Communication and Broadcast Engineering

VOL. 3 NO. 7

Radio Telegraphy
Radio Telephony
Wire and Cable Telegraphy
Wire and Cable Telephony
Broadcast Transmission
Carrier Transmission
Beam Transmission
Marine Radio
Police Radio
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JULY, 1936

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EDITORIAL

DIRECTION FINDERS TO THE FORE

ROTATING LOOP DIRECTION FINDERS, or radio compasses, have been a valuable marine navigation instrument for many years. Their uses have, in the main, been limited to frequencies below the broadcast band and to relatively short distances.

During the past few years, a number of new types of direction finders, utilizing a combination of directive and non-directive antennas, have come to the fore, and they are being used to a limited extent for both marine and aircraft work. In general, these instruments use a loop and a vertical antenna, and feed a right-left indicating meter. Also, they are designed to operate over the range from 200 to 1500 kc.

To overcome the limitation of "night effect," inherent in instruments employing loop antennas, Adcock antennas have been investigated in England and elsewhere. (The results of these investigations have been published in the IEE Journal.) Theoretically, such antennas should not be subject to "night effect" and should permit direction finding at considerable distances as well as at higher frequencies.

While the final word has probably not been written, it is evident that much thought is being given to this interesting subject and that new approaches to the problem are being devised and investigated. The need for accurate, foolproof equipment of the direct-indicating type becomes increasingly apparent with the opening of the long over-water flights in the Pacific and the proposed long over-land hops of the transcontinental transport planes. Whether relatively simple equipment on the plane or more elaborate equipment on the ground will be used is probably still an open question. In any case the need for better equipment is evident and therefore it may be expected that much more will be heard on this topic in the near future.

HIGH-POWER LONG-WAVE BROADCAST STATIONS

AT THE RECENT ENGINEERING HEARING on the allocation of ultra-high-frequency waves. Dr. Charles B. Aiken, who ably represented the National Association of Broadcasters, made some very interesting and timely recommendations to the Federal Communications Commission. Briefly, Dr. Aiken proposed that the following frequency bands be made available for aural broadcasting purposes: 180—210 kc, 520—1600 kc, 25,600—26, 600 kc 36,000—38,000 kc, 62,000—64,000 kc and 94,000—100,000 kc. It was also recommended that facsimile be permitted on all these bands.

One of Dr. Aiken's suggestions was received with considerable interest. This recommendation was that part of the low-frequency band (from 180 to 210 kc) be made available for high-power broadcast stations. According to Dr. Aiken, five stations with powers of 1000 kw could nearly cover the entire United States with an adequate daytime signal. Further data on this subject appears on following pages of this issue.

A great many localities in the United States do not have sufficient, if any, daytime coverage and such a system of superpower stations would be of considerable benefit to both the broadcasters and the people living in these areas. Dr. Aiken's opinions are greatly respected in engineering circles and it is sincerely hoped that the Federal Communications Commission will give due consideration to his recommendations.

EXPERIMENTAL TELEVISION TRANSMISSIONS

AS PLANNED, RCA have started experimental television transmissions from the Empire State Building transmitter. About 100 television receivers have been placed at various locations in and around New York City, and observers stationed at these locations will make reports on the performance of the system. As we have often pointed out, these field tests should do much towards solving the endless details of transmission, reception and program problems.

PRESENTING . . .

THE FOURTEENTH ANNUAL CONVENTION of the National Association of Broadcasters. which was held at the Stevens Hotel in Chicago from July 5 through 8, was quite successful. The registration was the largest in the history of the organization, some 450 station delegates being present and the total registration exceeding 600. A report of this convention will be found elsewhere in this issue.

IN OUR EDITORIAL for June, 1936, we discussed the RMA's five-point television program which was recommended to the Federal Communications Commission. The report of the RMA Television Committee on television standardization was delivered at a later date, and a discussion of it appears in this issue.

LOOK TO UTC for REAL ADVANCEMENTS IN AUDIO TRANSFORMERS!

Those who have followed the advancement of audio transformer design in the past few years realize that the pioneering work in this field has been done under the UTC insignia. The reputation of leadership which UTC has attained is not accidental but the result of years of design experience gained by exacting research and laboratory development.

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COMMUNICATION & BROADCAST ENGINEERING

FOR JULY, 1936

NAB ALLOCATION REPORT

Excerpts from the testimony delivered at the recent FCC Allocation Hearing by Dr. Charles B. Aiken, Technical Consultant for the National Association of Broadcasters

IT MUST BE ADMITTED that the present broadcast band is overcrowded, and yet the clamor for new frequency assignments steadily increases. The public has enthusiastically supported the majority of the stations in existence, and would certainly support more. There are many rural parts of the country that need additional service, especially during the day, when signals from a distance cannot be heard. Such stations can only be served by more stations or more power, or both.

An examination of existing frequency assignments in the United States has shown that, of 382 stations not included in the "local" classification, 182 are involved in violations of the minimum distances for nighttime operation on the same frequency; while 60 shared-channel stations violate the specifications of the daytime table.

One of the results of this overcrowding is that the type of interference best described as "flutter" is extremely serious on many channels, particularly at night. In some rural areas reception, which would otherwise be satisfactory, is often entirely ruined by interference of this sort, while in others the quality of service is often seriously impaired.

Overcrowding is a serious matter, not only because it tends to stop the growth of a service that has come to be regarded as a public necessity but because it also means that if a few channels were to be lost to American broadcasting, the effects would be disastrous. For some time we have been made painfully aware of the fact that certain other North American countries, particularly Mexico, regard their present frequency assignments as hopelessly inadequate and have every intention of insisting upon additional channels. This condition constitutes a very serious threat to the broadcast structure of the United States. If it is not adequately met by an expansion of the broadcast band, it may well result in aggravation of the present difficulties, and the choking of normal and justified growth.

Another fault to be found with the present system of allocation arises from the fact that broadcasting has been forced to use certain frequencies not well suited to its needs. While aware of the technical shortcomings of these frequencies, the industry has made every effort to utilize them as fully as possible, and, under direction of the FCC, has built up a system unequalled anywhere in the world.

RURAL COVERAGE

Obviously, rural areas should receive as good service as it is possible to give them. Not only the United States, but Canada and Mexico as well, contain large regions which can best be served by relative long-distance broadcasting. It would appear, therefore, that our needs for long-range transmission are better established than are those of any European nation except Russia. Although faced by the difficult problems raised by the clash of national interests, these nations have succeeded in allocating their broadcast services where they can be most effective, while the North American nations have completely failed in efforts to secure such allocations.

A more satisfactory broadcast structure can be obtained only by the assignment of new groups of frequencies in two widely separated portions of the spectrum. One group below 550 kc would do much to improve rural coverage in the United States and Canada, but would be of less use to Mexico because of the relatively high noise levels in low latitudes. Other groups, in the ultra-high frequency range, would do much to improve strictly local services and to relieve serious congestion on shared channels.

Not only should provision be made for the normal growth of aural broadcasting, but it seems likely that facsimile and television must be accommodated before very long. It is at least possible that these newcomers to the broadcast field may prove extremely important, and every opportunity should be provided for experimentation and commercial growth. Should successful services be instituted, they would probably be of tremendous value to the public, and would undoubtedly be stimulants to research and to industrial activity.

We believe that all the radio services should now adopt a long-range point of view, and, setting aside considerations of temporary expediency, should try to examine the technical possibilities for future development and growth. Certainly the difficult problems of frequency allocation, and of coordination of the conflicting demands of various services can best be solved by adherence to scientific principles, and by careful evaluation of all of the technical factors involved. Where complete technical data are lacking, as in the case of the ultra-short waves, assignments should be made with the realization that they may have to be changed. Steps should be taken to guard against premature entrenchments that might later be detrimental to the proper balance and high efficiency of all radio-communication services. Wherever uncertainties exist a policy of "evolution and experimentation," which has been recommended by the Commission, seems to be the only safe and logical one to follow.

Facsimile broadcasting requires a frequency channel having a width depending upon the speed of sending. Generally speaking, we may say that a

10 kc broadcast channel is entirely adequate for the transmission of facsimile signals.

It is recommended, therefore, that all frequencies which are, or will be, assigned to aural broadcasting be made available for use by facsimile. The use of existing facilities would undoubtedly aid experimentation and the development of a fascsimile service for home use.

While midnight to morning would probably be best for experimenting with this new service, it seems likely that there may ultimately be occasion to alternate facsimile and aural broadcasting on some channels, or even to make the former a 24-hour service.

Should television service be established on a large scale, it would of course be of great interest to the broadcasting industry. It is not within our province to consider all the problems which must be overcome before this can happen, and we shall merely assume that the Commission will try to make provision for visual broadcasting.

Mr. Baldwin has already suggested that it will either be necessary to provide more frequencies for international broadcasting or to admit that the United States cannot compete in this field. The bands at present provided for this service are, as you know, quite narrow. Moreover, because of the peculiar propagation characteristics of short waves, these bands cannot all be used at the same time with equal success. Consequently, the effective number of channels available is less than the total of assignments in the several bands.

Nor is this all. International broadcasting, by its very nature, is subject to serious long-range interference. The stations of not one, but several, nations must operate simultaneously, and hence the number of the channels available to any one country is necessarily small.

PROPOSED ALLOCATIONS

As a matter of record, our proposals of June 1 are repeated here. It is recommended:

A. That frequency assignments be made as follows:

180 to 210 kc incl. . Aural and Facsimile
520 to 1600 kc incl. Aural and Facsimile
25.6 to 26.6 mc. . . . Aural and Facsimile
36 to 38 mc. . . . . . . Aural and Facsimile
38 to 56 mc. . . . . . . Television
62 to 64 mc. . . . . . . Aural and Facsimile
64 to 94 mc. . . . . . . Television
94 to 100 mc. . . . . Aural, Facsimile, and frequency modulation
100 to 120 mc. . . . . Auxiliary broadcast service such as point-to-point relay for broadcasting, synchronization, mobile voice and facsimile pick-up.

B. That a minimum of 25 experimental television channels of 6 mc width be set aside in a manner consistent with the needs of other services beginning at about 130 mc.

C. That the existing international broadcast bands be enlarged as follows:

6 mc band to .5 mc width
9.5 mc band to .3 mc width
11.7 mc band to .4 mc width
15.1 mc band to .4 mc width
17.75 mc band to .3 mc width
21.45 mc band to .3 mc width

The frequencies below 100 mc are shown on the chart of Fig. 1.

The various problems of broadcast coverage have received a tremendous amount of attention from engineers and physicists the world over, and as a result a mass of information has been collected concerning the utility of the various wavelengths.

The range of clear-channel stations is very long at night, and large numbers of people are able to receive such stations in their secondary coverage areas, which are reached only by sky waves. In daytime sky waves are so much weaker that secondary coverage may be regarded as non-existent.

The result of this weakening of the sky wave is that very large rural areas, which depend upon relatively distant stations for evening reception, cannot hear them at all in daylight. In fact many regions are without daylight service of any kind. The great use of long-wave broadcasting stations would be to furnish daytime coverage over very extended areas. Furthermore, the nighttime service area lying within the zone of objectionable fading is very much larger at low frequencies than it is at high.

It is well known that, for a given radiated power, the radius of ground-wave coverage decreases rapidly as the frequency is increased, and that the zone of serious fading also draws in toward the transmitter. As a convenient summary of the data relating to ground-wave coverage there have been plotted in Fig. 2 the radii of certain field-strength contours as a function of frequency, for two different values of the ground conductivity.[1] We see that there is a tremendous change in ground-wave coverage with frequency, and it is therefore not surprising that there should be general agreement that the higher frequencies are not well suited to broadcasting, and that high power in the neighborhood of 1500 kc is not economically justified. The high frequencies can be used for local coverage only, and the problem of delivering a satisfactory service to large suburban regions and to rural areas can be solved only by the efficient use of longer waves.

An examination of the Berne List has shown that it should be possible to locate a broadcast band extending on either side of 200 kc without much inconvenience to other services. That such a band would have valuable characteristics is well known, and proposals for its use in this country have been made by Westrom and others, all of whom have indicated the great possibilities of long-wave coverage.

[1]The data for these curves have been taken from the *Report of the Committee Preparing Material for Question 7 for the Fourth Meeting of the C. C. I. R.*

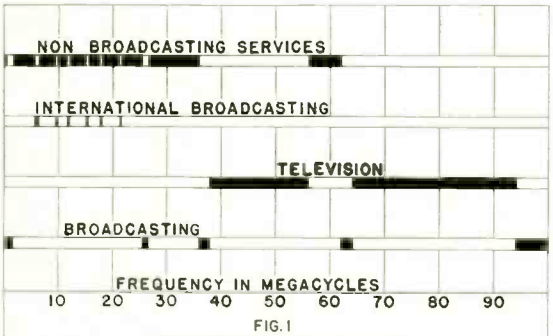


FIG. 1
PROPOSED ALLOCATION CHART

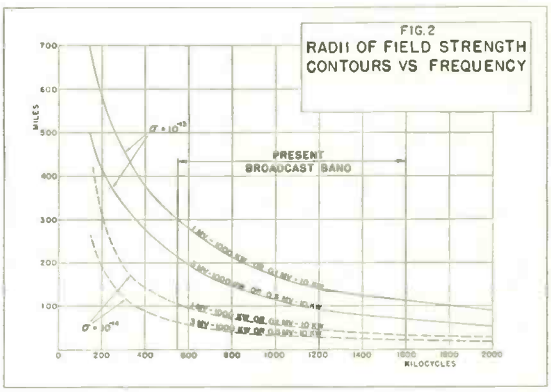


FIG. 3
3.0 MILLIVOLT CONTOURS
OF 1000 KW RADIO STATIONS
ON 200 KC

GROUND-WAVE RANGE

In Fig. 3 is shown the estimated 3-millivolt contours for stations located in various parts of the United States. It is assumed that each station radiates 1000 kw at a frequency in the vicinity of 200 kc. The contours for stations 1, 2 and 5 have been corrected for variations in the average conductivity of the soil, while those for stations 3 and 4 are based on an assumed constant conductivity of approximately 6×10^{-14}.

Perhaps station 1 is the most interesting from the standpoint of population coverage. Based on the census of 1930, there are within the 3 mv/m contour approximately 8,000,000 families, or about 25,000,000 people. The area within the 3 millivolt limit includes a great many cities of medium to large size, among them St. Louis, Chicago, Milwaukee, Indianapolis, Detroit, Toledo, Cleveland, Columbus, Cincinnati, Dayton, Youngstown, Louisville, Nashville, Chattanooga, Charlestown, W. Va., Wheeling, Pittsburgh, and Erie, while Buffalo is just outside this contour.

The three-millivolt line probably represents the useful limit of satisfactory coverage in summer, because of the high noise intensities, and should also coincide roughly with the nighttime limit set by fading. The field strength within the entire region bounded by this contour is sufficiently great to furnish high-grade service in the residential areas of all cities and towns lying within its borders. The provision of so high a field to override atmospheric noise would also take care of man-made interference in practically all residential zones.

The one-millivolt contour would include a considerably larger area, and it cannot be denied that rural and suburban homes lying within this boundary would receive excellent daylight service in winter. In fact, it is probable that many listeners located between 100 and 150 miles beyond the one-millivolt line would then find reception very satisfactory.

The average noise level due to atmospherics increases at the lower frequencies. While there is not as much information available as we could wish, the measurements of Potter, throw a good deal of light on the question. These measurements have been checked in the broadcast band by Byrne, and through theoretical calculations by Norton. Available data have been studied by the *Committee Preparing Material for Question* 9, *Proposed for the Fourth Meeting of the C. C. I. R.* The charts of this Committee show that nighttime noise is inversely proportional to frequency in the range from 100 to 1000 kc while the daytime noise varies somewhat more rapidly than the inverse square of the frequency in the same range. The noise intensity will, of course, change greatly from place to place and from time to time, but these curves may be taken as indicative of the variation with frequency at any given time and place. Curve B of the Committee's report indicates that a daytime field strength at 200 kc of approximately 300 μv/m is necessary, on the average, for barely satisfactory broadcast reception, and hence a field of 3 mv/m should be entirely satisfactory under average conditions. It is for this reason that the three-millivolt contour has been taken as the limit of the high-grade service area in summer.

At night, the average noise levels would be considerably higher; in fact, the Committee's curve C indicates that a field of about 6 mv/m should be required for barely satisfactory broadcast reception. However, the plotted points shown on this graph all lie below the curve; in fact, the point for 200 kc is at 0.5 mv/m. Moreover, if we assume that 1 mv/m will furnish reasonably satisfactory nighttime service at 600 kc, it follows from the inverse proportionality of noise level to frequency that 3 millivolts will be satisfactory on 200 kc. Hence, it may be questioned whether the curve is not somewhat high in this area. It is certain that during the winter 3 mv/m would furnish satisfactory reception most of the time, and that in mid-summer it would often be adequate even at 200 kc. More extensive data on noise levels are needed.

We may assume, then, that the 3-

millivolt contour will furnish satisfactory broadcast reception during most of the daylight hours throughout the year, and that the service rendered at night, while of a lower order of excellence, will nevertheless be of distinct value throughout the winter and during part of the time in summer. These arguments apply primarily to the northern part of the United States and Canada, and with less force to the southern United States.

RADIUS OF THE FADING ZONE

Here again, there is need for more information, but enough material is available to show that the radius of fading-free service would be large, even at night. Let us first estimate the zone on the assumption that 200 kc sky waves behave in the same manner as those in the present broadcast band.

The very extensive studies of Norton, Kirby, and Lester show that, for distances of from about 300 to 600 miles, the maximum night field due to waves reflected from the Heaviside layer is approximately that which might be expected from the inverse distance relation; and that for 1 kw of radiated power the maximum night field at a distance of 400 miles is of the order of 0.5 mv/m. An examination of the ground wave propagation charts previously referred to shows that 1 kw of radiated power will produce a groundwave field of only about one-fourth this value at 400 miles, and that the half-millivolt level is reached at about 215 miles. This refers to a ground conductivity of 10^{-13}.

