking three different stations for their area. And in Milwaukee, Wis., where WTMJ has long been an FM pioneer with W9XAO there is another 50 kw. application for a station that will be within earshot of 60% of Wisconsin's radio public.

A round-up of the FM picture would be incomplete without mention of the yeoman work being done in New England by The Yankee Network, FM's most avid booster of long standing. Already in operation is the 50 kw. W1XOJ at Paxton, Mass., serving most of middle New England. An application has been made for a 10 kw. station atop Mt. Washington, N. H. — 6,000 feet above a countryside noted for its poor broadcast reception—that will supply FM service to almost 40,000 square miles of territory.

FM approaches 1941 with a rather sizable head of steam. Set manufacturers, with heavy merchandizing campaigns poised for the fall market, expect gratifying sales. The general public seems receptive, waiting to be shown. And the number of broadcasters themselves who have announced their intention of utilizing the new FM system presents an imposing array of support. Already plans are afoot to establish a nationwide network about a year from this fall, devoted exclusively to FM.

What comes next is an interesting question. The radio industry has always been unpredictable and certainly susceptible to high-speed development. FM seems to be a neat chip off the old block.

Mutual Covers Republican National Convention

By R. A. Schlegel

[Democratic Convention was covered by Mutual's Chicago outlet, WGN.—Editor.]

A UNIQUE system of audio facilities was installed in the Mutual Broadcasting System's control booth at Convention Hall in Philadelphia for broadcasting the proceedings of the Republican National Convention of 1940.

The system consisted primarily of a 10 radio line mixing panel, 12 microphone mixing panel, a 10 drop PL control panel and 3 Western Electric 22D field amplifiers. The radio line mixer, microphone mixer and PL drop control panels were designed and constructed by the WOR engineering staff especially for handling special feature programs originating outside the studios.

The use of this special equipment, together with field amplifiers, provides an extremely flexible method of switching in any source of program and for repeating the MBS "round-robin" circuits as well as the simultaneous feeding of programs to other points. In this case, one program was fed to MBS while another went through to WOR and WFIL.

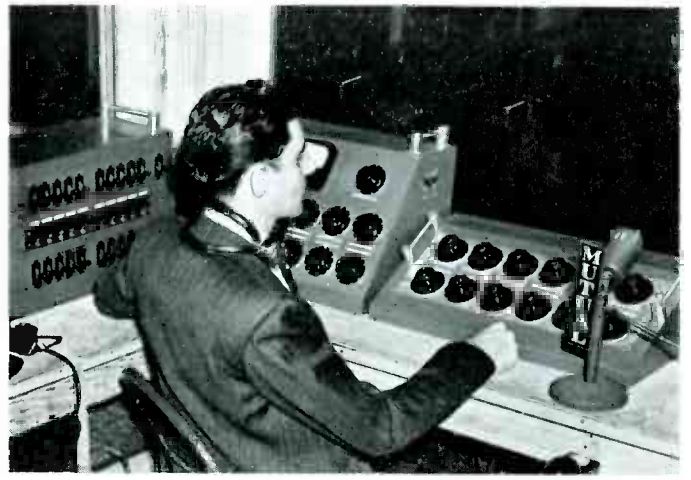
Another unusual feature of this arrangement of equipment was that the director of special events had a key circuit giving him control over his own microphone which permitted him to break into the program at any moment. Cue circuits were run to all of the commentators positions as well as the nemo points of broadcast. The nemos went on the air directly from a cue given by the special events director.

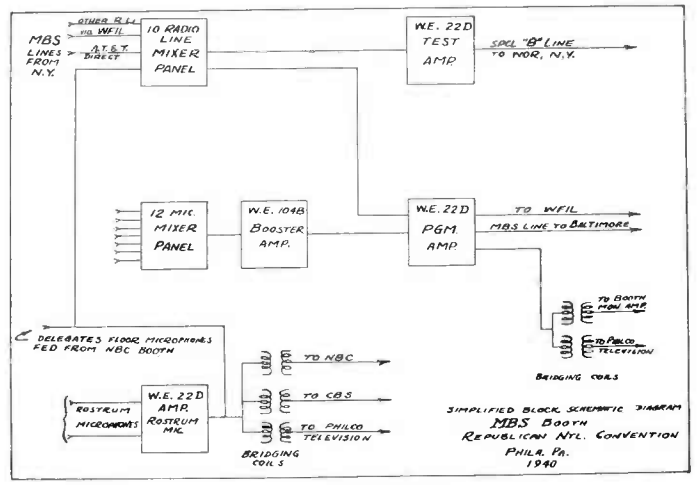
The two MBS microphones on the speaker's rostrum were fed directly into a 22D field amplifier. This amplifier's output, and the NBC output circuit of the delegates' microphone on the floor of the convention hall were fed into the radio line mixing panel, enabling us to feed a bridging circuit for emergency use to NBC and CBS and an audio circuit which was fed to the Philco television unit.

The 22D field amplifier is a compact unit with a four microphone mixer and a master gain control. The amplifier operates from batteries or a small AC power pack contained in the carrying case of the unit.

Mutual is indebted to Arnold Nigren and his WFIL staff upon the excellent manner in which they handled the local Philadelphia pickups and details of all local arrangements.

Ed. Content, assistant chief engineer, was in charge of technical facilities and supervised the installation of equipment by Max Urlass and Dick Davis. The programs from the convention hall were handled by Engineers Boher, Davis and Spencer.





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New Radio Compass for Pleasure Boats

For the boating enthusiast who never goes beyond sight of land a radio compass can usually be considered in the "excess baggage" class. Usually, but not always! An unexpected storm with land suddenly blotted from sight can cause a powerful lot of discomfort even ten miles off-shore, particularly if one is unfamiliar with that particular shore.

To the "deep-sea" boatman the story is different. A good modern radio compass provides the means for a continuous check on position, surroundings and progress, whether he is in familiar waters or not, and whether he is cruising by day or by night. He doesn't have to hug the shore line to maintain his bearings and as a result he can travel fast and economically, with a constant sense of security.

The earlier radio compasses were expensive, complicated and too limited in their use to appeal to the small boat owner. But today greatly widened utility has been accompanied by falling prices and increasing simplicity of operation. The result is that such equipment becomes entirely practical for the requirements of almost anything that floats on any sizable body of water.

The very latest in the field is the Model S-30 Radio Compass just introduced by Hallicrafters which combines in one unit a receiver with rotatable loop which permits position to be checked not only against regular long-wave beacon stations but against any shore radio-phone or broadcast station operating in the frequency range between 220 and 3000 kc.

The S-30 receiver is only 11 inches wide, 10⅝ inches deep and 7½ inches high. The added height of the 12-inch loop brings the overall height to 23½ inches. The receiver cabinet is welded aluminum with durable wrinkle finish and the loop is inclosed in an aluminum casting similarly finished. The use of magnetic materials is carefully avoided and it is for this reason that the vibrator power supply is a separate unit intended to be located at some distance from the receiver. Provision is made for a loudspeaker but this too is used externally and at some distance from the set.

The 3-band receiver, with ranges of 220-540, 535-1340 and 1200-3000 kc., utilizes six tubes including a 6SK7 r. f. amplifier, 6K8 mixer, 6SK7 i. f. amplifier, 6SQ7 detector and a. v. c., 6G6G output amplifier, and 6U5G tuning indicator and auxiliary null indicator. The controls include a main tuning knob (with fully frequency-calibrated dial moving behind a transparent window), band switch, r. f. gain control, a. f. gain control, speaker-headphone switch, compass-card adjustment knob, and handles for rotating the loop. A headphone jack is also provided on the front panel.

