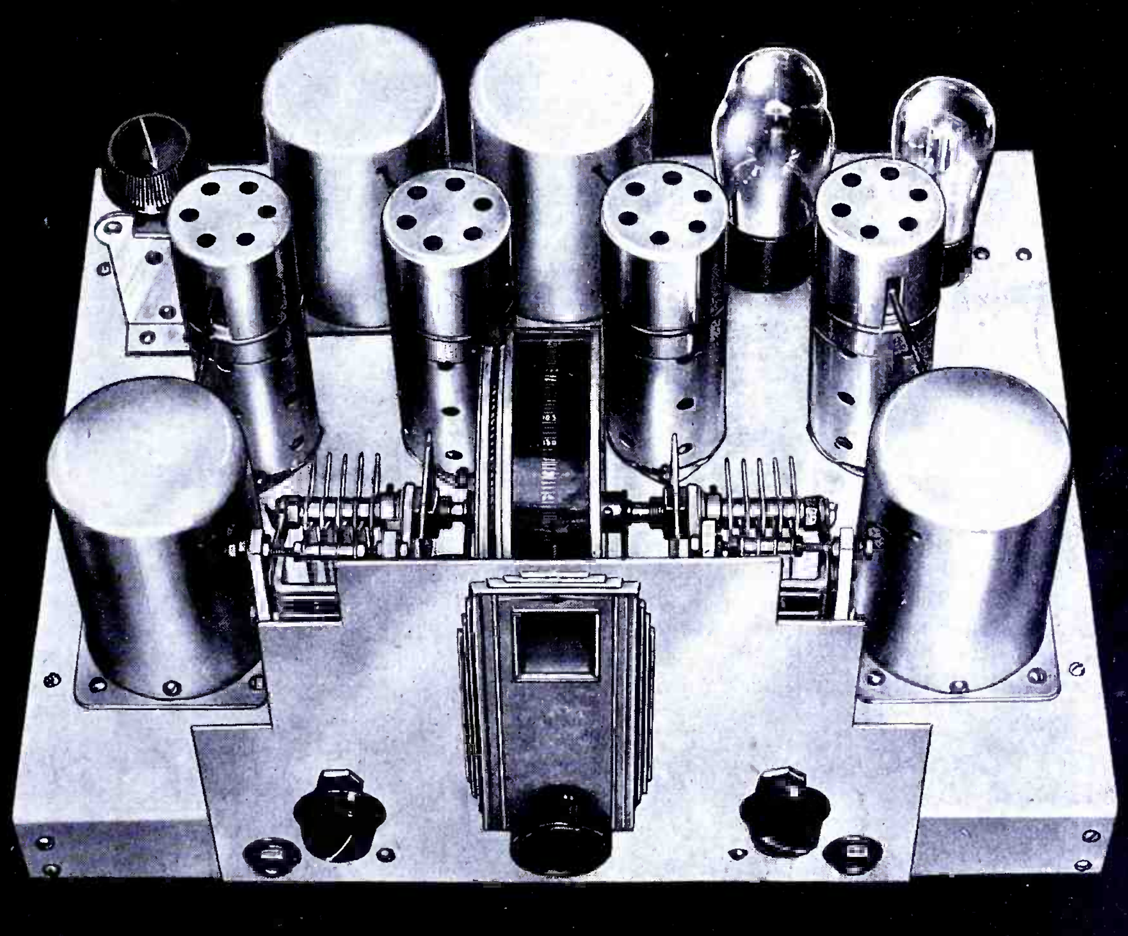
SHORT WAVE RADIO

March
1934

Edited by
Robert Hertzberg and Louis Martin

IN THIS ISSUE:

The Worcester "Forty-Niner"