It seems very likely that the situation on 200 kc is actually much better than is suggested by the above outline, since the sky wave intensity probabaly falls off rather sharply at frequencies as low as 200 kc. Thus, Monroe and Green, in their studies of 200 kc propagation phenomena in Australia, report a value of 0.1 mv/m for 1 kw radiated, and point out that T. L. Eckersley found a value of 0.3 for the higher broadcast frequencies in Europe. Accepting this three-to-one ratio, but assuming the 0.5 mv/m figure as correct for 1,000 kc on this continent, we should have a considerable increase in the radius of the fading-free area. Thus in the Middle West, 1 kw of radiated power would give a field strength of 1.67 mv/m for both ground and sky waves at about 300 miles, and it is likely that this is more representative of the actual radius of the fading ring than is the 200-mile figure.

During the past winter and spring, I have had occasion to make a number of night observations on Air Commerce stations operating between 200 and 300 kc at distances up to 250 miles. A receiver without automatic volume control was used, so that fading, had it occurred, would have been readily apparent. While no regular schedule was kept, a good many observations were made, and no case of fading can be recalled.

We must also consider the fact that fading on 200 kc will be much slower than at broadcast frequencies. Selective fading is always more serious when the carriers of the interfering waves are of the same magnitude and are at, or near, phase opposition. Since the sidebands may not balance out to the same degree, an effective over-modulation is produced, causing very violent distortion of the received signal. It seems likely that, when the carriers are not near to phase opposition, selective fading will produce little distortion of 200 kc signals.

This distortion-producing fading could occur only at those points at which the skywave amplitude was very nearly equal to that of the ground wave. If either component were a few db larger than the other, the fading should be substantially distortionless, and could therefore be smoothed out by the use of automatic volume control in the receiver. This fact should considerably reduce the importance of fading effects and should limit the zone of destructive interference to a relatively small percentage of the total service area. Both within, and, in considerable areas, without this zone, it should be possible to get very satisfactory nighttime reception.

To sum up: It would appear that the radius of destructive fading for a station located in a reasonably high conductivity area may be expected to be between 250 and 400 miles. The fading should have a long period, and selective fading should occur only in relatively limited regions.

As a result of these considerations, it may be assumed that a 200 kc station would serve a very large area at night as well as during the day, although the two areas might not be entirely coincident.

BLANKETING AREA

The blanketing area of a 1000 kw station on 200 kc would not necessarily be large insofar as reception of stations above 500 kc is concerned. In fact, when obsolete receiving equipment has been discarded, the blanketing area should be rather small. In order to see what may be expected, let us estimate the interfering signal that might be tolerated without resulting in objectionable cross modulation in the first r-f amplifier of a radio receiver.

The first tube of a well designed receiver should be a variable-mu pentode having an approximately exponential characteristic of plate current versus grid voltage. Calculations of the cross modulation to be expected in an ideal tube of this sort show that an interfering voltage of 1.54 volts could be applied to the grid before the modulation of the desired signal by the interfering program would be as much as 1 percent.

The characteristics of commercial variable-mu tubes are not strictly exponential, however, but depart from this theoretical form in such a way as to increase the cross modulation. In order, therefore, to allow a factor of safety, let us assume that the interfering signal of the first amplifier tube should not be more than half a volt.

Even a badly designed receiver, tuned to a frequency above 500 kc should attenuate a 200 kc carrier at least 60 db, and the majority of receivers should do better than this. By attenuation is meant the ratio of the signal on the grid of the first tube to that induced in the antenna. If we assume an effective antenna height of about 3 meters, then the interfering field strength that could be tolerated would be more than 100 v/m. It is of course possible that, with so high a field, direct pickup in the other parts of the set might cause the introduction of rectified signals into the audio-amplifier, but it is reasonable to suppose that with a properly designed receiver a field of the order of 100 v/m could be tolerated. To be extremely conservative we might take 10 volts per meter as the boundary beyond which cross modulation would be negligible. With a 1000 kw radiated this field should occur at about seven-tenths of a mile from the antenna.

At frequencies near that of the transmitter, cross modulation would, of course, be more troublesome, although even here it would not be serious if properly designed equipment were used. It is reasonable to suppose that a listener located not far from the transmitter, and receiving a nearby frequency, would be content to use a narrow passed band with a consequent increase in selectivity.

In addition to difficulties due to cross modulation, trouble may be expected from extra-band radiation by the interfering transmitter falling within the passed band of the receiver. On adjacent channels this latter would undoubtedly be the more serious limitation. It is perhaps idle to speculate as to just what sort of extra-band field a 1000 kw transmitter designed for 200 kc operation would lay down, but it is possible that the reception of low-intensity telephone signals in the next channel might be seriously affected.

In the case of broadcast reception this would not be serious, for a listener located within the 100 mv/m contour, could not reasonably expect service

(*Continued on page 17*)

RMA'S TELEVISION REPORT

TELEVISION occupied an important role at the recent engineering hearing called by the Federal Communications Commission. At this gathering, which was called for the purpose of obtaining information relative to the allocation of the ultra-high frequencies, James M. Skinner, Chairman of the RMA Television Committee, recommended the five-point program discussed in our editorial for June. Briefly, the five points were as follows:

1. One single set of television standards for the United States, so that all receivers can receive the signals of all transmitters within range.
2. A high-definition picture approaching ultimately the definition obtainable in home movies.
3. A service giving as near nationwide coverage as possible.
4. A selection of programs; that is, simultaneous broadcasting of more than one television program in as many localities as possible.
5. The lowest possible receiver cost and the easiest possible receiver tuning.

At this same meeting Albert F. Murray, also of the RMA Committee on Television, made recommendations concerning television standardization. It was the RMA's suggestion that the band allocated for television broadcasting extend continuously from 42 to 90 mc, with the exception of the 56-60 mc amateur band. An additional band beginning at 120 mc was also requested.

According to Mr. Murray, the following are the reasons for starting the television band at 42 mc:

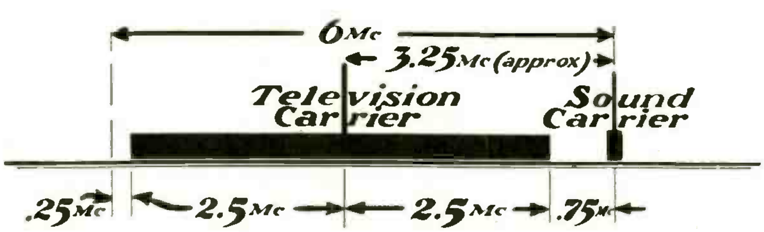
1. The frequency must be sufficiently high to eliminate multiple transmission paths.
2. The frequency must be sufficiently high to permit practical designs of circuits to pass the wide frequency bands required for picture transmission.
3. In the light of present engineering knowledge it appears that a large metropolitan area could be better served with frequencies near 42 mc than at higher frequencies, because the attenuation increases rapidly with frequency.
4. With existing transmitter design and the existing types of tubes greater power output for television can be obtained at the lower frequencies and relatively lower output at the higher frequencies.
5. It is believed that better and more economical receiver designs will result when starting the band at approximately this frequency.
6. It is recommended that television services be started in a frequency band for which there are tried engineering designs. The mentioned lower limit of 42 mc is considered satisfactory.

It is believed that the frequency band should extend to 90 mc so that a reasonable number of channels would be available. Further, single-dial receivers can be designed to cover the 42-90 mc range. The space above 120 mc was requested for the purpose of research, remote pickup, relaying and for future expansion.

Since it is essential that television have lasting entertainment value, it was recommended by the RMA that channel widths be at least 6 mc, that picture and sound carrier spacing be approximately 3.25 mc, and that there be between 440 and 450 lines per frame.

The bandwidth required for picture transmission is directly proportional to frame frequency and to the amount of information to be transmitted. A 6-mc channel permits sidebands up to 2.5 mc. A channel makeup, in diagrammatic form, is shown in an accompanying illustration. This gives a guard band of .25 mc, a lower sideband of 2.5 mc, an upper sideband of 2.5 mc, another guard band of .75 mc, and sound sidebands. The portion of the channel from the television carrier to the sound carrier is fixed by apparatus and performance considerations.

The lower picture sideband is not essential for the transmission of the picture, provided certain design considerations are taken into account. According to Mr. Murray, however, no method is known of designing a practical transmitter for completely eliminating one sideband. It is, nevertheless, possible in the transmitter and receiver to favor one sideband and partially attenuate the other. Future development may indicate how to obtain sufficient reduction in the lower television sideband so as to permit placing the sound carrier of the next lower channel closer to the television carrier of the channel under consideration than that indicated in the accompanying diagram.



Typical Television Channel

The spacing of the sound and picture carriers is determined by the width of the upper picture sideband and the practical circuit selectivity obtainable in the receiver so as to prevent crosstalk. The placing of the sound carrier at a higher frequency than the television carrier permits a better receiver design when using a superheterodyne circuit.

It was recommended by the RMA that a decrease in initial light intensity shall cause an increase in the radiated power. This means that negative transmission is recommended. Negative transmission permits more efficient use of the transmitter output.

A frame frequency of 30 per second and a field frequency of 60 per second, interlaced, is considered desirable. The reason for this is that the production of steady images at the receiver requires the frame frequency be an integral submultiple of the power-supply frequency.

It was also the recommendation of the RMA that the picture aspect ratio should be 4:3. This conforms with existing motion-picture standards.

In regard to the percentages of television signal devoted to synchronization, the RMA suggested that if the total amplitude of the composite television signal is taken as 100 percent, then not less than 20 percent should be used for synchronizing pulses. The reason for this is that receivers synchronize satisfactorily on 20 percent amplitude, and receivers designed to operate on a synchronizing pulse 20 percent in amplitude will also operate satisfactorily on pulses of greater amplitude.

The RMA made no further recommendation relative to synchronizing. While the necessity for such standards is readily apparent, it is felt that this matter is still in a state of flux. After further field tests, however, recommendations will probably be made.

WOR'S QUEEN MARY BROADCAST

AN INTERESTING broadcast setup was employed recently by WOR for broadcasting the initial arrival of the *Queen Mary* at New York City. An airplane, the roof of a building in downtown New York City, the deck of the liner, a Coast Guard cutter, and a pier in the North River were the various pickup points employed. All circuits and services were handled as remotes and were terminated in one studio at 1440 Broadway, New York City. This setup is shown in the accompanying illustration.

Although the *Queen Mary* was still 50 miles at sea, the first of WOR's series of broadcasts began at 9 a.m., June 1, with a word description of the new ship. This was accomplished by broadcasting from an airplane equipped with a transmitter operating on a frequency of 2060 kc and a receiver tuned to WOR's frequency of 710 kc.

On the roof of a downtown building in New York City a high-frequency transmitter operating on 31.1 mc and a receiver tuned to 34.6 mc were later placed in operation. This transmitter was used to cue the *Queen Mary* as well as the Coast Guard cutter, the latter having the same equipment as that used at the downtown pickup point.

The broadcast from the new ship was received at the downtown location and fed by telephone circuit to the studio, at 1440 Broadway, for mixing. The *Queen Mary* transmitted on 34.6 mc and received their cues on 31.1 mc. A microphone was also set up at the downtown location and used for reporting purposes.

BROADCASTING FROM THE DECK OF THE "QUEEN MARY."

Another broadcast was held as the Coast Guard cutter bearing newspaper men drew near the liner at quarantine. The cutter was also in contact with the airplane which was hovering over the *Queen Mary*.

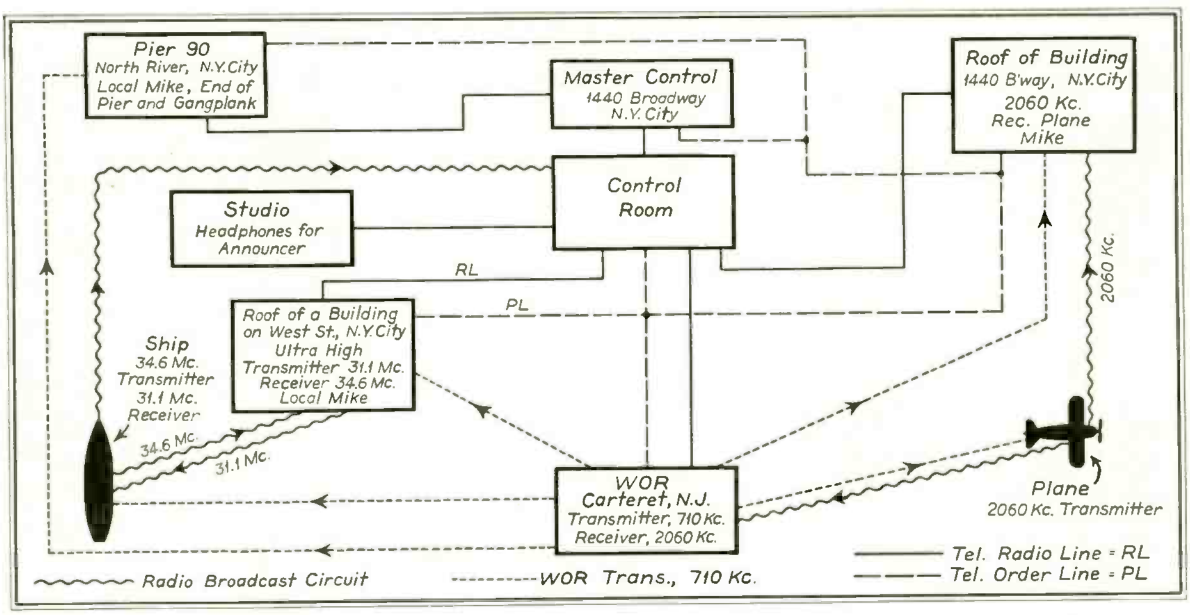
Besides the 10-watt, 34.6-mc transmitter and the 31.1-kc receiver on the liner, a battery-operated receiver tuned to 710 kc was in use checking directly with WOR. All 710-kc receivers were equipped with headphones for announcers to provide two-way communication.

The principal broadcast of the day featured New York City's welcome to the giant ship when the announcers from their various points of vantage described her trip to Pier 90 in the North River.

For the broadcast two-way service was maintained

From	*To*
Airplane	Studio
Airplane	*Queen Mary* (before ship reached quarantine)
Airplane	Coast Guard cutter
Studio	*Queen Mary* (after ship reached quarantine)
Downtown Building	*Queen Mary*
Additional Facilities 1440 B'way	Pier 90. North River, where *Queen Mary* docked.

In all, WOR staged five separate broadcasts during the day. These were as follows: at 9 a.m., the description of the new ship from the airplane; at 10:00 a.m., a two-way conversation between the airplane and the *Queen Mary*; at 11:45 a.m., a conversation between the cutter and the airplane; at 1:45 p.m., a broadcast from the deck of the *Queen Mary*; and at 3:15 p.m., the liner's reception.



NOTES ON THE NAB CONVENTION

At The Stevens Hotel In Chicago

THE FOURTEENTH ANNUAL CONVENTION of the National Association of Broadcasters was held on July 5, 6, 7, and 8 at the Hotel Stevens in Chicago, Illinois. With the surprising number of 200 being registered by Sunday night and this figure running well over 600 (including members, non-members, and guests) before the closing of the registration desk on Tuesday night, this convention may well be said to have been quite successful. It was the largest gathering in the history of the organization, and considerably exceeded the total registration of last year's convention at Colorado Springs, Colorado.

The convention was first called to order on Monday, July 6, by Leo J. Fitzpatrick, of WJR, Detroit. The address of welcome which immediately followed the call to order was delivered, in the absence of the Hon. Edward J. Kelly, Mayor of Chicago, by the Corporation Counsel for the City of Chicago.

In the principal address of the day, Judge Eugene Octave Sykes discussed the Federal Communications Commission's plans on reallocation. According to Judge Sykes, the Commission has been constantly trying to improve the broadcast service to the listening public, especially through betterment of broadcasting equipment. The quality of transmission from broadcast stations now surpasses the reception possible from most receiving sets, and the FCC's representative expressed hopes that the set manufacturers would increase the fidelity of their units. (See editorial page 2, June, 1936, *Radio Engineering.*) The Judge believes that some of the greatest improvements in broadcast equipment have been in antenna design.

CHARLES W. MYERS, NEW PRESIDENT, NAB.

Following Judge Sykes' address, Isaac D. Levy, of WCAU, presented the Treasurer's report. Most of this report was concerned with the copyright situation, and Mr. Levy expressed himself in not uncertain terms. James W. Baldwin, the Managing Director of the NAB, followed Mr. Levy with his report.

The principal address of Tuesday, July 7, was that delivered by C. H. Sandage, Chief, Division of Transportation and Communications, Bureau of Census, who quoted numerous statistics from the 1935 business census of the broadcasting industry. Complete figures have been compiled on 517 of the stations now in operation in this country. Since 1929 there has been a 90 percent increase in the number of receiving sets in use and an increase of 250 percent in the sale of time, according to the report.

The report of the Engineering Committee was interesting and to the point. This report was delivered by J. H. DeWitt, Chief Engineer of WSM, Nashville, Tennessee. Mr. DeWitt, who is Chairman of the Committee, pointed out among other things that clients are held by coverage results rather than by the power listed on the rate card.

The program for Wednesday, July 8, was concerned principally with the election and installation of officers and with the adoption of resolutions.

Officers elected were: President, Charles W. Myers, KOIN, Portland, Oregon; First Vice-President, John Elmer, WCBM, Baltimore, Maryland; Second Vice-President, Gardner J. Cowles, Jr., KSO, Des Moines, Iowa; and Treasurer, Harold Hough, WBAP, Fort Worth, Texas.

The members elected to the board of directors were: John Patt, WGAR, Cleveland, Ohio; Arthur B. Church, WMBC, Kansas City, Missouri; Edward A. Allen, WLVA, Lynchburg, Virginia; Gene O'Fallon, KFEL-KVOD, Denver, Colorado; L. B. Wilson, WCKY, Covington, Kentucky; and Frank Russell, WRC, Washington, D. C.

Numerous resolutions of thanks and appreciation were adopted during this final meeting, as well as many other resolutions concerning copyright, research, business, and the like. In this connection it is interesting to note that a resolution was proposed which, had it gone into effect, would have represented an NAB recommendation in favor of limiting powers of radio stations to a maximum of 50 kw. However after a brief discussion the resolution was tabled. It was pointed out that during the early days of broadcasting 5000 watts was considered by many as detrimental to the majority of broadcasters.