This new equipment brings one of the most valuable of the professional mariner's instruments within practical reach of the small boat owner, and in a form that is ideally suited to his needs.

communications

Model SX-28 Super Skyrider is a 6 band, 15 tube receiver giving you complete front panel control over every phase of the circuit. 2 stages of preselection . . . high fidelity push-pull audio . . . calibrated electrical bandspread . . . micrometer scale on main tuning knob . . . 6-position selectivity control . . . band pass audio filter . . . automatic noise limiter . . . new crystal filter circuit . . . ball bearing tuning mechanism . . . semi-floating main tuning and bandspread condensers. Covers 540kc to 43mc. Panel is exact rack size. Chassis has rigid girder construction. Hallicrafters-Jensen Bass Reflex speakers available. With crystal and tubes, less only speaker . . . . . $159.50 NET

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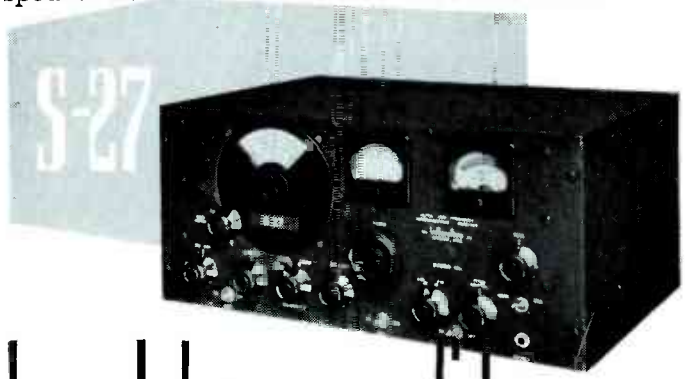
Model S-27 is the first general-coverage U.H.F. communications receiver to incorporate Frequency Modulation reception. Covers 3 bands: 27 to 46mc; 45 to 84mc; 81 to 145mc. Switch changing from FM to AM reception. Acorn tubes in R.F. and newly developed converter system. High gain 1853 tubes in I.F. stages. Beam power tubes and 6C8G phase inverter in A.F. Amplifier. A VR 150 voltage regulator tube is used to assure excellent electrical stability. 955 plate-tuned oscillator. I.F. selectivity automatically sharpened to receive amplitude modulated U.H.F. signals or broadened for wide band frequency modulated signals. With tubes, less only speaker . . . . . $175.00 NET



hallicrafters

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FM Notes

(Continued from Page Ten)

of the carrier wave, we produced a part of the intelligence carrying properties of the FM system. Note another departure from AM, wherein the carrier frequency remains constant. As an example, let us assume a self-excited oscillator-transmitter with a tuning condenser having a plate in the form of a diaphragm which could be pressure operated by talking against it, it can be seen that the frequency of the oscillator would be changed by the capacity variation of the condenser diaphragm which would move at a rate dependent on the voice frequencies talked into it. Since we are concerned with sound transmission, we must generate a wave which, upon reception, can be converted into sound having pitch, quality and loudness. Thus, if we have a method of carrier frequency variation, and the rate of change of carrier frequency depends upon the frequency of the wave impressed on a microphone, we have taken care of the transmission of pitch and quality,— pitch being the fundamental frequency of the sound source, and quality being determined by additional frequencies which make up the harmonic content of the sound. In AM, the differentiation between frequencies is accomplished by varying amplitude at the sound source frequency rate.

Condition (3): Here it is stated that the amount of deviation of our carrier from the assigned center frequency shall be proportional to the amplitude of the signal to be transmitted. Going back to our combination tuning condenser-microphone: loud tones, or those of high amplitude, will cause relatively large excursions of the diaphragm; in turn, this will produce large capacity variations which will swing our oscillator frequency between wide limits. Tones of lesser amplitude will cause smaller swings in frequency. With no impressed sound, there will be no frequency modulation, and the carrier stays on its center frequency. Under these conditions, we have made our carrier frequency deviate an amount proportional to the amplitude of the sound source and we now have a property in our FM system which allows for the differentiation of loudness. Remember in AM, the power in the side bands set up when the depth of modulation of a constant carrier frequently was changed, represented the degree of volume transmitted, whereas in FM, the extent of our frequency swing represents the degree of volume.

As has been pointed out, it at first seemed that material might be transmitted by FM using a very small frequency band about a center carrier frequency, say, for example, sending a 1,000 cycle note with only a 50 cycle band around the carrier. This was tried and the premise found untrue.

In the first place, detector systems for converting frequency variations to the amplitude variations of corresponding sound were none too well developed and had they been, the audio output of such a detector would have been extremely small using such a narrow swing. Other pit-falls for this type of FM were in store as is now shown.

Suppose we measure a certain sine wave of constant radio frequency, we would find only one wave occupying a single spot in the spectrum. Now let's change the frequency to another value 25 cycles away, leave it at constant frequency, and measure again. We will find our wave alright, and while it will be in a slightly different spot, it will be occupying one spot only and will still be a pure sine wave. Now let's continuously "wobble" our radio frequency wave within a 50 cycle band about a chosen spot in the spectrum at a 1,000 cycle rate. This would be FM with a very narrow swing. Well, what happened? Due to the continuous variable frequency, we lost the sine wave shape, since the time required to complete any certain fraction of a cycle differs from the time required for the next fraction of the cycle. In other words, due to the nature of our system, at one peak of our impressed modulating wave, we have pushed the carrier to a higher frequency than our chosen center, and thus the time of completion of an individual cycle of our wave has been lessened. Still continuously modulating our frequency, the modulating wave starts towards an opposite polarity and shifts our carrier down past the center to a lower frequency limit where the time for each individual cycle of carrier frequency is greater than before. Since the sine wave shape has been lost, then the resultant wave must contain more than one frequency. When the smoke of calculation and experimentation cleared away, it was found that a carrier wave at F_c, frequency modulated by a tone F_m, contained not only the first order side frequencies like AM, (one side frequency F_m cycles above and one side frequency F_m cycles below the carrier), but also many higher order side frequencies. The components may be shown as follows:

F_c, $F_c + \& - F_m$, $F_c + \& - 2F_m$, $F_c + \& - 3F_m$, and so on.

To be more analytical, it will be necessary to write the equation of our FM wave and examine the frequency components contained therein—a quantitative analysis so to speak.

$i = I \sin (Wt + P + m_f \sin Vt)$

i = Instantaneous amplitude of the modulated wave.

I = Peak amplitude of the carrier at center frequency.

W = 2Pi multipled by the carrier frequency.

V = 2Pi multipled by the modulating audio frequency.

P = Arbitrary phase constant.

t = Time.

m_f = Modulation index.

= Carrier deviation away from center frequency (in cps) divided by Audio frequency (in cps).

Mere inspection of this equation does not present as clear a picture of our FM wave as does a corresponding equation for AM. Expansion and analysis of the equation shows that the values of amplitudes of the carrier and side frequencies under modulating conditions vary according to Bessel Functions. The results of such analysis can best be shown by a graph of Amplitude vs. Modulation Index, as shown in Fig. 1, taken from the RCA Review of April, 1940, page 474.

Let us examine the graph and consider the coordinates. The meaning of amplitude, plotted on the vertical axis is, of course, evident, with the value of one indicating the amplitude of the carrier at center frequency. The Modulation Index, F_d/F_m, plotted horizontally is composed of two items and a variation of either one will change the index. With a constant modulating frequency, the index will vary directly as the deviation F_d. The deviation, remember, is proportional to the audio volume fed to the transmitter. With constant deviation then, the index will vary inversely as the modulating frequency F_m. As shown, the carrier amplitude varies according to the zero-order Bessel Function, $J_0 (F_d/F_m)$, the first side frequency is proportional to the first-order function, $J_1 (F_d/F_m)$, the second side frequency varies as $J_2 (F_d/F_m)$, etc.

Now for a few standards.

FM today, uses a modulation index of five for the highest audio frequency to be transmitted and may be called "FM-5". Also, "Deviation Ratio of 5" may refer to the same thing. Deviation

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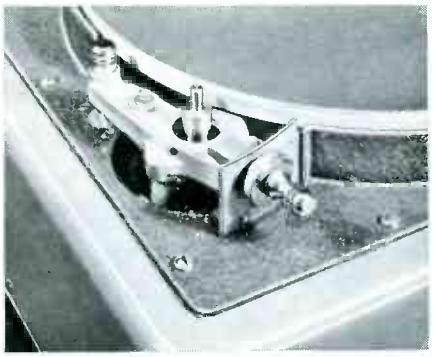
usually means the amount the carrier is deviated to one side of the carrier center frequency, whereas "swing" refers to the total excursion of the carrier both sides of center. The FCC has set up a channel separation of 200 kc for FM allowing for a Deviation Ratio of 5, with an overall microphone to antenna AF response of 20 to 15,000 cps. Obviously, such a channel separation and band width can be best accommodated in the UHF region where 200 kc becomes a relatively small band, in terms of percentage of mean frequency, and deviation linear with the signal to be transmitted is easily obtainable with practical transmitters. The FM broadcast band in which most present activity is concentrated extends from 41 Mc to 50 Mc. The minimum power for broadcasting purposes is one kw, and the maximum applied for to date is 50 kw. Considering the frequency of operation, 50 kw is a sizeable hunk of power to be spraying over the township and indicates a remarkable development in tube manufacture and the handling of mechanical and electrical circuit details.