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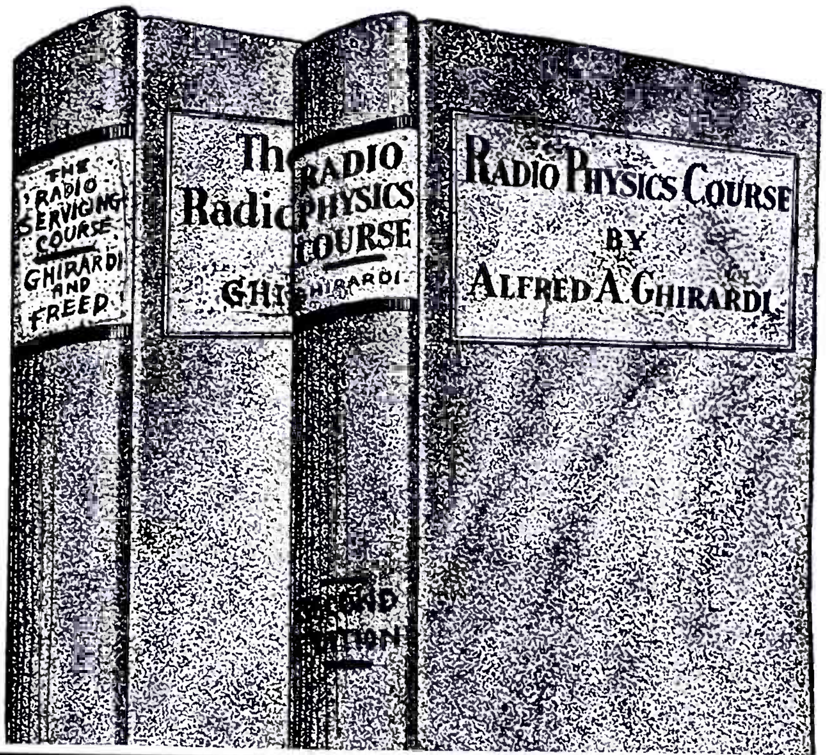

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SHORT WAVE RADIO

devoted to short-wave transmission and reception in all their phases

Robert Hertzberg, *Editor* — Louis Martin, B.S., *Technical Director*

March, 1934 — **Vol. 1, No. 5**

IN THIS ISSUE:

IN FUTURE ISSUES:

BARKHAUSEN AND KURZ OSCILLATIONS—The accidental discovery by two German scientists of the phenomenon of internal electron oscillation in vacuum tubes has led directly to the development of practicable ultra-high-frequency oscillators. The effect is simple, but not generally understood. Andrew Alford has written an excellent article telling all about it.

A VISIT TO RADIO CENTRAL—Have you ever wondered how the National Broadcasting Company works its spectacular short-wave rebroadcasts? To find out, the editors made a special trip to Riverhead, L. I., where "Radio Central" is located. The amazing receiving equipment that they saw will be described at length.

THE G. E. K-80 RECEIVER—One of the most interesting set developments of the current season is the G. E. Model K-80, which contains many unusual circuit features. Robert S. Kruse, who needs no introduction, analyzes this receiver in an article of outstanding merit.

COMMERCIAL SET REVIEW—We receive so many inquiries about factory-built receivers that we have decided to initiate a new monthly department in which representative receivers will be described truthfully and completely from the standpoint of the prospective purchaser. We expect that this series of articles will settle many questions in the minds of our readers.

CHARLES H. FARRELL, Advertising Manager

SHORT WAVE RADIO—Monthly. Entered as second-class matter September 15, 1933, at the post office at Chicago, Illinois, under the Act of March 3, 1879.