All in all, this convention was a distinct success. Much interest was evidenced in all of the meetings, and many new ideas were suggested. The broadcasting industry seems to be in a healthy condition.

LEO J. FITZPATRICK, FORMER PRESIDENT OF THE NAB.

FUNDAMENTALS IN THE APPLICATION OF

By JOSEPH D. PERNICE

MATRICES OF THE T NETWORK

LET US CONSIDER the equation

$$E_1 = z_{11} I_1 + z_{12} I_2 .$$

If the output of the Network of Fig. 3 is open circuited, I_2 becomes zero.

Thus

$$E_1 = z_{11} I_1 \quad \text{and} \quad z_{11} = \frac{E_1}{I_1} \quad \text{or}$$

$$z_{11} = \frac{(Z_1 + Z_2) I_1}{I_1} = (Z_1 + Z_2)$$

If the input of this network is open circuited then I_1 becomes zero, and

$$E_1 = z_{12} I_2 .$$

Under these conditions the voltage E_1 appears across Z_2 and hence

$$E_1 = I_2 Z_2 .$$

Thus

$$z_{12} = \frac{E_1}{I_2} = \frac{I_2 Z_2}{I_2} = Z_2 = z_{21}$$

Considering the equation

$$E_2 = z_{21} I_1 + z_{22} I_2 ,$$

when $I_1 = 0$ for the condition of open-circuited input, then

$$E_2 = z_{22} I_2 .$$

Thus we have that

$$z_{22} = \frac{E_2}{I_2} = \frac{(Z_2 + Z_3) I_2}{I_2} = (Z_2 + Z_3)$$

The impedance matrix for the T network is thus

$$\| z \|_T = \begin{Vmatrix} z_{11} & z_{12} \\ z_{21} & z_{22} \end{Vmatrix} = \begin{Vmatrix} (Z_1 + Z_2) & Z_2 \\ Z_2 & (Z_2 + Z_3) \end{Vmatrix}$$

In deriving the impedance matrix, use was made of the general voltage equations (11) and (12). In getting the admittance matrix we shall resort to the general current equations (9) and (10).

$$I_1 = y_{11} E_1 + y_{12} E_2$$

$$I_2 = y_{21} E_1 + y_{22} E_2$$

We will this time short circuit the voltage E_2 under which condition

$$I_1 = y_{11} E_1 \quad \text{and} \quad E_1 = I_1 \left(Z_1 + \frac{Z_2 Z_3}{Z_2 + Z_3} \right)$$

Thus

$$y_{11} = \frac{I_1}{E_1} = \frac{I_1}{I_1 \left(Z_1 + \dfrac{Z_2 Z_3}{Z_2 + Z_3} \right)} = \frac{(Z_2 + Z_3)}{Z_1 Z_2 + Z_2 Z_3 + Z_1 Z_3}$$

With E_2 short circuited,

$$I_2 = y_{21} E_1 .$$

But under this condition I_2 can be expressed in terms of I_1.

Thus

$$I_2 = -I_1 \left(\frac{Z_2}{Z_2 + Z_3} \right)$$

Therefore

$$y_{21} = \frac{I_2}{E_1} = \frac{-I_1 \left(\dfrac{Z_2}{Z_2 + Z_3} \right)}{I_1 \left(Z_1 + \dfrac{Z_2 Z_3}{Z_2 + Z_3} \right)}$$

$$= \left(\frac{-Z_2}{(Z_2 + Z_3)} \right) \left(\frac{(Z_2 + Z_3)}{(Z_1 Z_2 + Z_2 Z_3 + Z_1 Z_3)} \right) = \frac{-Z_2}{Z_1 Z_2 + Z_2 Z_3 + Z_1 Z_3}$$

or

$$y_{21} = y_{12} = \frac{-Z_2}{Z_1 Z_2 + Z_2 Z_3 + Z_1 Z_3}$$

If we now short circuit E_1 then under this condition

$$I_2 = y_{22} E_2 .$$

Hence.

$$y_{22} = \frac{I_2}{E_2} = \frac{I_2}{I_2 \left(Z_3 + \dfrac{Z_1 Z_2}{Z_1 + Z_2} \right)} = \frac{1}{\dfrac{Z_3 (Z_1 + Z_2) + Z_1 Z_2}{Z_1 + Z_2}}$$

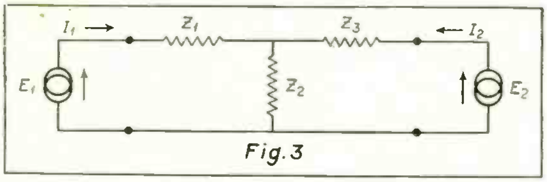


Fig. 3

MATRICES TO ELECTRICAL NETWORKS

PART II

or
$$y_{22} = \frac{(Z_1 + Z_2)}{Z_1 Z_2 + Z_2 Z_3 + Z_1 Z_3}$$

The admittance matrix for the T network is

$$\|y\|_T = \begin{Vmatrix} y_{11} & y_{12} \\ y_{21} & y_{22} \end{Vmatrix} = \frac{\begin{Vmatrix} (Z_2 + Z_3) & -Z_2 \\ -Z_2 & (Z_1 + Z_2) \end{Vmatrix}}{Z_1 Z_2 + Z_2 Z_3 + Z_1 Z_3}$$

The general circuit constants can be found from the impedance or admittance matrices by the use of the relations shown by equations 19A, 19B, 19C and 19D.

Thus
$$A = -\frac{y_{22}}{y_{12}} = \frac{z_{11}}{z_{12}} = \frac{Z_1 + Z_2}{Z_2} = \frac{Z_2}{Z_2} + \frac{Z_1}{Z_2} = \left(1 + \frac{Z_1}{Z_2}\right)$$

$$B = \frac{|z|}{z_{12}} = -\frac{1}{y_{12}} = \frac{Z_1 Z_2 + Z_2 Z_3 + Z_1 Z_3}{Z_2} = \left(Z_1 + Z_3 + \frac{Z_1 Z_3}{Z_2}\right)$$

$$C = -\frac{|y|}{y_{12}} = \frac{1}{z_{12}} = \frac{1}{Z_2}$$

$$D = -\frac{y_{11}}{y_{12}} = \frac{z_{22}}{z_{12}} = \frac{Z_2 + Z_3}{Z_2} = \left(1 + \frac{Z_3}{Z_2}\right)$$

The general circuit matrix for the T network is

$$\begin{Vmatrix} A & B \\ C & D \end{Vmatrix}_T = \begin{Vmatrix} \left(1 + \frac{Z_1}{Z_2}\right) & \left(Z_1 + Z_3 + \frac{Z_1 Z_3}{Z_2}\right) \\ \frac{1}{Z_2}\ . & \left(1 + \frac{Z_3}{Z_2}\right) \end{Vmatrix}$$

MATRICES OF THE π NETWORK

In the equation
$$I_1 = y_{11} E_1 + y_{12} E_2\ ,$$
let us make E_2 equal to zero by short circuiting it in Fig. 4. Under such a condition
$$I_1 = y_{11} E_1\ .$$

Thus
$$y_{11} = \frac{I_1}{E_1} = \frac{I_1}{I_1\left(\dfrac{Z_1 Z_2}{Z_1 + Z_2}\right)} = \frac{Z_1 + Z_2}{Z_1 Z_2}$$

If E_1 is short circuited then E_1 becomes zero and
$$I_2 = \frac{E_2}{\dfrac{Z_2 Z_3}{Z_2 + Z_3}} \quad \text{or} \quad E_2 = I_2 \frac{Z_2 Z_3}{Z_2 + Z_3}$$

$$I_1 = \frac{-E_2}{Z_2} = \left(-I_2 \frac{Z_2 Z_3}{Z_2 + Z_3}\right)\left(\frac{1}{Z_2}\right) = \frac{-I_2 (Z_2 Z_3)}{Z_2 (Z_2 + Z_3)}$$

From
$I_1 = y_{11} E_1 + y_{12} E_2$ with $E_1 = 0$, $I_1 = y_{12} E_2$ and
$$y_{12} = \frac{I_1}{E_2} = \left(\frac{-I_2 (Z_2 Z_3)}{Z_2 (Z_2 + Z_3)}\right)\left(\frac{Z_2 + Z_3}{I_2 (Z_2 Z_3)}\right) = -\frac{1}{Z_2}$$

Thus
$$y_{12} = y_{21} = -\frac{1}{Z_2}$$

With $E_1 = 0$, $I_2 = y_{22} E_2$ from the equation
$I_2 = y_{21} E_1 + y_{22} E_2$

Thus
$$y_{22} = \frac{I_2}{E_2} = \frac{I_2}{I_2\left(\dfrac{Z_2 Z_3}{Z_2 + Z_3}\right)} = \frac{Z_2 + Z_3}{Z_2 Z_3}$$

Therefore the admittance matrix for the π network is

$$\|y\|_\pi = \begin{Vmatrix} y_{11} & y_{12} \\ y_{21} & y_{22} \end{Vmatrix} = \begin{Vmatrix} \frac{Z_1 + Z_2}{Z_1 Z_2} & -\frac{1}{Z_2} \\ -\frac{1}{Z_2} & \frac{Z_2 + Z_3}{Z_2 Z_3} \end{Vmatrix}$$

To find the impedance matrix, let us consider
$$E_1 = z_{11} I_1 + z_{12} I_2\ .$$

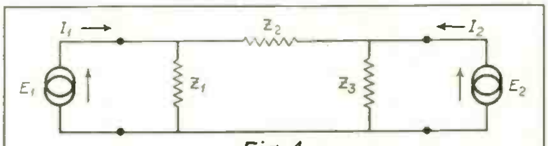


Fig. 4

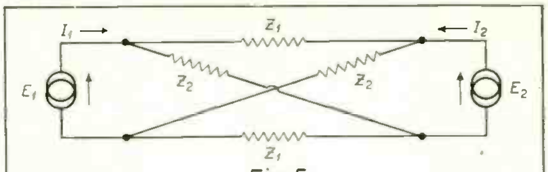


Fig. 5

If I_2 is made zero by inserting an infinite receiving impedance or by open circuiting the output, then

$$E_1 = z_{11} I_1$$

and

$$z_{11} = \frac{E_1}{I_1} = \frac{I_1\left(\frac{Z_1(Z_2+Z_3)}{Z_1+Z_2+Z_3}\right)}{I_1} = \frac{Z_1(Z_2+Z_3)}{Z_1+Z_2+Z_3}$$

Now if the input is open circuited then I_1 is made zero and

$E_1 = z_{12} I_2$ where $E_1 = I_2' Z_1$ and

$$E_2 = I_2 \frac{Z_3(Z_1+Z_2)}{Z_1+Z_2+Z_3}$$

But

$$I_2' = \frac{E_2}{Z_1+Z_2} = \left(I_2\frac{Z_3(Z_1+Z_2)}{Z_1+Z_2+Z_3}\right)\left(\frac{1}{(Z_1+Z_2)}\right) = I_2\frac{Z_3}{Z_1+Z_2+Z_3}$$

Thus

$$E_1 = \left(I_2\frac{Z_3}{Z_1+Z_2+Z_3}\right)Z_1 = I_2\frac{Z_1 Z_3}{Z_1+Z_2+Z_3}$$

and

$$z_{12} = \frac{E_1}{I_2} = \left(I_2\frac{Z_1 Z_3}{Z_1+Z_2+Z_3}\right)\frac{1}{I_2} = \frac{Z_1 Z_3}{Z_1+Z_2+Z_3}$$

Therefore $z_{12} = z_{21} = \dfrac{Z_1 Z_3}{Z_1+Z_2+Z_3}$

If in the equation

$E_2 = z_{21} I_1 + z_{22} I_2$, $I_1 = 0$ then $E_2 = z_{22} I_2$ and

$$z_{22} = \frac{E_2}{I_2} = \frac{I_2\left(\frac{Z_3(Z_1+Z_2)}{Z_1+Z_2+Z_3}\right)}{I_2} = \frac{Z_3(Z_1+Z_2)}{Z_1+Z_2+Z_3}$$

The Impedance Matrix for the π network is

$$\|z\|_\pi = \begin{Vmatrix} z_{11} & z_{12} \\ z_{21} & z_{22} \end{Vmatrix} = \frac{\begin{Vmatrix} Z_1(Z_2+Z_3) & Z_1 Z_3 \\ Z_1 Z_3 & Z_3(Z_1+Z_2) \end{Vmatrix}}{Z_1+Z_2+Z_3}$$

The general circuit constants for this network can be found from the relations shown in 19A, 19B, 19C and 19D.

$$A = -\frac{y_{22}}{y_{12}} = -\frac{\frac{Z_2+Z_3}{Z_2 Z_3}}{-1/Z_2} = \left(\frac{Z_2+Z_3}{Z_2 Z_3}\right)Z_2 = \frac{Z_2+Z_3}{Z_3}$$

$$B = -\frac{1}{y_{12}} = -\frac{1}{-1/Z_2} = Z_2$$

$$C = \frac{1}{z_{12}} = \frac{Z_1+Z_2+Z_3}{Z_1 Z_3}$$

$$D = -\frac{y_{11}}{y_{12}} = \left(-\frac{Z_1+Z_2}{Z_1 Z_2}\right)\left(-\frac{Z_2}{1}\right) = \frac{Z_1+Z_2}{Z_1}$$

Thus the general circuit constants' matrix is

$$\begin{Vmatrix} A & B \\ C & D \end{Vmatrix}_\pi = \begin{Vmatrix} \dfrac{Z_2+Z_3}{Z_3} & Z_2 \\ \dfrac{Z_1+Z_2+Z_3}{Z_1 Z_3} & \dfrac{Z_1+Z_2}{Z_1} \end{Vmatrix}$$

MATRICES OF THE LATTICE NETWORK

In the case of the lattice network of Fig. 5 we shall first find the general circuit constant matrix and then find the admittance and impedance matrices from the relations (17) and (18).

Let us consider the fundamental equations (13), (14), (15) and (16).

$$E_1 = AE_2 - BI_2 \qquad E_2 = DE_1 - BI_1$$
$$I_1 = CE_2 - DI_2 \qquad I_2 = CE_1 - AI_1$$

With an infinite output impedance I_2 would be equal to zero and $E_1 = AE_2$. It will be seen from Fig. 6 that

$$E_2 = -I_1' Z_1 + I_1'' Z_2 = \left(-\frac{E_1}{Z_1+Z_2}\right)Z_1 + \left(\frac{E_1}{Z_1+Z_2}\right)Z_2 = \frac{E_1}{Z_1+Z_2}(Z_2-Z_1)$$

But under these conditions

$$A = \frac{E_1}{E_2} = E_1\left(\frac{Z_1+Z_2}{E_1(Z_2-Z_1)}\right) = \frac{Z_1+Z_2}{Z_2-Z_1}$$

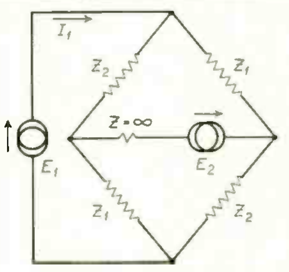
Now with $I_2 = 0$, $CE_1 = AI_1$ so that

$$C = A\frac{I_1}{E_1} = \left(\frac{(Z_1+Z_2)}{(Z_2-Z_1)}\right)\frac{I_1}{I_1\left[\frac{(Z_1+Z_2)\,(Z_1+Z_2)}{2Z_1+2Z_2}\right]}$$

or $$C = \left(\frac{(Z_1+Z_2)}{(Z_2-Z_1)}\right)\left(\frac{2(Z_1+Z_2)}{(Z_1+Z_2)^2}\right) = \frac{2}{Z_2-Z_1}$$

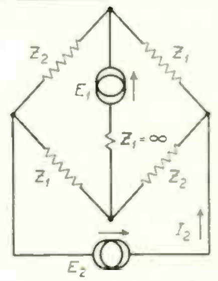
With an infinite input impedance I_1 would become zero and $CE_2 = DI_2$ so that

$$D = C\frac{E_2}{I_2}$$



Lattice Network of Fig. 5 with $I_2 = 0$

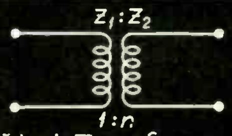
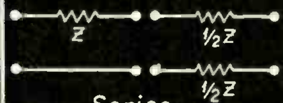
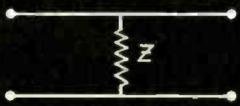
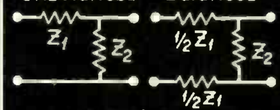
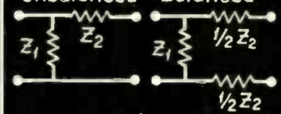
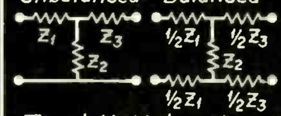
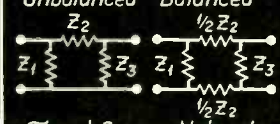
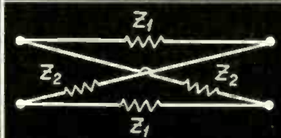
Fig. 6



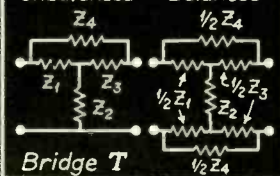
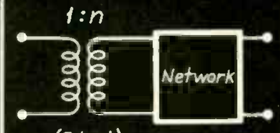
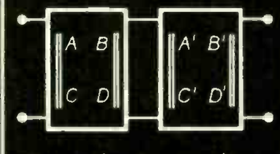
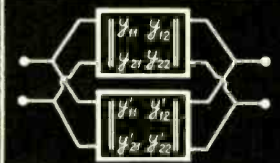
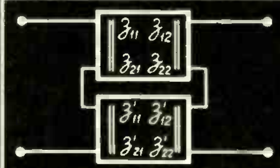
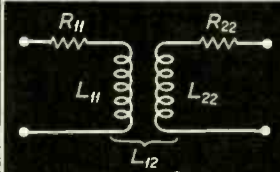
Lattice Network of Fig 5 with $I_1 = 0$