Under these standards, at the highest audio frequency to be transmitted, the Deviation Ratio could be five and our carrier swing would be 75 kc. Consulting the graph it can be seen that the carrier has reversed phase and has an amplitude of approximately 0.175 times its center frequency amplitude. The side frequencies would have relative values of about 0.325, 0.05, 0.37, 0.395, 0.26, 0.13, and 0.05 for the first to seventh-order side frequencies. Thus the seventh order side frequency will have a small amplitude 105 kc away from the center frequency. The value is small, to be sure, but with pre-emphasis it is larger than indicated on this graph. Also, it is interesting to note that at certain indices, the carrier and side frequency amplitudes become zero and reverse phase. In the case of the carrier, this aspect of the system affords a means whereby the deviation of a transmitter may be calibrated.

It can be seen that FM occupys much more space in the spectrum, in terms of cycles, than does AM, but the "state of the art" is such that the new method of broadcasting can be accommodated in the high frequency region. The cardinal virtue of FM is its noise reduction property, but to get equipment to work at the frequencies assigned to FM required considerable work in the laboratory and factory. Part 2 of this article will deal with the various makes, types, and circuits of such equipment, and will be presented in an early issue of the ATE Journal.

Having turntable trouble?

Presto 63-A dual speed 16" transcription table with pickup mounting bracket. Base plate is drilled to mount selector switch and scratch filter.



Unique Presto drive system. Step pulley on motor shaft drives against rubber tire on turntable rim. Lever changes speed instantly from 78 to 33⅓ RPM.

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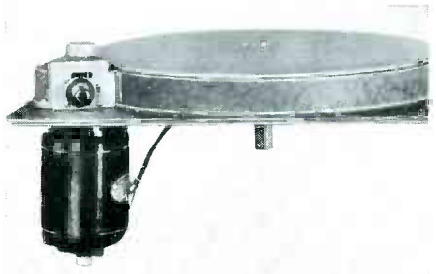
that are removing the playback pickups from their old transcription tables and remounting them on the new Presto 63-A table.

It's a simple change to make, because the Presto table is furnished with brackets to mount any standard make of vertical or lateral pickup and the base is drilled to mount your compensator controls and scratch filter. The entire changeover takes an hour at the most and costs very little.

You'll marvel at the reproduction of your transcriptions played on the 63-A table. It's the quietest, smoothest running turntable we've ever produced and it runs for months at a time with no service whatever. The new Presto drive system—a heavy, live rubber tire on the turntable rim driven by a steel pulley on the motor shaft—has only 2 moving parts, requiring a simple adjustment once or twice a year. Speed accuracy is .3%—less than 3 seconds time error on a 15 minute program. Vibration is negligible. Leading firms use and recommend the 63-A for playing both vertical and lateral recordings.

Give new life and realism to your transcribed broadcasts this fall. Install Presto turntables now. Literature and prices on request.

Recent purchasers include:
Associated Music Publishers, Canadian Marconi Co., Columbia Broadcasting System, Columbia Recording Corp., Federal Tel. & Tel. Co., Northern Electric Co., Westinghouse Radio Stations. Also stations KICA, WBNS, WBRW, WHO, WJMS, WMEX, WSYR, WTRY and Advertising Agencies Fuller & Smith & Ross, Inc., Lennen & Mitchell, Wm. Esty & Co., Maxon Advertising Agency and others.



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Why and How of FM

(Continued from Page Six)

FM 75 noise we actually hear corresponds only to the small cross hatched triangle and all the rest is rejected. The maximum height of this FM triangle, corresponding to voltage, is only one-fifth of the height of the AM rectangle. Such being the case the FM 75 advantage is 5 to 1, or 14 DB. Simple?

DEEMPHASIS

When the high frequencies are attenuated in a receiver, the high frequency noise is, of course, attenuated by the same amount. This may make a noisy signal more pleasant to the ear, but it degrades the fidelity. However, if the high frequencies are increased in amplitude in the transmitter, the overall fidelity will be restored. Nevertheless the noise which comes in at the receiver remains attenuated and therefore a reduction of noise results from this practice. The use of a 100 microsecond filter to accomplish this purpose has been adopted as standard practice in Television and UHF sound broadcasting by the Radio Manufacturers Association and recently by the FCC. It has actually been in use for several years. A 100 microsecond filter is a combination of resistance and capacity which will charge to 63% of maximum, or discharge to 37% of maximum in 100 microseconds.

It was shown that in FM, the noise amplitude decreases as its frequency decreases whereas in AM it doesn't. Therefore, deemphasis is more effective in FM. Consider Fig. 4. The full rectangle at the left is the AM noise spectrum. The full triangle at the right is the FM spectrum. The application of deemphasis reduces these areas to those combining the hatched and black sections. Squaring those ordinates gives the black areas, corresponding to power, or energy. Extracting the square root of the ratios of these black areas gives the RMS voltage advantage of FM over AM. It is 4, corresponding to 12 DB. Bear in mind that this 12 DB includes the gains contributed by both the triangular noise spectrum and deemphasis. The spectrum advantage was 4.75 DB. Hence the deemphasis advantage is 12 DB minus 4.75 DB or 7.25 DB.

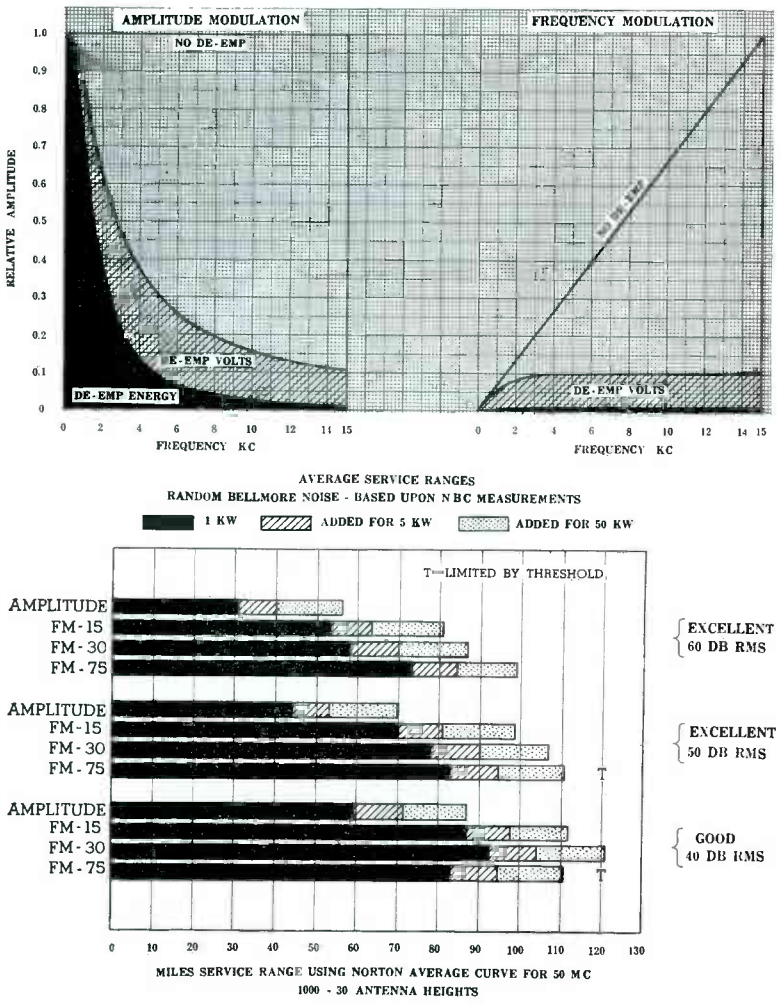
All commercial FM receivers include deemphasis and all FM TRANSMITTERS INCLUDE PREEMPHASIS. It's an FCC requirement.