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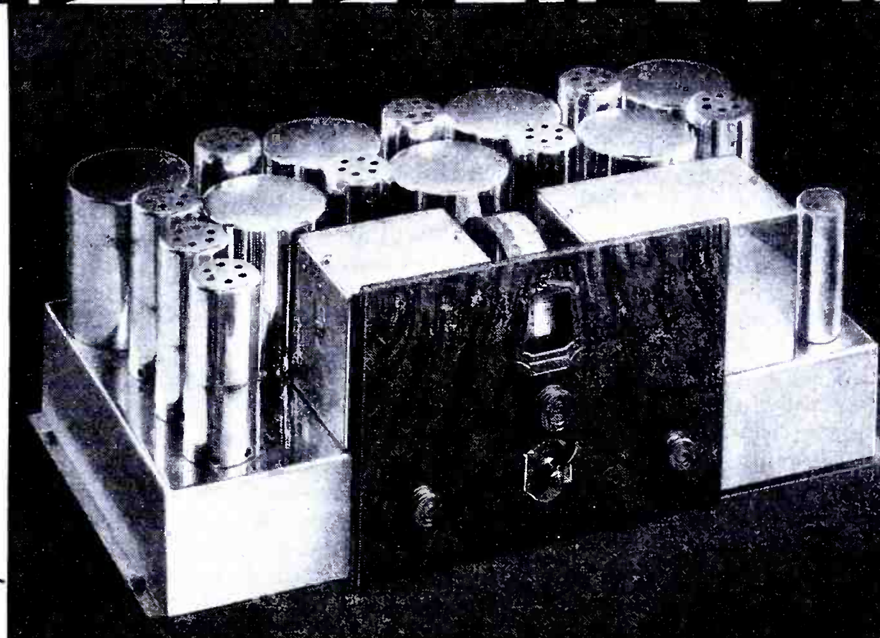

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TELEVISION—When and How

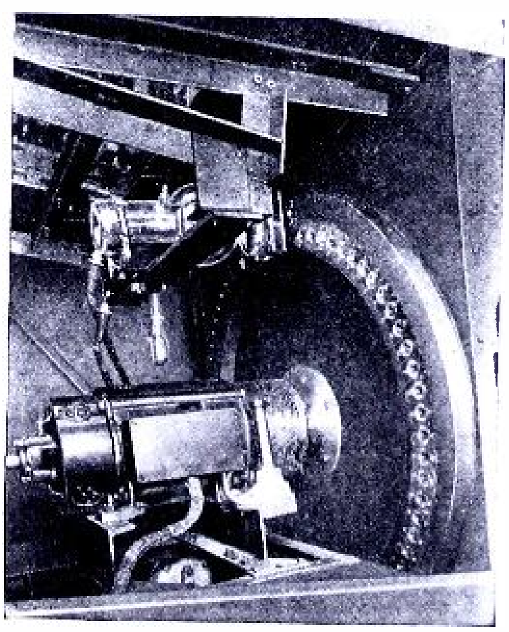
By The Editors

TELEVISION, the bad boy of the radio industry, again seems to be arousing general public interest. With the opening of the new and elaborate Radio City studios of the National Broadcasting Company in New York and the cautiously worded announcement that provision has been made in them for television programs, people are again asking the question, "When will television come around the corner?"

Its arrival has been delayed by much extravagant and unfortunate publicity, which has been the work of professional stock promoters rather than of competent engineers. About three years ago, the public was heavily oversold on the whole television idea, but since no provisions had been made for nation-wide broadcasting and no adequate receivers were available, the whole thing died a quick and not particularly mournful death. Radio people with the interests of both the public and their own industry at heart decried the ballyhoo because they knew that no tangible sales—except stock sales—could materialize from it.

The general public impression at the time was that the television receiver would be an accessory to the regular broadcasting receiver, something like the loudspeakers used to be in the early days of broadcasting. This possibility was definitely eliminated when the Federal Radio Commission took experimental television out of the broadcast band and placed it in frequency channels above 1500 kc.

No matter what happens in the television field, one thing is certain: the television receiver of the next year or two, if it materializes that soon, will be distinctly separate from the sound receiver. There will be no problem of synchronization, as there was with talking movies, as the sound and sight programs are transmitted simultaneously and both are represented over the air by instantaneous radio signals of exactly the same speed. Indeed, it would be quite a trick—well nigh an impossible one—to throw the sight and sound sections of the same program *out* of synchronization!



Photos courtesy Bell Telephone Labs.

A close-up of the lens-imbedded scanning disc used for reception purposes in the Bell Laboratories two-way wired television experiments of 1930. Note the large neon tube on the platform behind the top edge of the disc.