Fig. 7

Impedance, Admittance and General Circuit Matrices of Basic Networks and Matrices of Network Combinations

Type of Network	Impedance Matrix $\begin{Vmatrix} \mathfrak{Z} \end{Vmatrix}$	Admittance Matrix $\begin{Vmatrix} \mathfrak{Y} \end{Vmatrix}$	General Circuit Matrix $\begin{Vmatrix} A & B \\ C & D \end{Vmatrix}$
 Ideal Transformer	Non-existent	Non-existent	$\begin{Vmatrix} 1/n & 0 \\ 0 & n \end{Vmatrix}$
Unbalanced Balanced  Series	Non-existent	$\begin{Vmatrix} 1/Z & -1/Z \\ -1/Z & 1/Z \end{Vmatrix}$	$\begin{Vmatrix} 1 & Z \\ 0 & 1 \end{Vmatrix}$
 Shunt	$\begin{Vmatrix} Z & Z \\ Z & Z \end{Vmatrix}$	Non-existent	$\begin{Vmatrix} 1 & 0 \\ 1/Z & 1 \end{Vmatrix}$
 Double Shunt	$\begin{Vmatrix} Z_1 & 0 \\ 0 & Z_2 \end{Vmatrix}$	$\begin{Vmatrix} 1/Z_1 & 0 \\ 0 & 1/Z_2 \end{Vmatrix}$	Non-existent
Unbalanced Balanced  L-U Networks	$\begin{Vmatrix} (Z_1+Z_2) & Z_2 \\ Z_2 & Z_2 \end{Vmatrix}$	$\begin{Vmatrix} 1/Z_1 & -1/Z_1 \\ -1/Z_1 & \frac{(Z_1+Z_2)}{Z_1 Z_2} \end{Vmatrix}$	$\begin{Vmatrix} (1+\frac{Z_1}{Z_2}) & Z_1 \\ 1/Z_2 & 1 \end{Vmatrix}$
Unbalanced Balanced  L-U Networks	$\begin{Vmatrix} Z_1 & Z_1 \\ Z_1 & (Z_1+Z_2) \end{Vmatrix}$	$\begin{Vmatrix} (Z_1+Z_2) & -1/Z_2 \\ -1/Z_2 & 1/Z_2 \end{Vmatrix}$	$\begin{Vmatrix} 1 & Z_2 \\ 1/Z_1 & (1+\frac{Z_2}{Z_1}) \end{Vmatrix}$
Unbalanced Balanced  T and H Networks	$\begin{Vmatrix} (Z_1+Z_2) & Z_2 \\ Z_2 & (Z_2+Z_3) \end{Vmatrix}$	$\dfrac{\begin{Vmatrix} (Z_2+Z_3) & -Z_2 \\ -Z_2 & (Z_1+Z_2) \end{Vmatrix}}{Z_1 Z_2 + Z_2 Z_3 + Z_1 Z_3}$	$\begin{Vmatrix} (1+\frac{Z_1}{Z_2}) & (Z_1+Z_3+\frac{Z_1 Z_3}{Z_2}) \\ 1/Z_2 & (1+\frac{Z_3}{Z_2}) \end{Vmatrix}$
Unbalanced Balanced  π and Square Networks	$\dfrac{\begin{Vmatrix} Z_1(Z_2+Z_3) & Z_1 Z_3 \\ Z_1 Z_3 & Z_3(Z_1+Z_2) \end{Vmatrix}}{Z_1+Z_2+Z_3}$	$\begin{Vmatrix} \frac{(Z_1+Z_2)}{Z_1 Z_2} & -1/Z_2 \\ -1/Z_2 & \frac{(Z_2+Z_3)}{Z_2 Z_3} \end{Vmatrix}$	$\begin{Vmatrix} \frac{(Z_2+Z_3)}{Z_3} & Z_2 \\ \frac{(Z_1+Z_2+Z_3)}{Z_1 Z_3} & \frac{(Z_1+Z_2)}{Z_1} \end{Vmatrix}$
 Lattice Network	$\begin{Vmatrix} \frac{(Z_2+Z_1)}{2} & \frac{(Z_2-Z_1)}{2} \\ \frac{(Z_2-Z_1)}{2} & \frac{(Z_2+Z_1)}{2} \end{Vmatrix}$	$\begin{Vmatrix} \frac{(Z_1+Z_2)}{2Z_1 Z_2} & \frac{(Z_1-Z_2)}{2Z_1 Z_2} \\ \frac{(Z_1-Z_2)}{2Z_1 Z_2} & \frac{(Z_1+Z_2)}{2Z_1 Z_2} \end{Vmatrix}$	$\begin{Vmatrix} \frac{(Z_2+Z_1)}{(Z_2-Z_1)} & \frac{2Z_1 Z_2}{(Z_2-Z_1)} \\ \frac{2}{(Z_2-Z_1)} & \frac{(Z_2+Z_1)}{(Z_2-Z_1)} \end{Vmatrix}$

Impedance, Admittance and General Circuit Matrices of Basic Networks and Matrices of Network Combinations

Type of Network	Impedance Matrix $\Vert z \Vert$	Admittance Matrix $\Vert y \Vert$	General Circuit Matrix $\begin{Vmatrix} A & B \\ C & D \end{Vmatrix}$
Unbalanced Balanced  Bridge T	$\dfrac{\begin{Vmatrix} [d+(Z_1+Z_2)Z_4] & [d+Z_2Z_4] \\ [d+Z_2Z_4] & [d+(Z_2+Z_3)Z_4] \end{Vmatrix}}{Z_1+Z_3+Z_4}$	$\dfrac{\begin{Vmatrix} [d+(Z_2+Z_3)Z_4] & -[d+Z_2Z_4] \\ -[d+Z_2Z_4] & [d+(Z_1+Z_2)Z_4] \end{Vmatrix}}{dZ_4}$ where $d = Z_1Z_2+Z_2Z_3+Z_1Z_3$	$\begin{Vmatrix} \left[1+\dfrac{Z_1Z_4}{(d+Z_2Z_4)}\right] & \left[\dfrac{dZ_4}{(d+Z_2Z_4)}\right] \\ \left[\dfrac{(Z_1+Z_3+Z_4)}{(d+Z_2Z_4)}\right] & \left[1+\dfrac{Z_3Z_4}{(d+Z_2Z_4)}\right] \end{Vmatrix}$
 (Ideal) Input Transf. Connection	$\begin{Vmatrix} \dfrac{z_{11}}{n^2} & \dfrac{z_{12}}{n} \\ \dfrac{z_{21}}{n} & z_{22} \end{Vmatrix}$	$\begin{Vmatrix} n^2y_{11} & ny_{12} \\ ny_{21} & y_{22} \end{Vmatrix}$	$\begin{Vmatrix} \dfrac{A}{n} & \dfrac{B}{n} \\ nC & nD \end{Vmatrix}$
 (Ideal) Output Transf. Connection	$\begin{Vmatrix} z_{11} & nz_{12} \\ nz_{21} & n^2z_{22} \end{Vmatrix}$	$\begin{Vmatrix} y_{11} & \dfrac{y_{12}}{n} \\ \dfrac{y_{21}}{n} & \dfrac{y_{22}}{n^2} \end{Vmatrix}$	$\begin{Vmatrix} \dfrac{A}{n} & nB \\ \dfrac{C}{n} & nD \end{Vmatrix}$
 Cascade Connection	$\begin{Vmatrix} \dfrac{(AA'+BC')}{(CA'+DC')} & \dfrac{1}{(CA'+DC')} \\ \dfrac{1}{(CA'+DC')} & \dfrac{(CB'+DD')}{(CA'+DC')} \end{Vmatrix}$	$\begin{Vmatrix} \dfrac{(CB'+DD')}{(AB'+BD')} & -\dfrac{1}{(AB'+BD')} \\ -\dfrac{1}{(AB'+BD')} & \dfrac{(AA'+BC')}{(AB'+BD')} \end{Vmatrix}$	$\begin{Vmatrix} (AA'+BC') & (AB'+BD') \\ (CA'+DC') & (CB'+DD') \end{Vmatrix}$
 Parallel Connection	$\begin{Vmatrix} \dfrac{(y_{22}+y'_{22})}{(y^\circ_{11}y^\circ_{22}-y^{\circ 2}_{12})} & -\dfrac{(y_{12}+y'_{12})}{(y^\circ_{11}y^\circ_{22}-y^{\circ 2}_{12})} \\ -\dfrac{(y_{12}+y'_{12})}{(y^\circ_{11}y^\circ_{22}-y^{\circ 2}_{12})} & \dfrac{(y_{11}+y'_{11})}{(y^\circ_{11}y^\circ_{22}-y^{\circ 2}_{12})} \end{Vmatrix}$	$\begin{Vmatrix} (y_{11}+y'_{11}) & (y_{12}+y'_{12}) \\ (y_{21}+y'_{21}) & (y_{22}+y'_{22}) \end{Vmatrix}$	$\begin{Vmatrix} -\dfrac{(y_{22}+y'_{22})}{(y_{12}+y'_{12})} & -(y_{12}+y'_{12}) \\ -\dfrac{(y^\circ_{11}y^\circ_{22}-y^{\circ 2}_{12})}{(y_{12}+y'_{12})} & -\dfrac{(y_{11}+y'_{11})}{(y_{12}+y'_{12})} \end{Vmatrix}$
 Series Connection	$\begin{Vmatrix} (z_{11}+z'_{11}) & (z_{12}+z'_{12}) \\ (z_{21}+z'_{21}) & (z_{22}+z'_{22}) \end{Vmatrix}$	$\begin{Vmatrix} \dfrac{(z_{22}+z'_{22})}{(z^\circ_{11}z^\circ_{22}-z^{\circ 2}_{12})} & -\dfrac{(z_{12}-z'_{12})}{(z^\circ_{11}z^\circ_{22}-z^{\circ 2}_{12})} \\ -\dfrac{(z_{12}-z'_{12})}{(z^\circ_{11}z^\circ_{22}-z^{\circ 2}_{12})} & \dfrac{(z_{11}+z'_{11})}{(z^\circ_{11}z^\circ_{22}-z^{\circ 2}_{12})} \end{Vmatrix}$	$\begin{Vmatrix} \dfrac{(z_{11}+z'_{11})}{(z_{12}+z'_{12})} & \dfrac{(z^\circ_{11}z^\circ_{22}-z^{\circ 2}_{12})}{(z_{12}+z'_{12})} \\ \dfrac{1}{(z_{12}+z'_{12})} & \dfrac{(z_{22}+z'_{22})}{(z_{12}+z'_{12})} \end{Vmatrix}$
 Real Transformer	$\begin{Vmatrix} (R_{11}+j\omega L_{11}) & (j\omega L_{12}) \\ (j\omega L_{12}) & (R_{22}+j\omega L_{22}) \end{Vmatrix}$	$\begin{Vmatrix} \left(\dfrac{R_{22}+j\omega L_{22}}{m}\right) & \left(\dfrac{-j\omega L_{12}}{m}\right) \\ \left(\dfrac{-j\omega L_{12}}{m}\right) & \left(\dfrac{R_{11}+j\omega L_{11}}{m}\right) \end{Vmatrix}$	$\begin{Vmatrix} \left(\dfrac{R_{11}+j\omega L_{11}}{j\omega L_{12}}\right) & \left(\dfrac{m}{j\omega L_{12}}\right) \\ \left(\dfrac{1}{j\omega L_{12}}\right) & \left(\dfrac{R_{22}+j\omega L_{22}}{j\omega L_{12}}\right) \end{Vmatrix}$

where $m = \left(\dfrac{R_{11}}{\omega L_{11}} + \dfrac{R_{22}}{\omega L_{22}} + j\right) j\omega^2 L_{11} L_{22} + (R_{11}R_{22} - j\omega L_{12})$

From Fig. 7 it is obvious that

$$E_2 = I_2 \left[\frac{(Z_1+Z_2)(Z_1+Z_2)}{2\,(Z_1+Z_2)} \right] = I_2 \frac{(Z_1+Z_2)}{2}$$

Thus

$$D = \left(\frac{2}{(Z_2-Z_1)} \right) \left(\frac{I_2\,(Z_1+Z_2)}{2\,I_2} \right) = \frac{Z_1+Z_2}{Z_2-Z_1}$$

Now suppose that E_2 is short circuited so that it becomes zero, then $DE_1 = BI_1$ and

$$B = D\frac{E_1}{I_1} = \left(\frac{Z_1+Z_2}{Z_2-Z_1} \right) \left(\frac{I_1 \dfrac{2Z_1Z_2}{Z_1+Z_2}}{I_1} \right)$$

or $$B = \left(\frac{Z_1+Z_2}{Z_2-Z_1} \right) \left(\frac{2Z_1Z_2}{Z_1+Z_2} \right) = \frac{2Z_1Z_2}{Z_2-Z_1}$$

The matrix for the general circuit constants for the lattice network is

$$\left\| \begin{matrix} A & B \\ C & D \end{matrix} \right\|_{LA} = \left\| \begin{matrix} \dfrac{Z_2+Z_1}{Z_2-Z_1} & \dfrac{2Z_1Z_2}{Z_2-Z_1} \\ \dfrac{2}{Z_2-Z_1} & \dfrac{Z_2+Z_1}{Z_2-Z_1} \end{matrix} \right\|$$

Knowing the general circuit matrix, it is merely a matter of simple algebraic substitution in the equations (17) and (18) to find the admittance and impedance matrices.

$$y_{11} = \frac{D}{B} = \left(\frac{Z_2+Z_1}{Z_2-Z_1} \right) \left(\frac{Z_2-Z_1}{2Z_1Z_2} \right) = \frac{Z_2+Z_1}{2Z_1Z_2}$$

$$y_{12} = y_{21} = -\frac{1}{B} = -\frac{Z_2-Z_1}{2Z_1Z_2} = \frac{Z_1-Z_2}{2Z_1Z_2}$$

$$y_{22} = \frac{A}{B} = \left(\frac{Z_2+Z_1}{Z_2-Z_1} \right) \left(\frac{Z_2-Z_1}{2Z_1Z_2} \right) = \frac{Z_2+Z_1}{2Z_1Z_2}$$

The admittance matrix for the lattice is

$$\|y\|_{LA} = \left\| \begin{matrix} y_{11} & y_{12} \\ y_{21} & y_{22} \end{matrix} \right\| = \left\| \begin{matrix} \dfrac{Z_1+Z_2}{2Z_1Z_2} & \dfrac{Z_1-Z_2}{2Z_1Z_2} \\ \dfrac{Z_1-Z_2}{2Z_1Z_2} & \dfrac{Z_1+Z_2}{2Z_1Z_2} \end{matrix} \right\|$$

Similarly

$$z_{11} = \frac{A}{C} = \left(\frac{Z_2+Z_1}{Z_2-Z_1} \right) \left(\frac{Z_2-Z_1}{2} \right) = \frac{Z_2+Z_1}{2}$$

$$z_{12} = z_{21} = \frac{1}{C} = \frac{Z_2-Z_1}{2}$$

$$z_{22} = \frac{D}{C} = \left(\frac{Z_2+Z_1}{Z_2-Z_1} \right) \left(\frac{Z_2-Z_1}{2} \right) = \frac{Z_2+Z_1}{2}$$

Thus the impedance matrix for the lattice is

$$\|z\|_{LA} = \left\| \begin{matrix} z_{11} & z_{12} \\ z_{22} & z_{22} \end{matrix} \right\| = \left\| \begin{matrix} \dfrac{Z_2+Z_1}{2} & \dfrac{Z_2-Z_1}{2} \\ \dfrac{Z_2-Z_1}{2} & \dfrac{Z_2+Z_1}{2} \end{matrix} \right\|$$

All four-terminal networks have an impedance, an admittance, and a general circuit matrix with the exception of the ideal transformer, the series, and the shunt networks for which one or more of these matrices may be non-existent. We have just shown the method by which the matrices can be obtained for the T, π and lattice networks and this method is recommended for all simple-type networks. However, in actual practice, it is undesirable to waste time in finding these simple matrices whenever an occasion arises to make use of them. For convenience in the solution of problems there will be found an accompanying chart on pages 15 and 16 which gives the matrices of all the basic networks and useful combinations of networks. The information contained in the chart will be found most useful in analyzing the more complicated types of four-terminal networks.

The complicated networks can, in general, be broken up into combinations of basic networks the matrices for which are given in the chart, and if the basic matrices are properly combined, we can obtain the matrices of the more complicated network. Having found the matrices of the network, the terminal voltages and currents can, in general, be solved by the use of the system of general equations (9 to 16) and then, if problem conditions permit, it will be possible to obtain insertion losses or other desired information. The use of the chart and the method of combining basic networks will be illustrated in the next issue.

NAB ALLOCATION REPORT

(Continued from page 8)

from other low-frequency broadcast stations more than 600 miles away. In the case of telegraph on adjacent frequencies, conditions could be improved by the use of a narrow band in the receiver. In order to eliminate interference with this latter service, it might be necessary to use a high-pass filter, or a band-rejection filter, in the transmission line feeding the antenna of the station on the upper edge of the proposed long-wave broadcast band. The one on the lower edge could, of course, receive similar treatment if required. It should then be possible to free neighboring frequencies from any appreciable interference. While such filters would be moderately expensive, their use would doubtless be justified, and the difficulty of design might be reduced by permitting a certain amount of attenuation in the sideband adjacent to the filter cut-off frequency without causing objectionable degradation of quality.

There remains the question of the spurious responses of superheterodyne receivers. This is hard to estimate, since it is dependent upon many different factors. In the case of operation on channels near to that of the interfering station the image frequency would be too far away to fall within the long-wave broadcast band. Consequently spurious responses would have to be due to higher order modulation in the converter tube or to other less important factors. In the case of reception in the broadcast band it would also be impossible to get image-frequency interference, since the unwanted signal would have to be above the desired signal in frequency. It is evident then that troubles from spurious superheterodyne responses might be somewhat less pronounced than when the interfering station operates in the regular broadcast band.

Because of the variability of the spurious responses it is impossible to predict the field strength that can be tolerated without interference, but it is probably safe to assume that 100 to 200 mv/m would do little harm to well designed receiving equipment. This latter field would occur about 30 miles from the transmitter. Closer in, interference might be experienced when the receiver was tuned to certain frequencies, but would be absent on others. These troubles are not sufficiently serious to constitute any argument against the use of a 1,000 kw station.