Now let's sum up. We saw that the FM noise spectrum advantage was 4.75 DB, the deemphasis advantage was 7.25 DB and the deviation ratio of FM 75 was 14 DB. Combining these gives us 26 DB.

Now let's see what advantage we actually measured as part of the field test project. Your attention is directed to Fig. 5 which has on it a great deal of information.

It actually condenses to one page much of the data we sought and obtained. Many pages could be devoted to it. The curves may be extended to the upper left in parallel lines as far as desired. The actual field intensity of the noise can be determined from the AM curve. For instance, for 10 microvolts at the receiver terminals the AM signal

(Continued on Page Twenty)



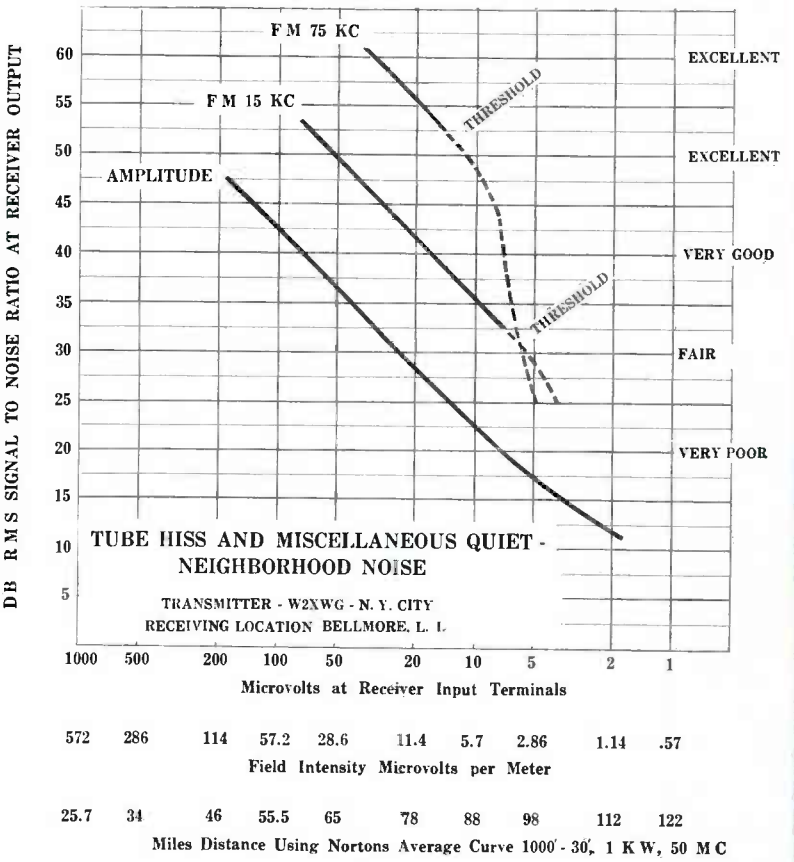


Fig. 4, top left

Fig. 5, above

Fig. 6, bottom left

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New York

By Ed Costello

Reports of vacation activities have brought to light some interesting hobbies. Hollis Young, for instance, spent his vacation up around Cape Cod with a weather eye cocked for antique door knobs. He was in the other day with a sample of the loot: two "Sandwich Glass" knobs which he tells us were last made about sixty years ago. For those of my readers in whom this little item may arouse a desire to go forth and do likewise, I pass on this example of door knob collecting technique as practiced by Hollis.

Having espied a door knob, the possession of which the collector is sure will turn all other door knob collectors green with envy, he approaches the attached door and knocks. "Madam," he says to the slightly bewildered old lady who answers, "madam, I have been admiring your door knob and I wonder if you would consider selling it." The very much bewildered old lady says, "Well—" at which sign of indecision the collector replies, "I'd be willing to pay you a dollar for it," at the same time giving her the dollar and removing the knob before she wakes up to the fact that she no longer has a door knob and it's going to cost her a dollar and a half to replace it, plus two dollars labor.

You can also take Petey Herrold for instance. He spent his vacation wandering around abandoned mines searching for semi-precious stones suitable for cutting and polishing. You probably didn't know that Petey is an amateur lapidary. Well, he is!

I hear Doc Miles is about ready to publish his book entitled "Know Yourself." Any of you fellows wishing to invest a dollar to become acquainted with your closest relative should get in touch with Doc here in New York. Don't blame the Doc, though, if after becoming acquainted, you find he (your closest relative) is not the nice guy you always thought he was.

One of the most interesting vacations reported to date was that taken by Phil Falconi and Rudy Bauer. But let's have Rudy tell us about it—

"New York to California in thirteen days—California to New York in thirteen hours. That's the trip Phil Falconi and I took on our vacation. We sailed from New York aboard the S.S. Washington with Havana the first port of call. The stop here allowed a quick round of the night clubs before sailing on to the thrilling transit of the Panama Canal — no pictures allowed here, cameras had to be checked. The stop in Balboa was long enough to permit a sampling of Panama City night life with a quick look at Coconut Grove. Quaint Acapulco, Mexico, was visited on the trip up the coast. The Tequilla was good and—on the thirteenth day, sure enough there was Los Angeles harbor. The attractions on the boat, however, were stronger than those of Los Angeles, so we continued to San Francisco on the S.S. Washington. After inspecting this delightful city for several days we flew to Yosemite Valley for a look at this natural wonderland and then flew on down to Hollywood. In Hollywood, with the excellent hospitality of the boys of the NBC studios, we discovered many more interesting sights. A side trip to Santa Barbara for a view of the annual fiesta in that city was considered well worth the time. On August the 17th we boarded TWA's stratoliner (and were tucked in by the hostess) for an overnight hop back to Radio City in approximately thirteen hours."

The July Journal was to my way of thinking the best since its inception. Here's my vote of appreciation to all the staff and in particular to Ed Stolzenberger for all his hard work, and to Bev Fredendall for a swell article.

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Why and How of FM

(Continued from Page Eighteen)

to noise ratio is about 25 DB or 18 to 1. Hence the noise is 1/18 of 10 microvolts, or .6 microvolts RMS.

The ordinates are identified in receiver input microvolts, microvolts per meter and miles distance. Use the one you are most interested in. If you want condensed distance tables refer to the bar chart, Fig. 6, which was made from the data on this sheet.

Compare the measured gains with the calculations we went through. They look to be the same. They are. That means we found that the theoretical gain of FM can be and was obtained in practice.

Note the dotted sections of the FM curves. They are dotted to indicate that operation is not only below the "noise threshold" but is far enough below it that a noticeable increase of noise results as soon as modulation occurs. The dotted sections represent noise in the unmodulated condition. During modulation they break even sharper than indicated. Since there is no such thing as a noise threshold in AM there is no such break. However, at distances where AM is better than FM it has small entertainment value because it is noisy. However, the AM signal is useful for intelligent transmission, i. e., telephone communication, code, etc. The result is that wherever useable AM entertainment service is provided, FM 15 is 12 db quieter and FM 75 is 26 db quieter.

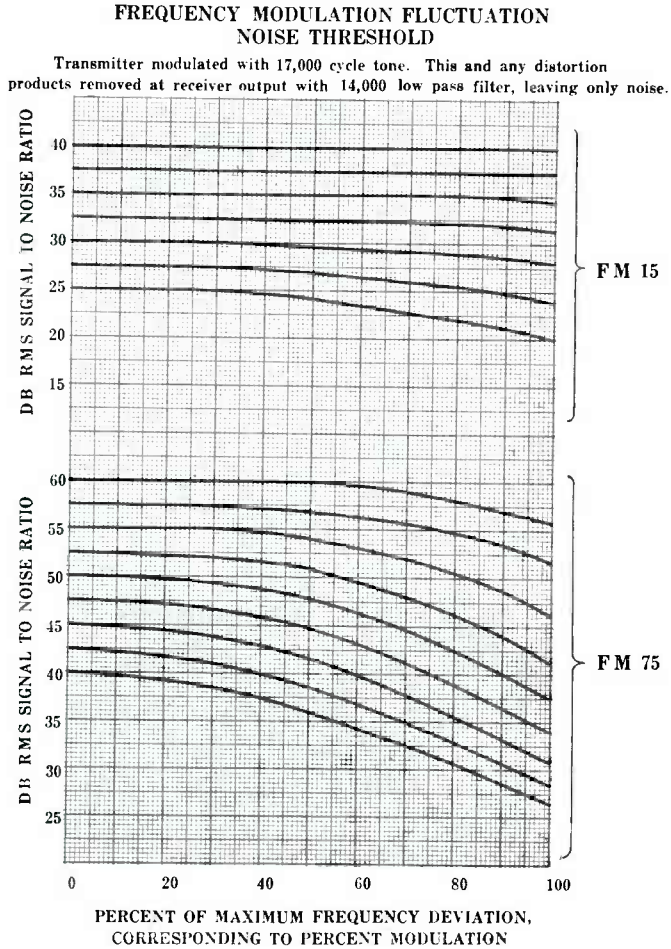
THE NOISE THRESHOLD IN FREQUENCY MODULATION

An interesting series of events takes place in a frequency modulated system when the noise peaks equal or exceed the peaks of the carrier. The result is a rapid increase of the noise level or decrease of the signal to noise ratio with modulation. In frequency modulation wherein the maximum swing is 150 KC the point where this begins to occur is reached when the unmodulated signal to noise ratio is about 60 db. When the unmodulated signal to noise ratio is less than about 60 db, or 1,000 to 1, the noise level rises with modulation, and, as the noise peaks exceed the carrier peaks by a considerable amount, this noise level may go up 20 db, or 10 times. When operating above the threshold limit the noise changes very little as the station is modulated. Below the threshold limit the effect is not unlike severe harmonic distortion in an overloaded amplitude transmitter.

In frequency modulation of a lesser swing, such as 30 KC, a similar effect occurs. In this case, however, the threshold limit occurs at about 35 db signal to noise ratio. Fig. 7 shows the results of some of the measurements we made. In order that the noise would not be confused with the small amount of inherent distortion in a practical FM system, the measurements were made in such a manner that the effects of distortion were completely eliminated. This was done by modulating the transmitter with a 17,000 cycle tone and eliminating at the output of the receiver with a 14,000 cycle low pass filter, not only the fundamental modulating tone but all distortion products, leaving only the noise.

This effect has no doubt been observed by many without being understood. It is an inherent limitation in a frequency modulation system. The noise threshold in the case of an FM 40

(Continued on Page Twenty-two)



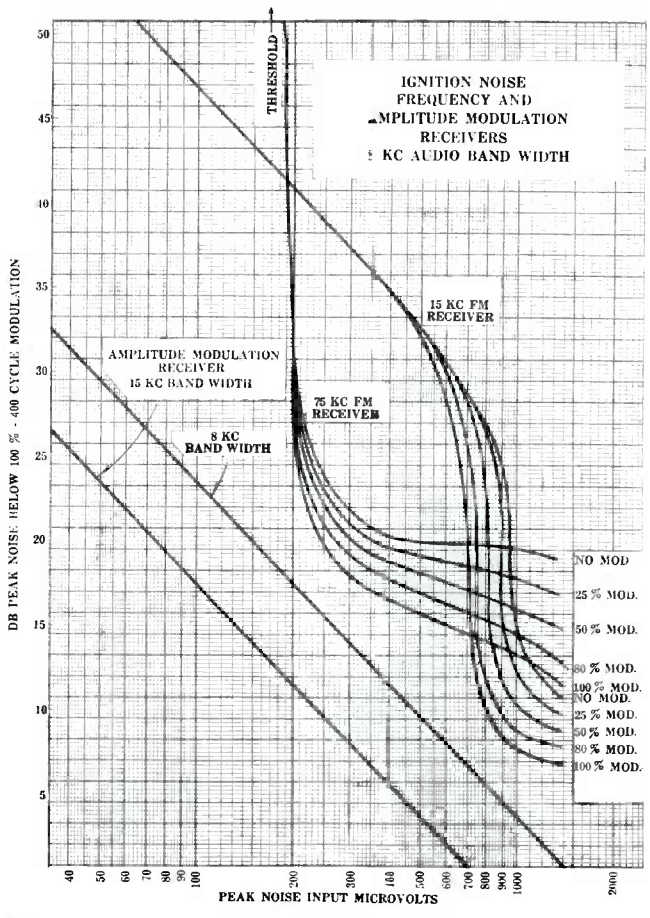


Fig. 7, left; Fig. 8, above

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WOR

By R. A. Schlegel

"Swell!" — "Best issue yet." — "Fine Business." These are some of the comments of the WOR gang when they had finished reading the July issue of the JOURNAL. Everyone pleased with the new format and enjoyed the articles very much . . . We won't mention the heat wave New York experienced because Bob Brooke will only use it for California propaganda . . . WOR opened new FM transmitter at 444 Madison Ave. . . . Sir Stork left a girl with the O'Connors on his first visit to that home . . . My vacation has gone wherever it is that vacations go when they are over . . .

Mackenzie Reid, Field Supervisor, spent an enjoyable vacation at Cape May, New Jersey, and disagrees with Shirley Davis as to the best place to catch striped bass. The gang were trying to picture Mac bobbing about in the surf on an inflated rubber raft. Reid spent thirteen years at sea and never learned to swim. I believe that Reid or Wheeler Davis wouldn't have much trouble in keeping afloat. Balloons stay on top of the water.

KFI's McDonald can tell Ray Moore that we added an air-cooling unit in the recording room. Did Ray mention the size of the room in relation to the amount of equipment? G. E. Stewart visited us and had to walk sideways through the room. Enjoyed Moore's visit, but why did he have to pick a time when the President was making a broadcast? Hope to see him again.

I am told that Jimmy O'Connor has instructions to move the transmitter so that there will be a place for the basinette. Perhaps he'll be able to set the rig under the kitchen range.

Pop Reveal, the ol' leatherneck and hoss trader, is again offering ham equipment for sale. This time it's a Collins 30FXC with no modifications, revisions or alterations. Those who know Reveal will not believe the latter assertion.

We haven't seen much of Kibling, but he's busy with Westchester remotes. Kib has a big deal on to sell one of his transmitters, but it didn't jell so Kib will continue with ham radio after all. The FCC orders didn't dampen his ardor.

Neil Spencer and Bill Boher spend most of their time fishing at Sheepshead Bay and at New London, Conn. Boher has offered to teach Reveal the art of catching fish. Ed Scatterday could stand some instruction along that line for he hasn't been able to make much of a showing. Ed pulled in four mackerel to Boher's twenty-six.

Shirley Davis is reported as having moved to Darien, Conn., where he is said to be enjoying the comforts of living in his own home.

Ray Lyon planning a modern house for a hillside plot out in the Jersey hills. The house will have dry wall construction and many up-to-date innovations.

Vacationists are coming and going. Ted Kasna back without a tan. Jim Carter up to the Boston area. I'm told that he is looking over his real estate holdings in Millets . . . Johnny Cook away, but no one knows where . . . Everyone anxious to know where and how Berger spent his vacation. Will he have some explaining to do! Tsk-tsk! . . . Cy Samuelson to Ogdensburg, N. Y., for the National Guard war games. Each year his uniforms have to be "let out" in the middle! Dick Borner probably will be found on the beach at Atlantic City . . . Henry Morgan comes up with, "The recordings used on this program were recorded."

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Why and How of FM

(Continued from Page Twenty)

system having a total band width of 100 KC occurs at about 43 db. Since this provides a very good signal-to-noise ratio and the required band width is only 100 KC, FM 40 is believed by many to have more overall merit than FM 75 when the comparative gains and limited space in the allocation spectrum are considered.

So far as is known, the data on the FM threshold effect presented here, and data published by Murray Crosby of RCAC constitute the only measured data ever published.

Fig. 8 shows ignition noise measurements with peak noise input microvolts plotted against peak signal to noise ratio, based upon the signal resulting from maximum 400 cycle modulation. The FM 15 threshold is shown. The FM 75 threshold is not shown because at the time the measurements were made AC hum within the system made the accuracy of S/N measurements in the 60 DB region uncertain.