Presumably the cost of radiating a

(Continued on page 25)

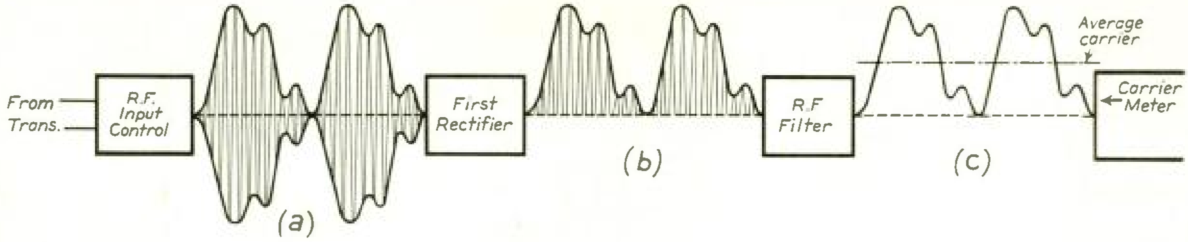


FIG. 1. A DIAGRAMMATIC ILLUSTRATION OF THE PROGRESSIVE ACTION IN MODULATION MONITORS OF THE TYPE DISCUSSED BELOW. SUCCESSIVE ILLUSTRATIONS ARE THE WAVEFORMS OF (A) MODULATED R-F INPUT, (B) RECTIFIED INPUT, AND (C) MODULATION ENVELOPE.

BROADCAST STATION

By JOHN P. TAYLOR

TECHNICAL REQUIREMENTS of the Federal Communications Commission, effective the first of November, not only specify compliance with definite standards of "good engineering practice" and a higher degree (85 percent) of modulation capability, but also make mandatory the use of a continuously-indicating modulation monitor of an approved type.

REQUIREMENTS

The specifications as drawn up cover both the design and performance characteristics of suitable monitors. Specifically they are as follows:

1. A d-c meter for setting the average rectified carrier at a specific value and to indicate changes in carrier intensity during modulation.
2. A peak-indicating light or similar device that can be set at any predetermined value from 50 to 120 percent modulation to indicate on positive peaks, and/or from 50 to 100 percent negative modulation.
3. A semi-peak indicator with a meter having the characteristics given below shall be used with a circuit such that peaks of modulation of duration between 40 and 90 milliseconds are indicated to 90 percent of full value and the discharge rate adjusted so that the pointer returns from full reading to 10 percent of zero within 500 to 800 milliseconds. A switch shall be provided so that this meter will read either positive or negative modulation and, if desired, in the center position it may read both in a full-wave circuit.

The characteristics of the indicating meter are as follows: Speed—The time for one complete oscillation of the

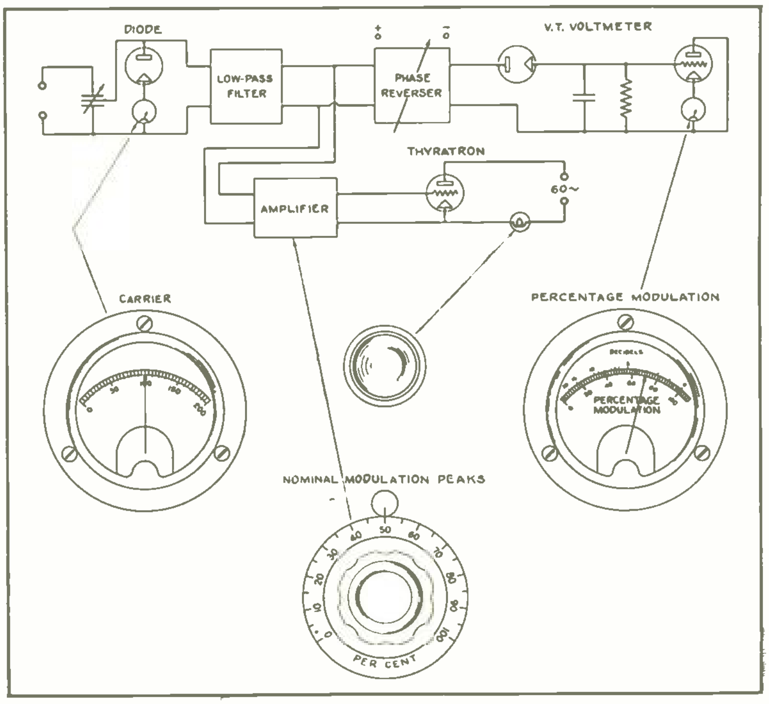


FIG. 2. FUNCTIONAL SCHEMATIC OF THE GENERAL RADIO 731-A MONITOR. THE ACTION IS AS INDICATED IN FIG. 1 WITH THE ADDITION OF THE "PHASE REVERSER" WHICH MAKES IT POSSIBLE TO MONITOR EITHER POSITIVE OR NEGATIVE MODULATION PERCENTAGE.

THE TYPE 731-A MONITOR.

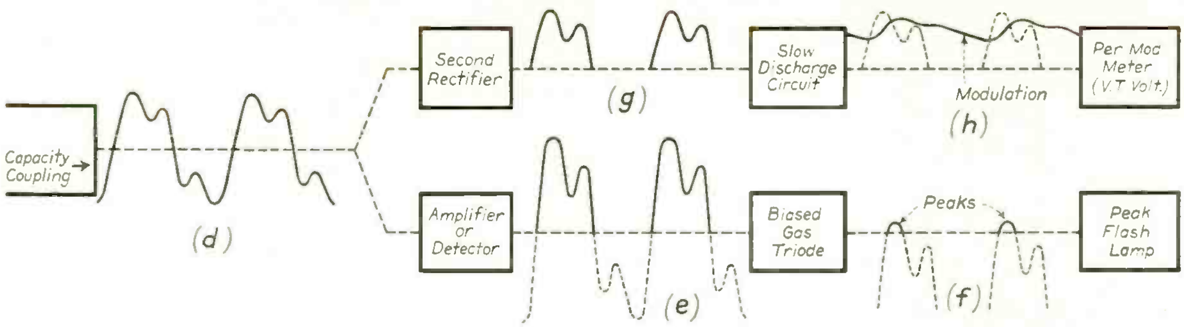


FIG. 1. A CONTINUATION OF THE DIAGRAMMATIC ILLUSTRATION BEGINNING ON THE OPPOSITE PAGE. ILLUSTRATIONS ARE: (D) AUDIO COMPONENT OF MODULATION, (E) AMPLIFIED AUDIO, (F) AUDIO PEAKS, (G, RECTIFIED AUDIO, AND (H) SLOW-DECREASE MODULATION-METER CURRENT.

MODULATION MONITORS

CONSULTANT

pointer shall be 290 to 350 milliseconds. The damping factor shall be between 16 and 200. The useful scale length shall be at least 2.3 inches. The meter shall be calibrated for modulation from 0 to 110 percent and in decibels below 100 percent with 100 percent being 0 db.

THE TYPE 66-A MONITOR.

The accuracy of the reading on percentage of modulation shall be ± 2 percent for 100 percent modulation, and ± 4 percent of full-scale reading at any other percentage of modulation.

4. The frequency-characteristic curve shall not depart from a straight line more than ± ½ db from 30 to 10,000 cycles. The amplitude distortion or generation of audio harmonics shall be kept to a minimum.

5. The modulation meter shall be equipped with appropriate terminals so that an external peak counter can be readily connected.

6. Modulation will be tested at 115 volts, ± 5 percent, and 60 cycles, and the above accuracies shall be applicable under these conditions.

7. All specifications not already covered above, and the general design, construction, and operation of these units must be in accordance with good engineering practice.

It will be seen that paragraphs 1, 2, 3 and 5 enumerate features which must be included in the design of the unit—and paragraph 3 also sets up certain performance requirements which must be met. Paragraphs 4, 6 and 7 further define satisfactory performance. All of these requirements are stated in some detail and are comparatively rigid. It seems possible that the Commission, in drawing up specifications for these modulation monitors, had in mind the

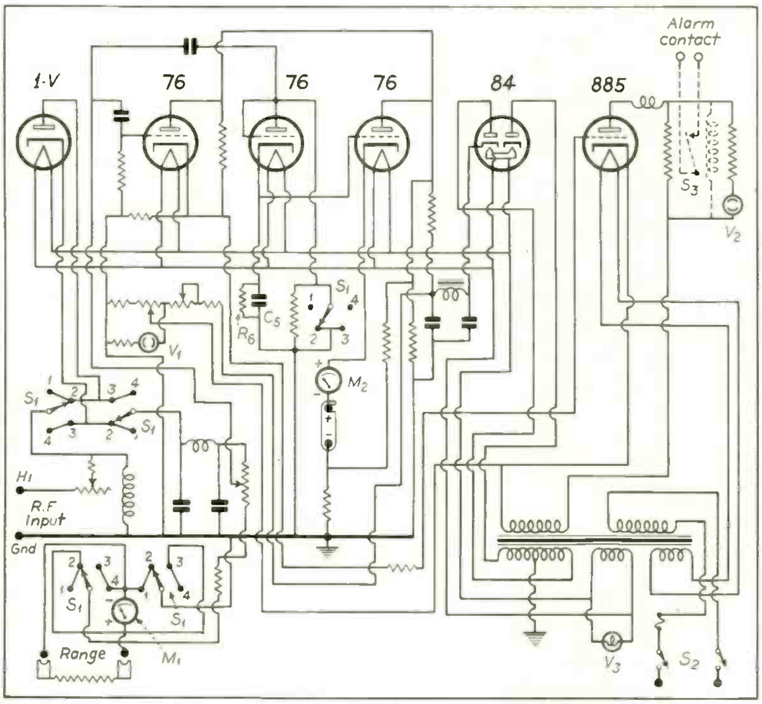


FIG. 3. COMPLETE SCHEMATIC OF THE RCA 66-A. S-1 IS THE PHASE-REVERSING SWITCH. C-5 AND R-6 IS THE SLOW-DISCHARGE CIRCUIT, AND S-3 THE PEAK-COUNTER RELAY.

desirability of greater uniformity than was obtained in the case of the frequency monitors installed several years ago. In any event, the designers of these equipments had relatively little leeway, and the production models announced to date are, therefore, almost identical in operation, and even quite similar in appearance.

OPERATION

The operation of these monitors is most readily understood by reference to Fig. 1. While details of the several available models vary considerably, the general arrangement is the same in all and a single diagram and explanation will, therefore, be sufficient. It should be understood that this diagram is somewhat idealized—a simplified waveform being used, and the action somewhat accentuated in order to make the operation more clear.

A small amount of radio frequency (obtained by coupling to the transmitter output) is employed to operate these monitors. An input control (a potentiometer or variable coupling capacity) provides for adjustment of the amount of r-f input. This modulated radio-frequency input wave—shown at (a) in Fig. 1—is rectified by a diode rectifier tube (Type 1-V) which is referred to as the first rectifier. The rectified r-f wave—shown at (b)—is then passed through a low-pass filter which removes the r-f component and passes on a pulsating direct current—shown at (c)—corresponding to the modulation envelope. A d-c milliammeter is placed in the circuit so that it reads the average value of this current. This reading, of course, is proportional to the average value of the transmitter carrier. The meter is calibrated in percent, and the previously mentioned r-f input control is to be adjusted so that for normal, or unmodulated, carrier it will read exactly 100 on the scale. Looking at (c), it is obvious that if unsymmetrical modulation occurs it will be indicated on this meter, and hence it provides an indication of "changes of carrier intensity during modulation" such as required by paragraph 1 of the specifications.

Capacitive coupling is employed to impress the audio component of the modulation envelope—shown at (d)—on two branch circuits. In the lower branch—referring to Fig. 1—this audio voltage is first impressed on a tube (Type 76 or 6C6) designated as an amplifier or detector. The difference is not important, as the result in either case is to amplify or to accentuate the positive peaks—as shown at (e). The output of this tube is impressed on a gas triode (Type 885), which acts as a relay tube to trigger the flash lamp. The bias of this tube may be adjusted from the front of the panel so that modulation peaks of any desired degree will cause plate current to flow—as in (f)—and the lamp to flash, thereby causing it to act as a "peak-indicating light" as required by paragraph 2. The bias control is calibrated directly in percent modulation, so that it may be set to flash the lamp at any desired degree of modulation.

In the upper branch—again referring to Fig. 1—this audio voltage is rectified by a diode rectifier (Type 1-V or diode-connected 76) referred to as the second rectifier. The rectified output of this—shown at (g)—is used to charge a capacity. During the intervals when the output of the rectifier is zero, the capacity discharges into a resistance whose value is sufficiently high as to make the rate of discharge relatively slow. Voltage across this resistor—which is of the form of (h)—is impressed on the grid of the vacuum-tube voltmeter (Type 76 or 75) causing the microammeter in the plate circuit to act as a "semi-peak indicator" as per paragraph 3 of the specifications.

METER SPEEDS

The action of this semi-peak indicator deserves somewhat further attention. As previously noted, paragraph 3 specifies this action in some detail. On first glance these specifications are somewhat confusing. However, when analyzed with respect to common experience with ordinary volume indicators—to which this semi-peak indicator is a first cousin—the intent and desirability of these requirements become more clear.

Every engineer who has had much experience "riding gain" is familiar with the eccentricities of volume-indicator meters. Without considering the discrepancies appearing between meters of different makes, there have been in use, during the past several years, three distinct types of meters of acknowledged different characteristics—that is the so-called "high-speed," "general-purpose" and "slow-speed" models. Of these, the "slow-speed" meter has the characteristic of rising very slowly—approximately one-half second being required for full deflection. Its advantage lies in the fact that its movement is easily and comfortably followed by the eye—its disadvantage the fact that, on peaks of ordinary duration, it does not reach or even approach the true peak reading (for instance, on a peak lasting 0.1 second it reads 10 db low). The "high-speed" meter, on the other hand, rises very rapidly—reaching true level in one-tenth second. Thus, for average peaks, it reaches or comes very close to true level—but it has the disadvantage of being very difficult to follow, and is uncomfortable as a means of continuous monitoring. The "general-purpose" type may be said to represent a compromise between the other two. Its characteristic is the most satisfactory for ordinary use. However, all three leave something to be desired.

Obviously, the ideal indicator would be one which reached its true reading in a very short time, and held this reading for sufficient time to enable easy observation. It is this which the specifications of paragraph 3 attempt to accomplish. A meter having an oscillation time of 200 to 350 milliseconds is called for. This, of course, refers to the meter only (as distinguished from the meter together with the retard circuit). It is met by the meter with the "high-speed" type of action. But, this meter requires 90 milliseconds to reach 90 percent of true level—whereas paragraph 3 requires 90 percent indication for peaks "of duration between 40 and 90 milliseconds." In order to obtain this reading for the shorter (40 millisecond) peaks, the current passed by the second rectifier is used to charge a condenser (see above) which stores the energy long enough for the meter to come up to the desired reading. The condenser discharges into a high resistance—of the order of 50 megohms—and hence the discharge rate is very slow. This provides the slow pointer return, that is "to 10 percent of zero within 500 to 800 milliseconds" as required. The whole process is such as to provide the action indicated by the solid curve of (h). When a peak of modulation occurs the meter pointer begins to rise, and if the peak is 40 milliseconds long it reaches a deflection of 90 percent of true level (although the peak indication will occur slightly after the actual peak of modulation). On longer peaks it reaches a deflection of from 90 percent to 105 percent. After the peak is passed the pointer returns very slowly—corresponding to the slow discharge of the condenser—and, as shown at (h), for ordinary modulation, will not return at all to zero, but rather will provide between peaks a "floating" reading. Thus, the peaks of the envelope of the modulation are accurately indicated, while at the same time the wild gyrations of the pointer, otherwise accompanying the "high-speed" action, are eliminated. Dependable monitoring with the least fatigue is thus provided. The arrangement appears to be a considerable improvement over presently-used monitoring systems, and will quite likely become accepted as a reference, if not as a standard.

PERFORMANCE

Performance is ordinarily the first

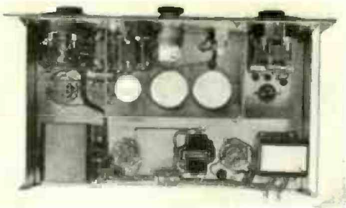
criterion in the choice of an equipment for broadcast-station use. But in the case of these modulation monitors it is unnecessary to give lengthy consideration to this factor, nor to balance the merits of one make of unit against another. Paragraphs 3, 4, and 6 are as rigid a specification for performance as any station engineer could desire. Moreover, since these monitors have been tested by the Bureau of Standards, for the FCC, and approved, it can be assumed that their performance actually comes up to these specifications.

The specifications themselves allow unusually small tolerances, and insure characteristics which are probably at least several years in advance of requirements, a feature which is, of course, desirable from the point of view of preventing rapid obsolescence. For instance, in the case of the percentage-modulation reading the allowable error of ± 2 percent at 100 percent modulation is but slightly more than that of the expectable error in the meter itself—while the allowable error of ± 4 percent (of full-scale reading) at other percentages obviously necessitates rectifiers of unusually good linearity. Together these two requirements insure an error in amplitude response as small as is presently feasible in standard equipment. Similarly, the frequency response has been made as uniform—within $\pm \frac{1}{2}$ db from 30 to 10,000 cycles—as is practical. The third of the usual trio of performance characteristics, that is, volume or dynamic response, does not, of course, enter into consideration of these units, inasmuch as present usage requires visual monitoring (as contrasted to aural monitoring) only of peaks—i.e., one end of the volume range.

It is interesting to note that while the tests conducted by the Bureau of Standards on these units do not guarantee the maintenance of these high-performance standards, it is, nevertheless, fairly safe to assume for them a high order of permanence. This follows from the fact that most of the components which go to make up the circuits of these monitors have little bearing on the performance accuracy. As far as the amplitude characteristic is concerned, the use of diode-connected rectifiers, plus the use of compensated vacuum-tube voltmeter circuits, is insurance against change. And, since there are no transformers and all circuits are resistance-coupled, the frequency characteristic should also maintain itself. Finally, the compensating circuits provided—and tested as per paragraph 6—make these monitors independent of any normal fluctuations in supply voltage.