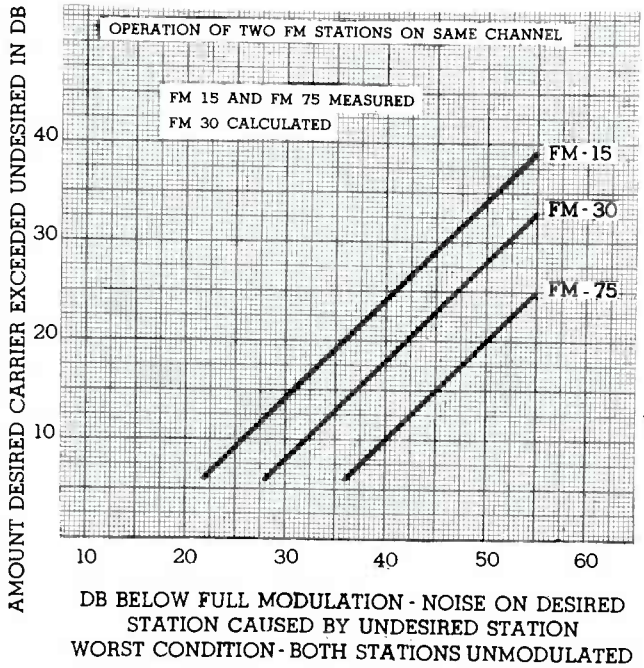
It should not be assumed that peak S/N ratios of 20 or 30 DB are unuseable when the noise arises from ignition systems because it isn't true. The relative infrequency of ignition peaks produces an audible result which is very deceiving. Ratios as low as 10 DB, while distracting, do not entirely ruin service as is the case with fluctuation noise. It will be noted that the curves of ignition noise threshold flatten off at the bottom. This is to be expected from the character of ignition noise. The impulses are very short in duration, very high in amplitude and relatively widely separated. They literally blank out only small portions of the signal waves, without impairing the remainder. The short blanked out intervals of the signal change little over a wide range in noise peak amplitude. Once an ignition peak has risen to the value required to control the receiver and blank out the signal a further rise in the noise level will not occur until the peak increases in breadth, or duration, or until there is a sufficient rise in certain low amplitude components of ignition noise having fluctuation noise characteristics. The peculiar shapes of such curves below the threshold values are due to the wave shapes and crest factors of ignition noise, but they are also influenced by the method of measurements.

OPERATION OF TWO F-M STATIONS ON THE SAME CHANNEL

By referring to the section covering noise interference it can be seen that the worst condition of shared channel operation occurs when both stations are unmodulated and a fixed beat note, therefore, results. It will also be seen that the higher this beat note the greater will be its amplitude. Fig. 9 was made on the basis of the worst conditions, which occur when the difference in carrier frequency reaches approximately 5,000 cycles. Were it not for the effect of de-emphasis in the receiver the beat note amplitude would rise with frequency. However, de-emphasis of the high frequencies prevents that from happening and the effect may be further understood by referring to the section on pre-emphasis and de-emphasis. It will be noted that the noise on the desired station caused by the undesired station varies inversely with the deviation ratio. F-M 75 has a deviation ratio of 5 compared with 1 for F-M 15.

When either of the stations producing the beat note becomes modulated, the beat note disappears because one carrier sweeps across the other one. When the desired station is approximately 20 db stronger than the undesired station, interference and cross talk effects become unnoticeable. At 12 db difference they are noticeable but it is the opinion of some engineers that the 12 db ratio would be tolerable. Frequency modulation offers a great advantage over amplitude modulation in the allocation of stations on the same frequency. In A-M the carrier amplitude of the desired station must be 100 times, or 40 db greater than the undesired carrier amplitude for a 40 db signal to beat note ratio. For F-M 75 it need be only 10 db, or 3 times greater. For FM 30 it need be only 17.5 db or 8 times greater. For FM 15, it need be only 24 db, or 10.5 times greater.

The result is that FM stations can be located much closer geographically, and therefore many more station assignments can be made per channel. All interference due to sky wave transmission from distant stations is automatically rejected in FM because the interfering signals never reach the high amplitude required. This is not so in amplitude modulation.



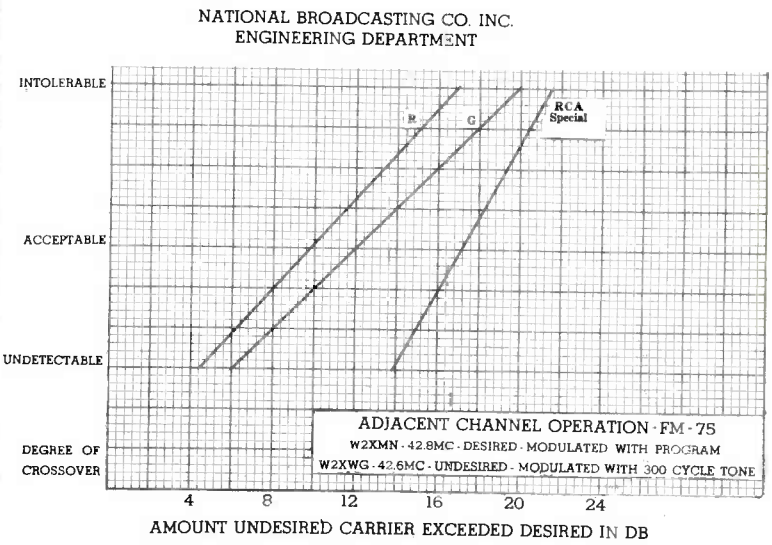


Fig. 9, left; Fig. 10, above

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OPERATION OF FM ON ADJACENT CHANNELS

Can FM stations operate in the same areas on adjacent channels without interfering with each other? Fig. 10 shows some data we accumulated proving that they can't. The Commercial receivers have objectionable cross-talk if the undesired station signal intensity is more than about 10 DB, or 3 times greater than the desired signal intensity. The special RCA receiver is about 7 DB better than the others but it has 5 I. F. stages compared to 3 for the others. Intolerable cross-talk occurs on all the receivers when the carrier ratio becomes about 20 DB, or 10 to 1.

In making these measurements the field intensity ratios were changed by controlling the power of W2XWG.

Lack of space makes it seem impractical to try to include more data at this time although much more was obtained. Practically all of it was presented in condensed form by your humble scribe at the recent FM hearing and presumably it was of some value to the FCC in drafting the new rules and standards for FM stations. That's why it was introduced, at any rate.

The new FM allocations have some interesting aspects. Six adjoining channels are provided for towns or cities having less than 25,000 population and where not more than 500 square miles are served. Since adjoining channels cannot be used in the same city, only three stations are actually provided for per city.

For stations of less than 3,000 square miles service area 22 adjoining channels are provided, giving 11 as a limit per city.

For stations of more than 3,000 miles service area, which means the biggest and most important urban areas, only 7 adjoining channels are provided, making possible a maximum number of only 4 stations, one more than the smallest city. Don't ask me.

A maximum of 6 stations will be permitted any licensee, although presumably many thousands could be accommodated in the U. S. A maximum of three television stations are allowed to any licensee although presumably several hundred could be accommodated in the U. S. Oh, me!

KFI-KECA

By H. M. McDonald

No column this month; too busy trying to prove to the F.C.C. when and where we were born and we've got troubles; see you in the Army.

San Francisco

By H. N. Jacobs

Vacations are occupying the limelite now, and there's not much new here. CR supervisor and wife to Honolulu along with Cliff Engle and wife; Cliff's on the announcers' list.

Joe Baker's first real voyage in the 28-footer was to Santa Cruz, down the coast a day's run. He reports a fine trip.

Harry Jacobs decking over his little 18-footer and hopes to launch it during vacation in October.

Curtis Peck, engineer-in-charge to NY for the annual engineer's meet.

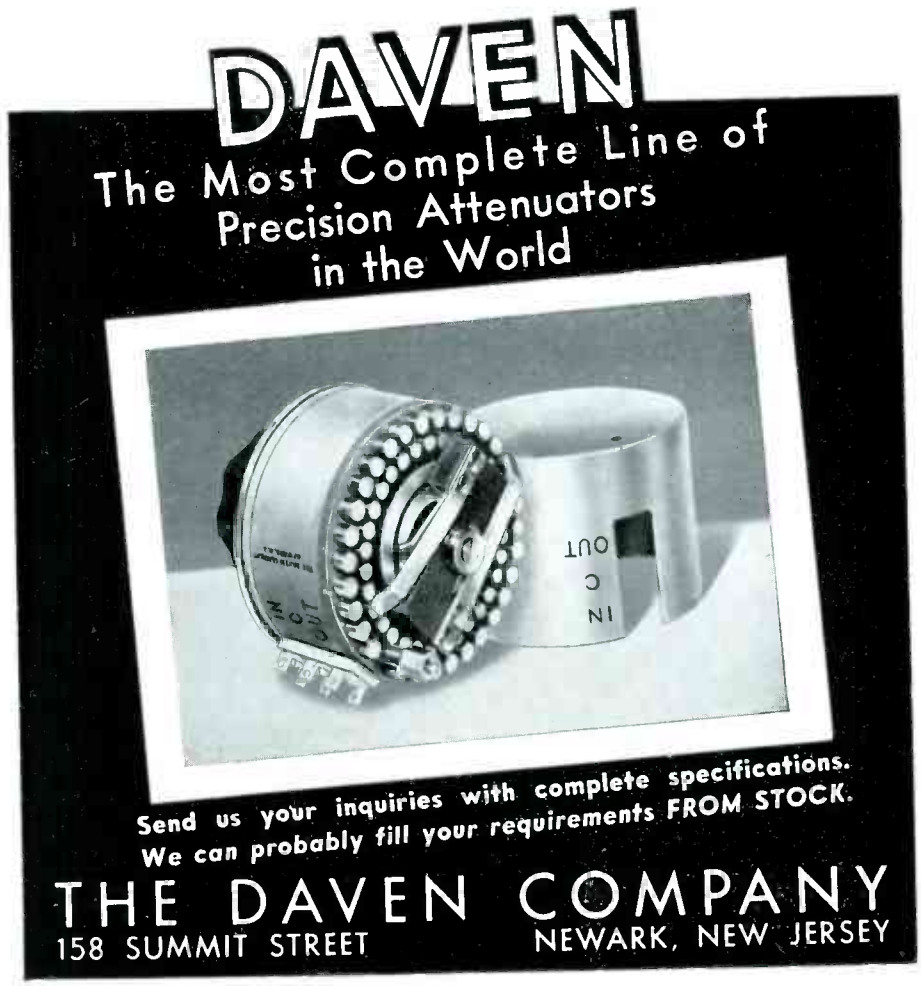
Reference recording room finally dressed up with nice new racks. The new equipment didn't arrive in time for the big recording issue, but Alan O'Neil is very happy about it anyway. Better late than never!

Annual NBC outing at Beresford Country Club saw the usual turnout and a fine time was had, as usual; hangovers were had by most, as usual.

From the Chicago Tribune of August 30th, we learn that the Chicago Police awarded a contract to the Radio Engineering Laboratories, Inc., for 200 FM transmitters for use in their Squad Cars. The award was made to REL after exhaustive tests and recommendation by Fred Schnell, police radio engineer.

Major Lenox R. Lohr's book, Television Broadcasting (McGraw - Hill, 6¼" by 9¼", 269 pages, $3.00), is now available, and should be regarded as "must" reading by the Program, Production, and Engineering personnel of every up-to-the-minute broadcaster. David Sarnoff says in the Forward, "Mr. Lohr is ably qualified to appraise the problems and the possibilities inherent in the field of public service that television has now entered."

Advise your local ham clubs that they can receive a courtesy copy of the ATE Journal by addressing our Circulation Dep't, giving list of Club Officers, Call Letters, and total membership.



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Washington

By A. R. McGonegal

The Washington office of The National Broadcasting Company has announced that A. E. Johnson, Washington Engineer-in-Charge, will supervise all campaign speech pickups for Wendell Willkie, Republican Presidential candidate, in addition to those of President Roosevelt. Mr. Johnson has supervised all Presidential pickups for NBC for the past sixteen years, including speeches by every President since Harding. One of his outstanding assignments was a trip by air several years ago to Rio de Janeiro and Buenos Aires, for the purpose of supervising President Roosevelt's South American broadcasts.

NBC contact and announcing in connection with the Willkie broadcasts will be handled by Charles Barry, Night Manager of the Washington office. Mr. Barry has had several years experience in special events work in Washington, which will help him considerably in his new assignment. Carleton Smith, Washington Assistant Manager and Presidential announcer since 1932, will continue to handle contact and announcing on all of President Roosevelt's campaign addresses.

Work on all three of Washington's major construction projects is progressing rapidly. At the WRC transmitter, both new towers are up and painted, tuning houses finished, tuning equipment installed and the concentic lines completed. Plans are completed for the new WMAL plant, and construction will start in a few days, at the new location on Bradley Boulevard. At the studios, a complete new suction system built by Spencer Turbine has been installed, two new Scully master recording machines have been delivered and installed, along with the necessary amplifiers. We soon won't know the old place.

At WRC, vacations are being postponed due to pressure of work on the new installation. Al Powley drew a postponement, due to his being sent to Hyde Park, N. Y. "The President and I can't both get off at the same time," says Al. Your correspondent managed to get in a week at Atlantic City, where good food and rest added ten pounds to his chest, or thereabouts.

It's a boy at the home of Announcer Bill Crago. August 10th—seven pounds nine ounces. The event was duly publicized on "Esso News" of that date.

Hollywood

By Bob Brooke

FOG . . . Well, fellers, looks like we had our summer last winter . . . Average temperatures until late August have been lower than those of last winter . . . Our Eastern visitors want to stay now because it's cool . . . Last winter they wanted to stay because it was warm . . . Palm Springs has been doing a record summer business and most of our vacationing engineers have spent at least some of their time down on the desert or in the interior.

VISITORS . . . Ray Guy traveled west by car to deliver a lecture on FM before the Pacific Coast IRE Convention at Los Angeles . . . Other visitors included Rudy Bauer and Phil Falconi of NY, who came out on the SS. Washington's first trip via the Panama Canal . . . Rudy and Phil were entertained by the Joe Kays while here . . . Jake O'Kelly hosted Charley Snyder and Alex Gresham of the WHAM transmitter and took them deep sea fishing . . . Andy Andresen of San Francisco spent most of his vacation looking over Hollywood beauty and dance bands . . . Understand he showed Tiajuana the fine points of San Francisco sight seeing . . . Andy says he concurs heartily with all my reports on Hollywood weather and that I NEVER exaggerate . . . Speaking of visitors it would be a good idea if we had a visitors' log and then we could print a list of visitors to each office each month in the Journal . . . A working visitor was R. A. Lynn of the NY development Lab who spent several weeks installing special equalizers on the new Sculley master recorders . . .

STORY . . . Daily Variety reporter was writing his morning column in the many windowed Variety office next to Tips . . . Looked out and saw a gal in slacks arm in arm with a man in a kimona . . . Said scribe, "G——, I hope they're tourists" . . . You can see some odd native sights at the corner of Hollywood and Vine, but you should see what gets out of cars bearing Iowa, New York, Illinois, Oklahoma, etc., license plates . . .

STODDART . . . Dick Stoddart leaves Hughes Aircraft . . . Dick reports his resignation from the Hughes organization to accept a position as Vice-President of Lear Aviation Radio Company . . . Dick will be in charge of the West Coast branch and handle the business of the company with the big plane manufacturers and government agencies on the Coast . . . Good luck, Dick . . .

Chicago

By Ray Bierman

Am wondering how many of you om's have ever tried to run gain on an outboard motor. Especially the borrowed type. By the time you've missed a few faders on the throttle, choke, and spark controls, to say nothing of forgetting to put the cap back on the extra fuel, why you're up the proverbial creek, as the fella says. Only in this case the creek happens to be a lake about three miles wide.

Dave (Isaac Walton) Kempes in the Canadian wilds after big fish, and bigger game. Dave returned to his favorite vacation haunt armed with a high-powered rifle, new outboard motor, and some more fishing tackle. And we mean tackle. Dave will probably have to tackle the fish in order to get it into the canoe. Ought to mention here, too, that Dave has a new Pontiac, and we have it on good information that it has a fast pickup. Many of the local female gentry will miss our most eligible bachelor while he is away.

Woody Lahman, after eight unsuccessful years predicting what horse would come in first, finally called a winner. Paid $2.10.

We greet Hugo Beck, new WMAQ relief transmitter engineer, replacing C. F. Kotcher, who has taken a position as Radio Inspector at the Great Lakes Monitoring Station. FB, Kotcher. Hope you like your new job.