APPLICATIONS

It is hardly necessary to point out



INTERIOR OF THE 731-A. THE VARIABLE INPUT CAPACITY AND FIRST RECTIFIER ARE AT RIGHT FRONT, THE SECOND RECTIFIER AND V-T VOLTMETER AT LEFT FRONT, GAS-TRIODE AND POWER SUPPLY AT BOTTOM.

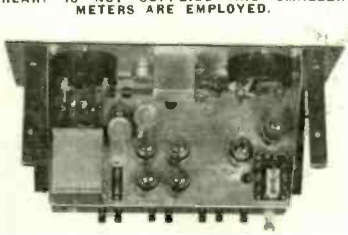
the application and desirability of these modulation monitors. They are intended, of course, to be placed on the control desk or control rack—wherever they may be best observed—and to be used by the transmitter operator as a means of continuously and accurately monitoring the transmitted carrier. The percentage-modulation meter will, of course, be the most important indicator for this purpose. It should provide, once and for all, a satisfactory answer to the problem of obtaining that desirable goal, the highest correct modulation, without running the constant risk

THE TYPE 66-B MODULATION MONITOR.

of equally undesirable overmodulation. Greater efficiency, less distortion and less probability of "monkey-chatter" interference should be direct results.

While the percentage-modulation meter will always be the final criterion of correct modulation, the peak-flash lamp can be of great assistance in routine monitoring—and this is particularly true once the gain has been set for the particular type of program. Various types of program material, such as symphonic, jazz, solo and speaker, have more or less characteristic forms and the peak lamp will flash at a rate corresponding to these forms. After a short time the operator should become accustomed to the flash rate for each type of program, and may then depend to a considerable degree on this means of monitoring—thus partially relieving the fatigue which would be caused by continuously following the modulation meter. Of course, the aural monitoring, if provided by a high-fidelity monitoring system, will be still further help in this respect.

INTERIOR OF THE 66-A. THE 66-B IS IDENTICAL WITH THE 66-A, WITH THE EXCEPTION THAT THE PEAK-COUNTER RELAY (RIGHT REAR) IS NOT SUPPLIED AND SMALLER METERS ARE EMPLOYED.



The carrier-shift meter provides still another monitoring means—although, of course, of a different character. It provides, at an easily-observed point, a continuous indication not only of carrier shift, but also of carrier intensity. Thus, if unsymmetrical modulation, due to any cause whatever, occurs it will be immediately indicated—as will any inadvertent change in transmitter output. While these same factors could be observed by noting the readings of the antenna ammeter and the last-stage plate-current meter, the combination of the two—and the grouping with other monitoring indicators—makes it much more likely that they will be immediately detected whenever they occur.

The final advantageous application of these monitors, although more or less of an indirect result, is nevertheless worth mentioning. This is its use in measuring overall transmitter response—or, if desired, the overall response of the whole station installation. This is easily accomplished by feeding various audio frequencies to the input of the transmitter—or the input of the studio mixers—and reading the overall response on the percentage modulation meter. If a beat oscillator is used as an audio source it can be quickly run over the whole audio range, and a complete and accurate frequency response made in a few minutes. In order to facilitate such measurements the modulation meter is calibrated in decibels below 100 percent. One of the monitors shown even has a shunt resistor which may be connected in the input circuit in order to increase the decibel range of this meter.

REFERENCES

Circular R-1002-C, Weston Electrical Instrument Corporation "A Note on Measurements of Meter Speed," *The General Radio Experimenter,* Vol. X, No. 7.

"Monitoring of Broadcast Stations," *The General Radio Experimenter,* Vol. 9, No. 9.

"A New Modulation Unit," *Broadcast News,* No. 19.

Form 382-A, General Radio Company.

Form 894, RCA Manufacturing Company.

TELECOMMUNICATION

PANORAMA OF PROGRESS IN THE FIELDS OF COMMUNICATION AND BROADCASTING

EIFFEL-TOWER TELEVISION-STATION CHANGES

THE IMPROVED Eiffel Tower television station, which went into operation May 24, 1936, has 10 times the power of the original station; the original power of 2 kw being raised to 25 kw and the power at the antenna being raised from 1 kw to 10 kw. The temporary installation could only transmit images 30 kms, and although definite tests have not been made with the new apparatus, it is estimated that images can be received as far as 70 kms, according to Assistant Trade Commissioner Lestrade Brown, Paris.

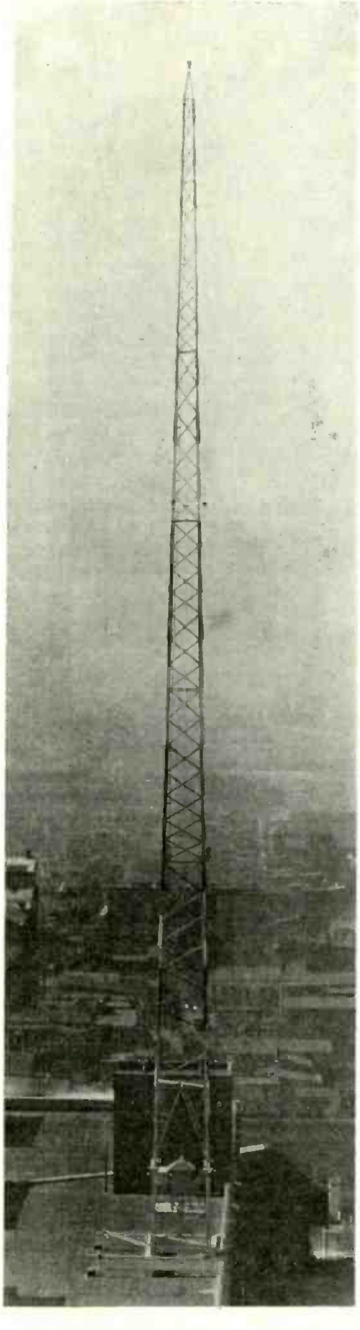
It was necessary to reduce the power of the lights at the studio from 25,000 to 10,000 lux per square centimeter. This reduction in power, which was done by the adding of an additional electron multiplier, at the same time improving the character of the image amplifiers, has in no way decreased the efficiency of the apparatus.

WTMJ SAFETY BROADCASTS

SHORT-WAVE has made possible a unique and educational radio feature broadcast by WTMJ in Milwaukee. Each Sunday afternoon, in cooperation with the Milwaukee Safety Commission, the WTMJ cruising radio car visits busy downtown corners in Milwaukee and describes the driving which the announcer sees. Good driving habits are pointed out and driving mistakes are also mentioned.

Dr. B. L. Corbett, Executive Secretary of the Milwaukee Safety Commission, and other members of this group have accompanied the announcer during these broadcasts and given timely safety tips during the program.

The safety car is a standard coupe which carries the portable-mobile transmitter W9XAJ. It operates on a frequency of 40.6 megacycles with a power of 7½ watts. The power is secured from a 300-volt dynamotor operating from a 6-volt storage battery. Both dynamotor and battery are located under the turtle back of the coupe. The transmitter itself is mounted on a panel on the ledge back of the head of the driver, who is also the operator of the transmitter. A vertical quarter-wave antenna is fastened to the side of the car.



THE NEW LEHIGH VERTICAL RADIATOR AT WRAW, READING, PENNSYLVANIA.

The crystal microphone uses a preamplifier which is strapped to the announcer's belt. This preamplifier is coupled to a cable which allows the announcer to move within a radius of 50 feet of the car.

The short-wave signals are picked up at the WTMJ experimental laboratories which are located in the penthouse on top of the 27-story Schroeder Hotel building in downtown Milwaukee. Here also is located station W9XAZ which is used for talking back to the car during the safety broadcast. A short-wave receiving set in the car picks up the signals from this control station. The car is also equipped with headphones wired for duplex operation either off the short-wave receiver or off the standard car radio which of course is constantly tuned to WTMJ's frequency of 620 kilocycles.

TELEPHONE SERVICE TO EL SALVADOR

TELEPHONE SERVICE with El Salvador, Central America, was opened on June 10 with an exchange of greetings between Secretary of State Cordell Hull, at Washington, and Dr. Miguel A. Araujo, Minister of Foreign Relations for El Salvador, at San Salvador.

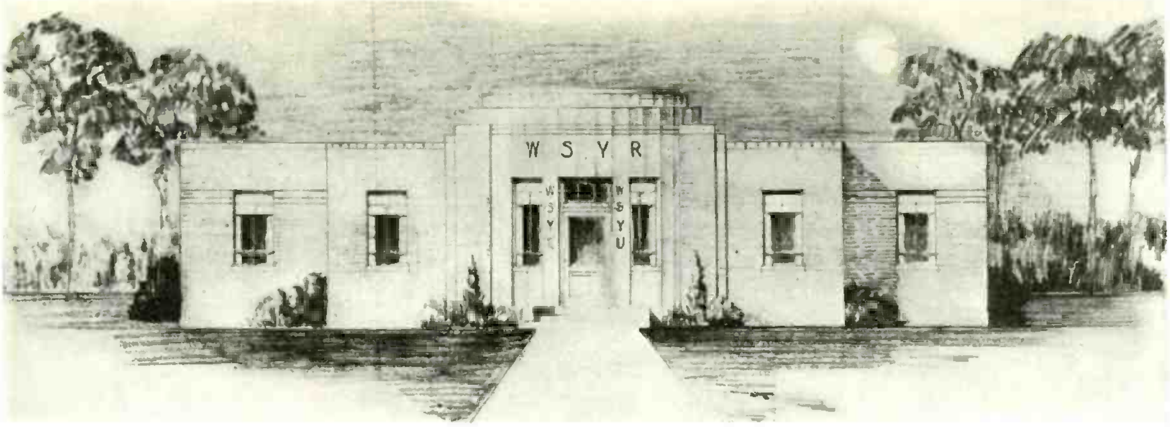
With the extension to El Salvador, service from Bell and Bell-connecting telephones will be available to all of the Central American Republics. El Salvador is a densely-populated country having a population estimated at 1,670,000 in an area of 125 square miles.

Connection is established over a short-wave radio telephone circuit between A. T. & T. Company stations at Miami, Fla., and a Salvadoran radiotelephone station located at San Salvador.

THE NEW WSYR

THE Central New York Broadcasting Corporation, operating station WSYR in Syracuse, a basic NBC network station, has been granted a construction permit for 1000 watts power, unlimited time, utilizing a directional antenna.

Construction of the new broadcast station, and the antenna, is already under way and is being pushed rapidly to complete the project and be on the air before the first of September.



ARCHITECT'S DRAWING OF NEW WSYR-WSYU.

Two 330-foot International Stacey steel, free-standing radiators are being erected spaced 720 feet apart. The buried ground system for each radiator will consist of a ground screen 60 feet in diameter at the base of each tower, with underground radials running 400 feet, 5 degrees apart, or a total of 72 radials for each tower. In laying out this ground system 7000 feet of ground screen and 10 miles of copper wire will be used.

The directional scheme and layout were designed by Paul F. Godley, Consulting Radio Engineer of Montclair, N. J. This station was designed by Lockwood Greene Engineers, Inc., under the direction of Howard C. Barth, General Manager of the company.

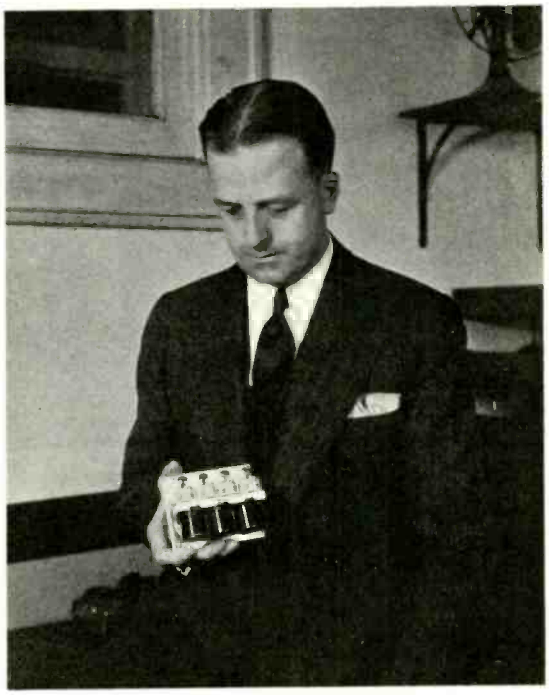
The broadcast transmitter is the RCA Manufacturing Co.'s 7-D equipment. The speech-input racks are also RCA. The present WSYR transmitter will be installed in the new station as an auxiliary.

The general contract for the building has been awarded to the J. D. Taylor Construction Corporation of Syracuse, and that for the erection of the tower to the General Erecting Co., of Syracuse.

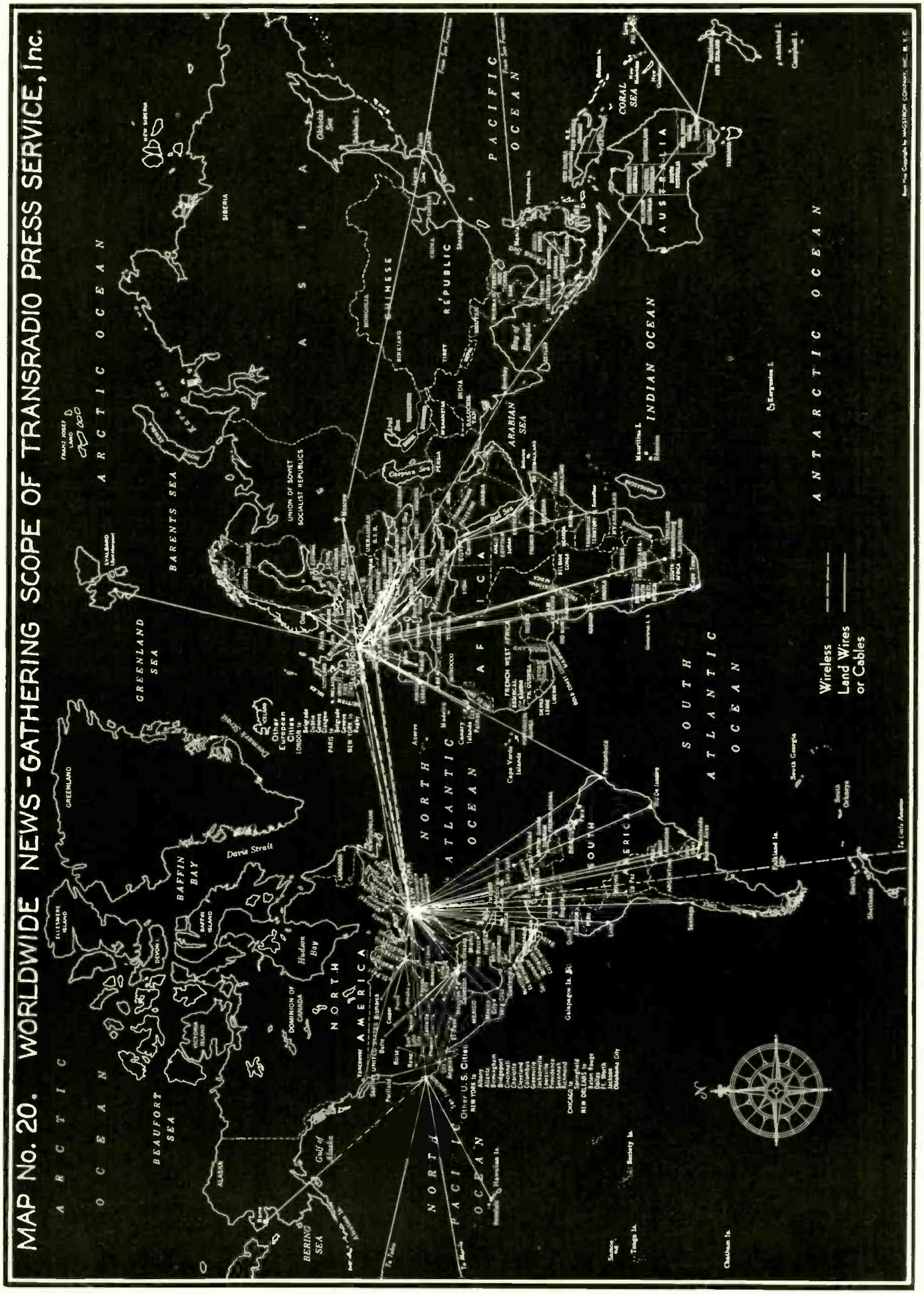
MIDGET PREAMPLIFIER

IN AN ACCOMPANYING ILLUSTRATION, Mr. J. R. Poppele, Technical Advisor, WOR, Mutual Broadcasting System, is shown holding a recent WOR engineering development—a midget microphone preamplifier. This unit, which was developed for use during the Democratic National Convention, is believed to be the smallest practical amplifier of this type ever built. It weighs less than three pounds, measures only 4¾ x 3¾ x 2½ inches, has a net gain of 90 db, provides linear response from 20 to 20,000 cycles, and combines a two-circuit mixer with a three-stage, audio-frequency amplifier. Its small size is made possible by the use of new Amer-Tran midget audio transformers and RCA acorn tubes.

NBC HOLLYWOOD HEADQUARTERS DESIGNED BY THE AUSTIN COMPANY.