Since the Showboat Show has been moving from one studio to another, Lanterman and Brooks have been moving the air lines for the air calliope all over the place. Brooks knows the complete ceiling layout for the nineteenth and twentieth floors of the Mart. Lanterman is buying up old vacuum cleaner attachment hose to make a patchcord system for the air lines.

The WENR transmitter recently played host to 350 visiting hams. The date was August 12, and the occasion was the annual Hamfesters' picnic. The boys tell me all the spare tubes remained intact and there were no transmitter outrages due to ham curiosity.

Latest game the WENR boys are playing is Guess Who. They are having a lot of fun looking at each other's "passport" pictures which were taken in connection with the recent F.C.C. order for pictures, finger prints and birth data from all radio operators. Now that the government has all us boys fingerprinted it begins to look like a lot of us will have to watch our step. I'm even afraid to steal a watermelon now.

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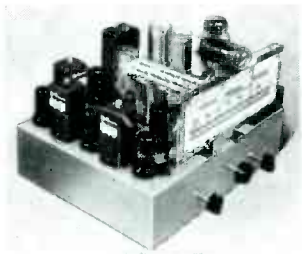
BROADCASTING DEMANDS
Meissner Quality in F-M

Among the first in the commercial field with the introduction of Frequency Modulation, Meissner has pioneered in the development of highest quality parts and complete receivers.

TABLE MODEL F-M RECEIVERS

A fine, twelve-tube complete F-M Receiver, fully engineered for maximum sensitivity and tonal quality. Covers F-M band only, 42 to 50 MC; "converter" connection may be used to drive any high-quality audio system. Built-in audio system drives 8" hi-fidelity P-M speaker; five-position tone control provides any desired combination. Beautiful, two-toned walnut cabinet, 12¼ inches high, 22¾ inches wide and 11 inches deep—a modern design fitted equally well for home or studio use.



F-M CHASSIS ONLY

Where it is desired to incorporate Frequency Modulation receivers in connection with studio or control-room equipment, this complete chassis is available separately. Same twelve-tube unit as used in the above Table Model receiver. May be built into rack-panel or other special type of construction. Power consumption, 110 watts at 117 volts, 60 cycles. Power output, 6 watts undistorted. Selectivity, 170 KC broad at two times signal. Sensitivity, 10 Microvolts, average.

MEISSNER LEADS THE FIELD!

From the very first announcement of Frequency Modulation broadcasting, Meissner has been determined to obtain and maintain the foremost position in the design and construction of the highest quality receiving equipment.

How well this goal has been reached can only be witnessed by the performance of the receivers described herewith. Nothing has been spared—no minor detail has been overlooked—in the sincere effort of Meissner engineers to attain this objective.

Only a few of the more important features can be briefly mentioned here. Others will be immediately apparent upon examination and trial of the instrument itself. Ceramic insulation, voltage regulation, temperature capacity compensation, specially designed tuning condenser, high-gain "television" type tubes, dual-shadow tuning indicator,—all contribute to stability, ease of operation and over-all performance.

WRITE FOR FURTHER INFORMATION

Meissner engineers are always ready to help with any special problems. Write for complete bulletin of Meissner Products describing entire line of F-M and A-M Receivers, parts for special construction and designs. Consultation with Meissner sales representatives may be arranged to suit your convenience.

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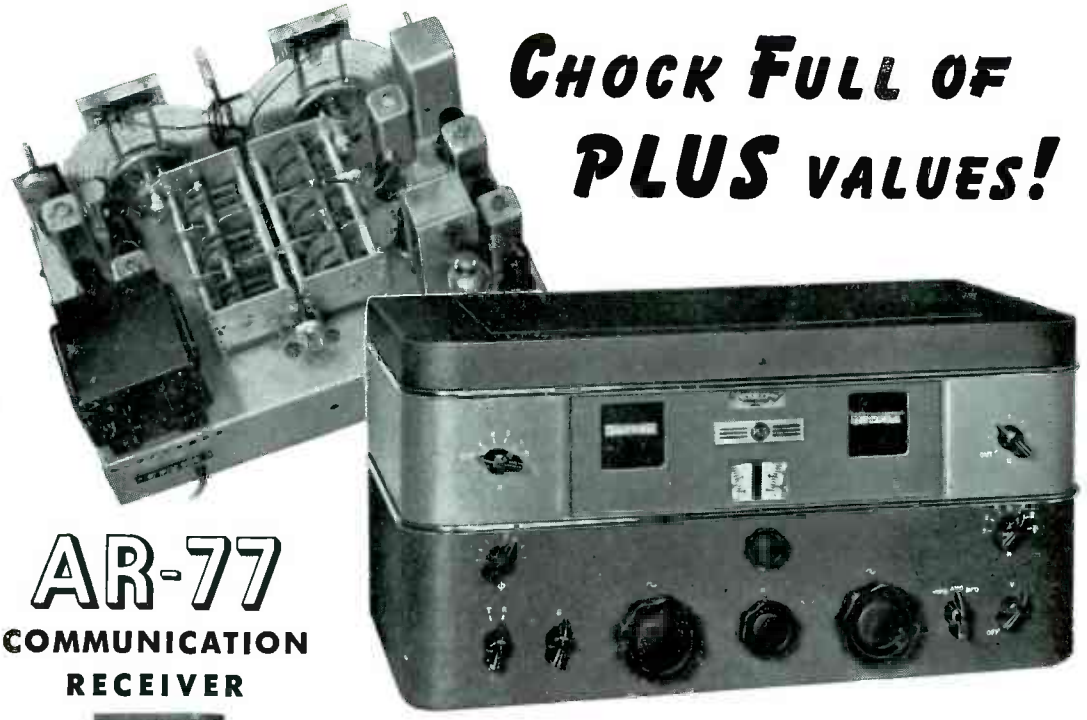

AR-77
COMMUNICATION RECEIVER

Double-Purpose Value

During off periods of "QSO-ing", when you are busy with the soldering iron and pliers experimenting or just relaxing, you will want to have some good entertainment programs permeate the shack. To meet this extra requirement, we offer a new Extended Range Loudspeaker MI-8314-A for the AR-77. A combination hard to beat for faithful reproduction of all modulated signals.

Amateurs' Net Price for both AR-77 Receiver and MI-8314-A Speaker $154.50

"STAY-PUT" TUNING
Tests under average conditions show maximum drift at 30 Mc to be only 3.0 Kc on one hour run, thereby keeping signal audible.

ADJUSTABLE NOISE LIMITER
Can easily be regulated to meet local conditions. Easily understood signals obtained through noise peaks hundreds of times higher than signal level.

"BREAK-IN" OPERATION
Used on a separate antenna, receiver recovers instantly when transmitter key is up. Ideal for "traffic hounds" to move a hook full of messages promptly. *(Receiving antenna should resonate in higher frequency band than transmitter frequency to prevent excessive voltage pick-up from transmitter.)*

HIGHEST SIGNAL-TO-NOISE RATIO
A 2-to-1 ratio of signal-to-noise is obtained at an average sensitivity of 2 microvolts throughout range.

UNIFORM SENSITIVITY
Each r-f circuit has dual alignment with air-dielectric trimmers for high-frequency end and inductance adjustment of coils for low end.

BANDSPREAD TUNING
Calibrated bandspread for 10, 20, 40, and 80-meter bands extends to nearly full rotation of dial for "split-kilocycle" readings. *Carrier level meter* serves for both peak tuning and to measure signal strength in popular "S" scale.

6-STEP SELECTIVITY
Wide choice of selectivity assures operator control of signal interference.

IMPROVED IMAGE REJECTION
Image ratio of approximately 40-1 at 30 Mc is obtainable.

NEGATIVE FEEDBACK
Smooths out and extends the audio response curve.

Give it a Whirl! Other worthwhile features of the AR-77 include Uni-view dials; accurate signal reset; standby switch with relay terminals; temperature and voltage compensated oscillator; high-gain pre-selector stage and a popular tuning range of 540 to 31,000 K. C. Write for Bulletin—or, go to your nearest RCA Amateur Equipment Distributor and compare the performance. You be the judge! *Amateurs' Net Price $139.50. MI-8303 Table Speaker in matched cabinet $8.00 extra. All prices f. o. b. factory.*

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