J. R. POPPELE, OF RADIO STATION WOR, AND THE MIDGET PREAMPLIFIER.


MAP No. 20. WORLDWIDE NEWS-GATHERING SCOPE OF TRANSRADIO PRESS SERVICE, Inc.
ARCTIC OCEAN
GREENLAND SEA
BARENTS SEA
BEAUFORT SEA
BAFFIN BAY
Davis Strait
Hudson Bay
GREENLAND
NORTH AMERICA
DOMINION OF CANADA
UNION OF SOVIET SOCIALIST REPUBLICS
SIBERIA
ASIA
CHINESE REPUBLIC
AFRICA
AUSTRALIA
CORAL SEA
ARABIAN SEA
INDIAN OCEAN
PACIFIC OCEAN
NORTH ATLANTIC OCEAN
SOUTH ATLANTIC OCEAN
NORTH PACIFIC OCEAN
ANTARCTIC OCEAN
BERING SEA
Gulf of Alaska
ALASKA
SOUTH AMERICA
Caspian Sea
Bay of Bengal
Wireless
Land Wires or Cables

NAB ALLOCATION REPORT

(*Continued from page* 17)

given amount of power at 200 kc would differ from that at higher frequencies chiefly insofar as it was affected by the cost of the antenna system. In the existing broadcast band considerable success has been had with vertical radiators between five and six-tenths of a wavelength high, but it seems unlikely that such antennas would prove in at 200 kc. The reduction in sky wave which can be obtained is less marked at three to four hundred miles than it is at fifty to one hundred. This is due to the fact that the difference in the vertical radiation pattern of a half-wave and a quarter-wave antenna is not pronounced at the rather low angles at which this long-distance sky wave leaves the radiator. Consequently the "anti-fading" characteristics of the high mast would be less marked at longer wavelengths, and it is doubtful if the rather small increase that can be obtained in the ground wave could possibly justify the cost of a mast some 2,400 feet high. On the other hand a quarter-wave mast about 1,200 feet high is not out of the question, and with the steadily falling prices of such structures, should not be an undue economic burden.

Because of the field strength involved and the long distances to be covered, it would probably be desirable to cut off the audio program fed to the transmitters sharply at 5 kc, thereby avoiding any sideband overlap. A coupled circuit capable of faithfully receiving an overall bandwidth of 10 kc at a mid-frequency of 200 kc can readily be built for use in the receiver.

THE ULTRA-HIGH FREQUENCIES

The great possibilities of ultra-high frequencies for aural and facsimile broadcasting, television, and other radio services are now generally realized, and constantly increasing technical and commercial attention is being directed toward the quasi-optical waves. The sum total of knowledge concerning the characteristics of these waves is much greater than it was a few years ago and is increasing rapidly, but every new advance creates new problems, and it cannot be denied that we should have more information before the best distribution of frequency assignments can be finally made. For this reason it is felt that growth by "evolution and experimentation," as recommended by the Commission, is vastly to be preferred to any inflexible development of an allocation structure.

At present we do not know what the best frequencies are for any given class of service. At 30 to 35 megacycles, long-distance interference is known to occur quite often, while at 50 megacycles it is very rare. On the other hand, the progress of the sun-spot cycle may increase the frequency with which long-range transmission occurs, and what is now regarded from the standpoint of practical operation, as an interference-free wavelength may be subject to serious "jamming" in a few years.

Because sky-wave transmissions are returned to earth only at long distances, it does not follow that they are incapable of affecting the service area of an ultra-high frequency station. It is inevitable that listeners in suburban regions who are fortunate enough to have relatively noise-free receiving conditions will fall into the habit of using rather low field strengths; but even so, they will often get high-quality programs from their local transmitters. Long-range transmissions from stations of equal or greater power may at times be almost as strong as the local fields, and for considerable periods may make the nearby station practically useless. We are all too familiar with this unfortunate state of affairs on shared channels of the present broadcast band.

There is not complete agreement between radio engineers as to what constitutes the best band width for use in aural broadcasting. Recommendations have been made for the transmission and reception of frequencies up to 15,000 cycles, but many engineers, and I am inclined to agree with them, believe that it is quite impossible to justify so wide a band. Many persons are relatively deaf at these frequencies, only a few instruments give off any appreciable energy above 10,000 cycles, and the use of so wide a band increases the noise output of the receiver. Moreover, the manufacture of both transmitting and receiving equipment having characteristics substantially flat up to 15,000 cycles is expensive. In the case of high-frequency apparatus the technical difficulties are somewhat reduced, but the cost of the audio-frequency amplifiers, and particularly of the loudspeaker, remains high.

In the case of television stations, the frequency separation problem is more troublesome, and will have to be treated with due regard to the various combinations of local conditions that may occur. Single-sideband transmission offers one of the most obvious and attractive possibilities. It would be very difficult to obtain true single-sideband operation, but a system might be developed allowing the transmission of all of one sideband and a small portion of the other, thus saving very nearly the same amount of frequency space and at the same time reducing the difficulties that are met in filtering out the unwanted frequencies.

OVER THE TAPE...

NEWS OF THE RADIO, TELEGRAPH AND TELEPHONE INDUSTRIES

IRE NOMINATION

L. C. F. Horle, well-known radio consulting engineer, has been nominated for the office of President of the Institute of Radio Engineers. Besides being a member of the Board of Directors of the IRE and Chairman of the IRE Standards Committee, Mr. Horle is also active in RMA, having developed the ignition radiation measuring equipment for the RMA-SAE committee, and represented the Engineering Division of the RMA at the recent FCC high-frequency allocation hearing.

WARD LEONARD BULLETINS

The Ward Leonard Electric Company, Mount Vernon, New York, have just issued bulletins describing their new Vitrohm field rheostats and accessories.

Manual- and motor-drive accessories, and intermittent-duty field-discharge resistors are listed in Bulletin 60A, as well as overall and mounting dimensions, formerly given in Bulletin 60D.

Approximately fifty rheostats have been added to the listing. Bulletin 60B is arranged according to resistance values to aid in selecting the proper rheostat for the application.

To facilitate the work of purchasing, receiving and inspection departments, all Vitrohm field rheostats are listed by catalog number in Bulletin 60C, which is now combined with Bulletin 60B.

PERRON RECEIVES APPOINTMENT

The Cornell-Dubilier Corporation, 4377 Bronx Boulevard, Bronx, New York, manufacturer of fixed condensers for more than twenty-six years, announces the appointment of Ray T. Perron, as Sales Director for the New England territory. Mr. Perron will operate out of his offices at 211 Winthrop Street, Taunton, Mass.

LEICH BULLETINS

The Leich Electric Company, Genoa, Illinois, have recently released a 4-page Bulletin describing their No. 62 and No. 90 handset telephones. Also described is their high-efficiency No. 11B battery-feed repeating coil. These coils are said to be very effective and to give a high grade of transmission. This bulletin will be sent free on request.

WESTERN UNION APPOINTMENT

Appointment of George W. Janson, of 56 South Spring Garden Avenue, Nutley, N. J., as Equipment Engineer, was announced recently by F. E. d'Humy, Vice-President in Charge of the Engineering Department, The Western Union Telegraph Company. Mr. Janson succeeds the late Herbert W. Drake of East Orange.

WESTERN ELECTRIC BULLETIN

The Western Electric Company, 195 Broadway, New York City, have available an attractive 20-page technical bulletin on their 5-kw radio transmitter. The high-quality transmitter described in this bulletin features stabilized feedback and complete a-c operation. It is similar to the unit recently installed at WSAI.

TRANSMITTER AND P-A MANUAL

The Research Department of the United Transformer Corporation has just completed a study of transmitter and public-address hookups, circuits and applications. This information has been compiled into an attractive 44-page illustrated bulletin which is now being printed. A limited number of copies will be available at local distributors.

AIEE OFFICERS

Mr. A. M. MacCutcheon, Engineering Vice-President, Reliance Electric and Engineering Company, Cleveland, Ohio, was elected President of the American Institute of Electrical Engineers for the year beginning August 1, 1936, as announced at the Annual Meeting of the Institute held at Pasadena, Calif., during the Annual Summer Convention of the Institute. The other officers elected were: Vice-Presidents A. C. Stevens, Schenectady, N. Y.; O. B. Blackwell, New York, N. Y.; C. Francis Harding, Lafayette, Ind.; L. T. Blaisdell, Dallas, Tex.; C. E. Rogers, Seattle, Wash.—Directors: K. B. McEachron, Pittsfield, Mass.; C. A. Powel, East Pittsburgh, Pa.; R. W. Sorensen, Pasadena, Calif.—National Treasurer: W. I. Slichter, New York, N. Y.

"PRACTICAL WAX RECORDING"

Everitte K. Barnes, M. E., Recording Engineer, has just written a treatise on "Practical Wax Recording." This 34-page booklet is copyrighted by the Universal Microphone Company, Ltd., Inglewood, California, and it may be obtained from them for fifty cents. While "Practical Wax Recording" is written in a manner easily understood by the beginner, it should also prove of interest to the more experienced recording engineer.

RECORDING BULLETIN

The Cellutone Record and Manufacturing Company, 1135 West 42 Street, Los Angeles, California, have issued a very interesting 4-page bulletin covering acetate recording. The Cellutone Recording Microscope is described in this bulletin and numerous photo-micrographs are reproduced in order to illustrate the many uses of this instrument. This informative bulletin may be obtained by writing to the above organization.

MUTUAL GOES COAST-TO-COAST

The Mutual Broadcasting System will expand its network to coast-to-coast proportions before snow flies. Completion of negotiations by which the Don Lee Network in California (KHJ, Los Angeles; KFRC, San Francisco; KGB, San Diego; KDB, Santa Barbara) will become a member of the Mutual System was announced recently by W. E. Macfarlane. President of the Mutual network.

Adding as a Rocky-Mountain region outlet stations KFEL-KVOD, operating on a single channel in Denver, Mutual will begin transcontinental operations sometime not later than December 29 . . . perhaps earlier. Negotiations are also in progress to bring several other stations in major population centers into the Mutual chain.

GEAR CATALOG

A new 128-page catalog describing the complete line of spur, bevel, worm and other gears, also motorized speed reducers, etc., manufactured by The Ohio Gear Company, 1333 East 179th Street, Cleveland, Ohio, is now available on request. In addition to the above information, it furnishes useful technical data on gearing, S. A. E. standard heat-treatment methods, and other handy facts.

"CONSTRUCTION ABROAD"

The Bureau of Foreign and Domestic Commerce, U. S. Department of Commerce, Washington, D. C., are offering a new free service which is designed to acquaint American manufacturers with new construction projects in foreign countries. In order to enable interested firms to send descriptive literature and contact appropriate officials connected with each project, the Bureau will endeavor to obtain and publish complete names and addresses. Those desiring to receive the Bureau's Bulletin, "Construction Abroad," should write to Andrew W. Cruse, Chief, Electrical Division.

CINAUDAGRAPH FORMS NEW DEPARTMENT

A new department, to be known as the Magnet Steel Division, has been formed at the Stamford plant of the Cinaudagraph Corporation, and operations are ready to commence. Mr. Halton H. Friend will be in charge of this new department.

TELEPHONE BATTERY CHARGERS

A bulletin describing self-regulating battery chargers for telephone exchanges is available from The North Electric Manufacturing Company, Galion, Ohio. These units employ full-wave rectification. Typical performance curves, specifications, and illustrations are included in this bulletin.

(*Continued on page* 30)

THE Group Subscription Plan for COMMUNICATION AND BROADCAST ENGINEERING enables a group of engineers or department heads to subscribe at two-thirds the usual yearly rate.

The regular individual rate is $3.00 a year. In groups of 4 or more, the subscription rate is $2.00 a year. (In foreign countries, $3.00.)

Each subscriber should print his name and address clearly and state his occupation—whether an executive, engineer, department head, plant superintendent, or foreman, etc.

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THE MARKET PLACE

NEW PRODUCTS FOR THE COMMUNICATION AND BROADCAST FIELDS

VOLUME CONTROLS

A compact and modern volume control, backed by nearly four years of research and development work, has just been made available to the radio industry with the introduction of the IRC Type "C" volume control by the International Resistance Company of Philadelphia.

Mechanical principles of interest include an extremely hard coating as well as the "5-finger Spring Contactor," a combination which reduces wear of the element. Each silver-plated contact finger operates independently, making contact in exactly the same track with each rotation. Operation is quiet.

A detailed description of this Type "C" volume control is found in the IRC 1936 Catalog, which may be had by writing the International Resistance Company, 401 N. Broad Street, Philadelphia.

CABLE CONNECTOR

To fill the need for a small and inexpensive cable connector, the Bruno Laboratories, Inc., 20 West 22nd Street, New York City, announce a cable connector, Model CI. This is a small, all-metal coupling unit which permits instant connection or disconnection of two single-conductor shielded cables.

Its contact points are said to be positive in action, self-wiping, and maintained under extremely high pressures.

The Bruno Cable Connector is finished in gunmetal and accommodates cables 5/16" in diameter or less.

HIGH-FREQUENCY CONDENSERS

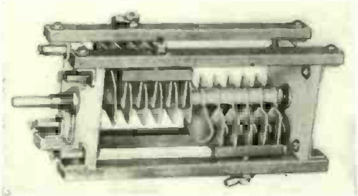
In step with the rapid progress being made in the field of high and ultra-high frequencies, the Allen D. Cardwell Mfg. Corporation, of Brooklyn, N. Y., has developed two types of variable air condensers which combine all of the essential features of design which must distinguish a unit capable of efficient performance at frequencies of the order of 30 megacycles up, it is stated.

Both types feature: no metallic closed-loop circuits to absorb energy or encourage parasitics, maximum leakage path between elements, high-frequency insulation, having the required mechanical strength—Mycalex and Isolantite.

The JD-28-GD, shown, illustrates the balanced type of "all insulation" frame high-frequency variable air capacitor, which has following specifications:

Maximum capacity per section...28 mmfd.
Minimum capacity per section....5 mmfd.
Airgap .... .125"
Voltage rating.......4600 v peak flashover
Plates .... .040"—buffed and polished
Insulation...Isolantite end plates, Mycalex tie rods—stator supports
Mounting ....Front panel

The NP-35-GD is for amateur high-frequency transmitters of moderate power, and is widely used in the therapy field, for resonating the output or patient-pad circuit.



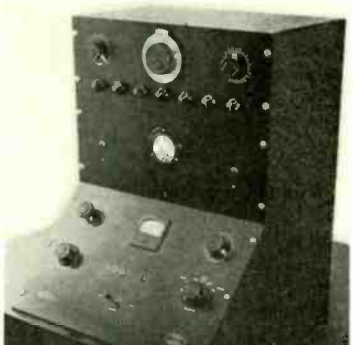
HAMMARLUND "SUPER PRO"

The Hammarlund Manufacturing Co., Inc., has just developed a 16-tube superheterodyne to meet the precision requirements of the professional and amateur operator. It is known as the "Super Pro" and has, among its features, an electrostatically-shielded input; a new silver-plated 5-band switch; 4 air-tuned i-f transformers; continuously-variable selectivity;

high fidelity; 2 tuned r-f stages on all bands; 3 audio stages; visible tuning meter; accurate directly-calibrated tuning dial in megacycles and kilocycles; band-spread tuning dial; individual audio-frequency, radio-frequency, and i-f controls; variable beat oscillator; tone control; speaker-phone switch; send-receive switch; avc-manual switch; cw-modulation switch, and a separate power-supply unit.

STUDIO AMPLIFIER

The Model 50A Vibro-Master studio



amplifier, shown in the accompanying illustration, has been announced by Dencose, Incorporated, 1650 Broadway, New York City, N. Y.

This amplifier is said to have a power output of 18 watts, a distortion factor of 2 percent total, and a gain of 147 db. The frequency response is flat within ½ db from 30 to 16000 cycles, or it may be furnished with a rising or falling characteristic on either end with as much attenuation or rise as 6 db. The hum level is minus 114 db.

The Model 50A uses the following tubes: four 6J7s, two 6C5s, two 38s, and four 6A3s. The 6A3 tubes are arranged in two push-pull output circuits, each with its own individual output control.

This amplifier may be used for the operation of a recording mechanism on one channel and the operation of a monitor or speakers on the other channel. It incorporates a radio tuner of the t-r-f band-selector type, having a total of 6 tuned circuits. Diode detection with a one-stage audio amplifier is used.

Further details on request from Dencose, Inc.

HIGH-SENSITIVITY D-C RECORDER

The improvements and refinements embodied in the Esterline-Angus Model AW instruments have made it possible for this company to bring out a graphic meter of the direct-writing type. This instrument combines sensitivity and accuracy on one hand, with reliability and ruggedness on the other. The new instrument is an integral part of a heavy-duty line.

This instrument can be housed in any of the 4 standard types of cases; portable, wall, front switchboard or flush switchboard. It can be provided with any of the standard types of chart drives; spring-clock, synchronous-clock or external-motor drive, making available thirteen different chart speeds ranging from ¾ inch per hour to 3 inches per second. The measuring element consists of a D'Arsonval mechanism. The simple construction involves a minimum number of operating parts, and gives a high speed of response.

The use of this instrument is indicated wherever it is desired to make a permanent record of small electrical currents or voltages. Since it is particularly adaptable for use with vacuum tubes, it can be employed to measure any other quantities which can be converted into electrical impulses, and amplified or controlled by thermionic means.

These instruments are being used by broadcast stations and chain headquarters for automatically monitoring audio-frequency level. They are used by broadcast stations, radio consulting engineers, and government departments, for mapping field strength and studying fading.

For further information write to the Esterline-Angus Company, Indianapolis, Indiana.

DUPLEX RECEIVER TRANSMITTER

Fixed or Mobile

- Type TR-6A6 — 10 Watts Output

Employing new 6E6 UNITY COUPLED P.P. oscillator, 6A6 Class B, 6A6 Class A. Phone or I.C.W. without external batteries. Four tube non-radiating receiver. 7½"x15"x8". **$39.75**

SPECIAL EQUIPMENT FOR ALL REQUIREMENTS

FINEST FOR FIELDWORK

PORTABLE PACK
Transmitter and Receiver
Type PTR-19

Frequency range 30-41 Mc. front panel control—special Hiperm Alloy Transformers having uniform freq. response 40 to 12000 cycles per second—Transmitter unity coupled push-pull 19 Oscillator, 19 class B Modulator, 19 class A driver and 30 class A microphone amplifier — Carrier power, 2 watts—peak, 8 watts—receiver; one 30 tube in super-regenerative circuit—ample battery provision, carrying case; etc. Weighs only 35 lbs. with batteries and all accessories.

Bulletin C will interest you. Write for it—it's FREE.

RADIO TRANSCEIVER LABORATORIES
8627 - 115th Street, Richmond Hill, N. Y.
Export Division: 15 Laight St., New York, N. Y., U. S. A.

PRECISION FREQUENCY MEASUREMENTS

TRU-AXIS LOW DRIFT CRYSTALS

RADIO ENGINEERING CONSULTANTS

Commercial Radio Equipment Co.
7205 BALTIMORE AVE., KANSAS CITY, MO.

RECORDING EQUIPMENT

PORTABLES — STUDIO MODELS

Write for new Price List

RADIOTONE RECORDING CO.
6103 MELROSE AVE. HOLLYWOOD, CALIF.

"THE CRYSTAL SPECIALISTS SINCE 1925"

PIEZO-ELECTRIC CRYSTALS

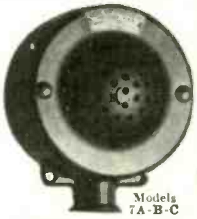
GUARANTEED Accurate to BETTER than .01%

SCIENTIFIC RADIO SERVICE

Send for FREE Booklet and Price List!
UNIVERSITY PARK - - - - HYATTSVILLE, MD.

IMPROVED PERFORMANCE AT LOWER PRICES

GREATER SENSITIVITY— EXTREME RUGGEDNESS



Models 7A-B-C

An inquiry on your letterhead will bring immediate information.

RADIO RECEPTOR

Dynamic Moving Coil

MICROPHONES

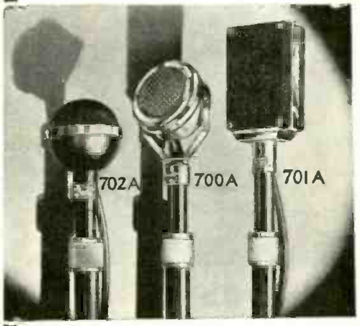
have been drastically reduced in price, due to greatly increased production and improved manufacturing facilities.

The Moving Coil Dynamic Microphone is undoubtedly the most practical and efficient of all types of microphones.

They are not limited as to distance from amplifier; wide angle pickup; uniformity of product.

RADIO RECEPTOR CO., INC.
Manufacturers of Radio and Sound Equipment Since 1922
106 SEVENTH AVENUE NEW YORK, N. Y.

"MICROPHONE HEADQUARTERS"
Presents
The NEW SHURE "Ultra" WIDE-RANGE



Crystal Microphones

with these

8 EXCLUSIVE FEATURES

- Ultra "Wide-Range" Reproduction from 40 to 10,000 cycles with a uniformity of response closely approaching the most rigid True High-Fidelity tolerances.
- New Shure "Cruciform" Crystal Mounting makes possible highest output level ever attained in a diaphragm-type crystal microphone of comparable frequency response.
- Dual-Drive High - Capacity Grafoil Bimorph Crystal.
- New single high - efficiency Curvilinear Diaphragm.
- Internal Screen - Protected Cartridge Unit—no exposed diaphragm when case is opened.
- Complete Barometric Compensation.
- Crystal "Moisture - Sealed" by new special process.
- Semi - Nondirectional and Semi-Directional models with new Spherical, Swivel and "Grille-Type" case designs.

Only Shure "ULTRA" Crystal Microphones can give you these new "highs" in performance, dependability and utility at such low cost! Three models . . . Spherical, Swivel, and "Grille-Type" . . . List price, each, only $25.

Write for data today!

(Models 701A and 702A available now. Model 700A available August 15.)

Licensed under patents of the Brush Development Company. Shure patents pending.

SHURE *Cable Address* SHURMICRO **MICROPHONES**
SHURE BROTHERS • MICROPHONE HEADQUARTERS
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JUST OUT!

AmerTran "Midget" Audio Components

35 Designs for

- Mixing
- Line Matching
- Line to Grid
- Interstage
- Plate to Line
- Audio Reactors

Suitable for —80 to 0 dB operating levels. Useful frequency range 20 to 20,000 cycles. Shielded electromagnetically and electrostatically. Average weight 3¼ oz. Cubic content, 2¼ cu. in. Ideal for low-level preamplifiers for portable or aircraft service.

Send for Bulletin No. 1003

AMER TRAN **TRANSFORMERS**
Manufactured Since 1901 by—
AMERICAN TRANSFORMER COMPANY
172 Emmet St. . . . . . . Newark, N. J.

TIMING DEVICES

Struthers Dunn, Inc., electrical control specialists of 139 N. Juniper St., Philadelphia, have recently added several motor-operated timing devices to their line of timing devices which also includes thermal, inertia, air dash pot and capacitor types.

One of these is of the immediately re-cycling type. The synchronous motor of the timing device drives cams through a chain of gears. At the time the starting impulse is received, the motor starts and a solenoid is energized to operate a clutch which connects the cams to the motor. At the end of the cycle, the motor is de-energized by means of a contact on one of the cams, and the clutch holds the cams in position. When the solenoid is deenergized, the cams are returned to the starting position by means of a spring. The timing is adjustable over a wide range and practically any desired arrangement of load contacts may be furnished.

Another of these timing devices is of the continuously rotating type. By means of gears the cams of the timer are made to revolve at 1 rpm or any other desired speed. The contacts can be arranged to be closed for any time up to half the time required for one revolution if the timing is adjustable, or up to the full revolution time if the timing is not adjustable. Almost any desired number of adjustable or non-adjustable contacts can be furnished.

Complete information on these and many other types of timing devices may be obtained by writing to the above company who specialize in building control devices to meet particular requirements.

AMPLIFIER CIRCUIT

A new amplifier circuit, employing the popular 6B5 tubes in push-pull, has just been released by Jefferson Electric Company, Bellwood, Illinois, and described in detail in Bulletin PA-11. This circuit features a double-channel input from low- and moderate-level sources with gains of 138 or 98 db. Input from either channel is controlled by a single center-tapped potentiometer. Flat frequency response and low harmonic distortion contribute to give an amplifier of exceptional tone quality at all output levels, it is stated.

This amplifier is adaptable to all types of public-address and station-amplifier work, the output being sufficient for 1 to 4 dynamic speakers.

GRID-CAP ASSEMBLY

Isolantite Inc., 233 Broadway, New York City, has placed on the market a new grid-cap assembly for the all-metal tubes. The use of permanent low-loss insulation at this point is now made possible without any changes in tube design or assembly equipment as the unit is directly interchangeable with assemblies previously used.

"FLEA POWER" MOTOR

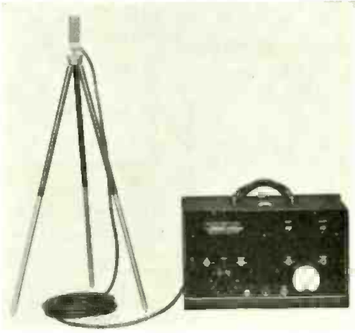
The Speedway Manufacturing Company, 1834 South 52nd Ave., Cicero, Illinois, manufacturers of SpeedWay Electric tools and motors, announce a new "flea power" worm-drive, back-geared motor that comes not only in a-c, d-c and universal, but at the same time can be assembled with drive shaft to right, to left, up or down. This new feature, it is claimed, greatly simplifies mounting problems and will eliminate the need for complex and angular drives. Literature is available from the above organization.

SOUND-LEVEL METER

A new sound-level meter which will give a quantitative measure of noise independent of the personal element, and at the same time give results commensurate with the sensations experienced by the ear, has been announced by the General Electric Company. The meter was developed to provide performance in accord with the newly-adopted ASA standards. Special precautions have been taken to make the amplifier unit of the instrument suitable for use in the neighborhood of electrical machinery where stray magnetic fields are common. The complete instrument, including microphone, tripod, calibrating unit, and batteries is contained in a compact metal case 15¾ by 9½ by 8¼ inches. The carrying weight is approximately 39 pounds.

The microphone is a small, non-directive, piezo-electric type with practically flat frequency response up to 8000 cycles per second.

The five-stage amplifier is resistance-transformer coupled and has special small-size, low-drain tubes mounted in shock-reducing sockets. A convenient switch permits the selection of either a flat frequency response to measure sound intensity, or a weighted response which approximates that of the ear at a loudness of 40 decibels. The sound-level meter is calibrated to read in decibels above the standard reference level of 10^{-16} watts per square centimeter at 1000 cycles. The range of the instrument is 30 to 120 decibels. This is sufficient for noises ranging from those in quiet country homes to sounds that are intense enough to be painful to the ear. Suitable jacks are provided in a 500-ohm interstage circuit to permit the use of auxiliary equipment such as an analyzer or a vibration-velocity unit or special filtering and control circuits as needed.



A receptacle is provided for connecting external batteries where the instrument is to be used on permanent location.

A simple mouth-blown calibrating unit is provided to insure accurate overall field calibration. Factory calibration is obtained by placing the microphone in a standardized sound field.

OVER THE TAPE

(*Continued from page 26*)

RADIO BROADCASTING IN CANADA

An organization to control radio broadcasting in Canada patterned after the British Broadcasting Corporation has been unanimously recommended by a special committee of the Canadian House of Commons which has studied the radio situation in the Dominion, according to a report to the Commerce Department from Assistant Trade Commissioner A. F. Peterson, Ottawa.

The proposed unit, the report points out, would replace the three-man radio commission now supervising radio activities in the Dominion. It would be headed by a board of nine honorary governors which would determine broadcasting policy, the functions being carried out by a general manager.

Technical features of radio control should be under the direction of the Minister of Marine through the Radio Branch of that Department, in the opinion of the committee. At present this is the licensing authority in Canada and questions of wave-length, power of stations, collection of license fees and other operating matters should be directed from this Department, according to the committee. Additional power to control outside sources of local interference were recommended.

The committee recommended that the proposed corporation in control of radio broadcasting should immediately consider ways and means of extending national coverage either by connecting additional private stations to its network or by the creation of new outlets. It was recommended that the corporation be authorized to borrow up to $500,000 from the federal government to extend coverage.

The radio committee's report, Assistant Trade Commissioner Peterson points out, does not indicate any fundamental change in policy regarding broadcasting in Canada. The principle of complete nationalization of radio broadcasting was reaffirmed but pending the realization of this objective it was recognized that private stations will necessarily continue to provide a large portion of programs for listeners and it was recommended that complete cooperation should be maintained between the proposed government radio corporation and private stations.

The committee indicated that in case the corporation should take over any private outlets no value should attach to the license and no person should be deemed to have any proprietary right in any radio channel, the Trade Commissioner reported.

AMERICAN LAVA OPENS NEW PLANT

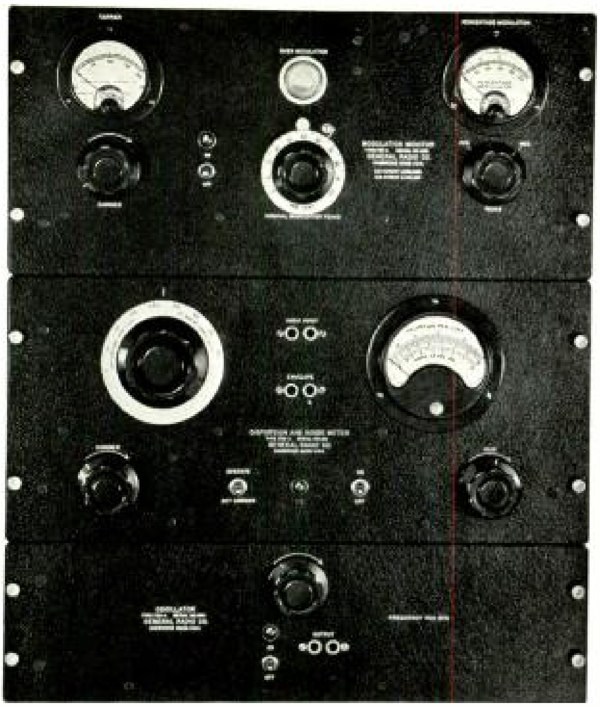
On June 24 the American Lava Corporation, Chattanooga, Tenn., completed moving into its new plant. The removal from the old location required about a month and was accomplished without serious interruption to a daily production schedule of over a million pieces.

NEW TECH CATALOG

A new catalog covering precision type resistance instruments and allied products is announced by Tech Laboratories, 703 Newark Avenue, Jersey City, N. J. The products covered in this catalog comprise: volume control attenuators, attenuators for measurements, L, T and H pads, fixed loss pads, taper pads, voltage dividers, faders, output controls, speaker pads, precision attenuators for laboratory use, gain sets, transmission measuring sets, volume indicators, decade resistance boxes, r-f precision laboratory resistors, decade potentiometers, etc.

This new catalog covers a number of new developments which have been made by the Tech Laboratories during recent months. It is of the loose-leaf binder type and additional sheets, now in preparation, will be added from time to time. This catalog should be of special interest to manufacturers of sound transmission equipment, broadcast stations and laboratories of all kinds.

INDEX OF ADVERTISERS



This is the Unit approved by the FCC

Approval Number 1551,
dated April 24, 1936

This Modulation Monitor Features:

- A d-c meter for setting carrier and for indicating carrier shift with modulation.
- A peak flashing light which operates on all peaks exceeding any predetermined value.
- A high-speed meter indicating continuously percentage modulation on either positive or negative peaks.

This instrument is sold separately and is supplied with tubes and accessories for immediate operation.

Type 731-A Modulation Monitor: $195.00

CLASS 730-A TRANSMISSION MONITORING ASSEMBLY

THE General Radio Class 730-A Transmission Monitoring Assembly is composed of these three units, each of which are individually complete and self-operated. The assembly enables the station operating staff to be certain that peak transmitter efficiency is obtained at all times. A complete run on the station for hum, noise, modulation and distortion can be made in less than ten minutes. Measurements can be made on any portion of the circuit to isolate sources of trouble. The assembly is furnished with all tubes, inter-connecting cords and accessories necessary for immediate operation. **Class 730-A Transmission Monitoring Assembly: $462.00.**

Type 732-A Distortion and Noise Meter

This meter measures total harmonic distortion and noise and hum levels present in the output of a transmitter. Distortion measurements on the audio syst.m alone may be made. The input to the meter is accessible for line testing. A Weston Model 643 meter, calibrated directly in per cent distortion with full-scale meter values of 1, 3, 10 and 30 per cent and calibrated in decibels noise level from 30 db to 70 db below the value of modulated carrier or 65 db below an a-f signal of zero level, is provided. A frequency of 400 cycles is used for distortion measurements and 30 to 10,000 cycles for noise and hum measurements. The over-all accuracy is better than ±5% of full-scale meter readings. **Type 732-A Distortion and Noise Meter, complete with tubes and all accessories. Price: $205.00.**

Type 731-A Modulation Monitor

This monitor gives continuous indication of percentage modulation on either positive or negative peaks and also visual indication of over-modulation peaks. The decibel scale on the percentage modulation meter can be used for measurements of fidelity characteristics of the transmitter. A Weston Model 301 high-speed meter is used as the modulation indicator. The flashing circuit of the over-modulation lamp is entirely automatic and is independent of line voltage and carrier amplitude. The percentage modulation measurements can be relied upon within 0.5 db for modulation frequencies from 30 to 10,000 cycles to an accuracy of better than 2% at 100 per cent and 0 per cent levels. The modulation monitor is well shielded so that no special precautions are necessary even when it is used near a powerful transmitter. **Type 731-A Modulation Monitor, complete with tubes and accessories. Price: $195.00.**

Type 733-A Oscillator

This oscillator is designed for use with the Type 732-A Distortion and Noise Meter. Its frequency is ±2% of 400 cycles, output 30 milliwatts and internal output impedance 50, 500 and 5000 ohms. The distortion is 0.1 per cent to 0.2 per cent, depending upon load. **Type 733-A Oscillator, complete. Price: $62.00.**

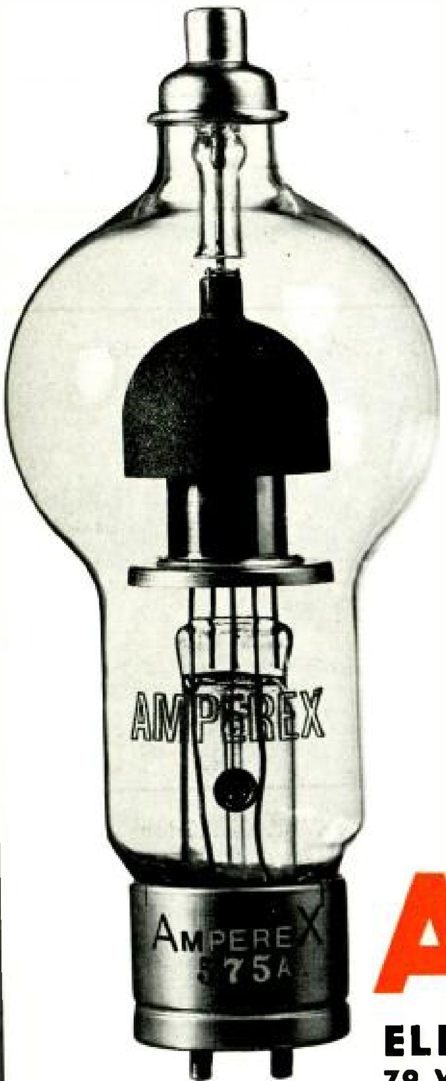
GENERAL RADIO COMPANY

CAMBRIDGE, MASSACHUSETTS

YOU ASKED FOR THIS

NEW

AMPEREX 575A



MERCURY VAPOR RECTIFIER

The development of the Amperex 575A, a high voltage Mercury Vapor Rectifier, is a result of the continued requests for an intermediate rectifier which would fill the gap between the 872A and 869A.

Designed and proportioned along the lines of the 869A with only slightly lower voltage current characteristics, yet the cost of the Amperex 575A is only a small fraction of that of the 869A.

$35

RATING AND CHARACTERISTICS

HALF WAVE
MERCURY VAPOR RECTIFIER

Filament: Voltage	5 Volts A.C.
Current	10 Amperes
Overall Length	10½ inches
Maximum Diameter	3-3/16 inches
Plate Cap Diameter	.500 inch
Base	Standard 50 Watt

MAXIMUM RATINGS

For operation at supply Frequency up to 150 cycles and Ambient Temp. Range of 15°-50° C.

Peak Inverse Voltage	15,000 Volts
Peak Plate Current	6 Amperes
Average Plate Current	1.5 Amperes
Average Tube Voltage drop	10 Volts

AMPEREX

ELECTRONIC PRODUCTS, INC.
79 WASHINGTON STREET BROOKLYN, N.Y.