In order to avoid premature publicity that will do more harm than good, several of the largest firms in the industry have been guarding their television experiments with a secrecy not practiced since the days of the World War. In fact, although it is definitely known that research is going on at a furious pace, not a single satisfactory report of the work has reached the public prints. Extremely private and closely guarded demonstrations for the benefit of patent licensees have been held from time to time, but all the people who attended these must have been warned pretty strongly about keeping quiet, for not a word could ever be obtained out of them.

Why All the Secrecy?

"Why all the secrecy?" you may ask. Well, it is a long story, friends. The main answer is that the leaders of the radio industry are determined NOT to have television repeat the frenzied history of broadcasting. Broadcasting, like Topsy, "just growed." It started altogether accidentally, without any deliberate effort on anybody's part. The nucleus for the present world-wide audience of radio listeners was a group of several thousand pioneer "wireless" amateurs who built their own receivers and saw nothing particularly significant or startling in the voice and music transmissions of the early amateur and experimental radiophone stations. The Westinghouse Company through W8XK (KDKA), broadcast the Harding election returns in 1920 and the families and friends of these amateurs suddenly discovered that it was all very interesting. The boom was on, and the people who were least prepared to capitalize on it were the very people already in the radio business. Broadcasting stations by the hundred sprang up overnight, and every shop containing a vise and a drill press became a radio factory. Fortunes were made and lost in quick succession. The thin authority exercised over broadcasting by the Department of Commerce was proved to be illegal and confusion reigned supreme. Only in 1927, six years after the start of the boom, did Congress pass controlling legislation, and even at that the early Federal Radio Commissioners, selected more for their political affiliations than their technical accomplishments, did not cover themselves with any particular glory.

Today broadcasting is a very highly organized industry, representing an investment of millions of dollars and employing thousands of men and women. The Radio City studios of the NBC alone, which are breathtaking in their size, equipment and cost, are tangible evidence of the maturity of the business.

Now, no one wants uncontrolled television development to upset the applecart of broadcasting prosperity, which was one of the anomalies of the economic depression. The big moguls of radio have no intention of releasing television to the public until they have something that can be merchandised, just as they now successfully merchandise regular radio receivers through thousands of wholesale and retail channels throughout the country. If television is to be sprung on the public, it probably will be sprung all at once, at such time as television receivers can be produced in quantities and shipped, handled, installed, and operated just like any other piece of household radio equipment. The television receivers shown to date require the services of half a dozen engineers, cost more than a dozen radio sets, and are laboratory instruments rather than devices for home entertainment. The radio industry does not want experimental equipment—it wants outfits that require no more manipulation than a sound

The magical television-telephone booth of the Bell Laboratories. Behind the glass screens are the photoelectric cells on which the image of the subscriber is impressed. The receiving screen is in front of the subscriber and cannot be seen in this view. The telephone apparatus is also hidden by the man's body.

receiver. Perhaps the images produced by the first commercially available receivers will not be perfect, but simplicity of control will certainly be an important sales feature.

The radio production people, who plan and stage commercial programs, are keeping a wary eye on developments, for the advent of television will certainly involve a change in their technique. The subject has already been given consideration in several books, and some enterprising broadcasters have even thought up the idea of televising sponsors' trade marks and replicas of their products.

Some Predictions

Our belief is that the change in technique will not be as startling as some people think, there being a number of important psychological factors to consider. For instance, a listener can turn on a radio receiver in his home and listen to one program after another, at the same time carrying on normal conversation, dancing, walking, reading, scrubbing floors or washing dishes. Casual attention of this kind to television programs is impossible, as the listener, or rather "looker," must seat himself in front of the televisor and concentrate on the screen just as he does at any picture show. If a program depends too strongly on visual appeal, it will suffer considerably. People sitting in the comfort of their own homes are not likely to exercise so much concentration and they will certainly be bored much more readily with a dull television program than with a dull sound program. It is difficult enough to keep some people quiet in a picture theatre!

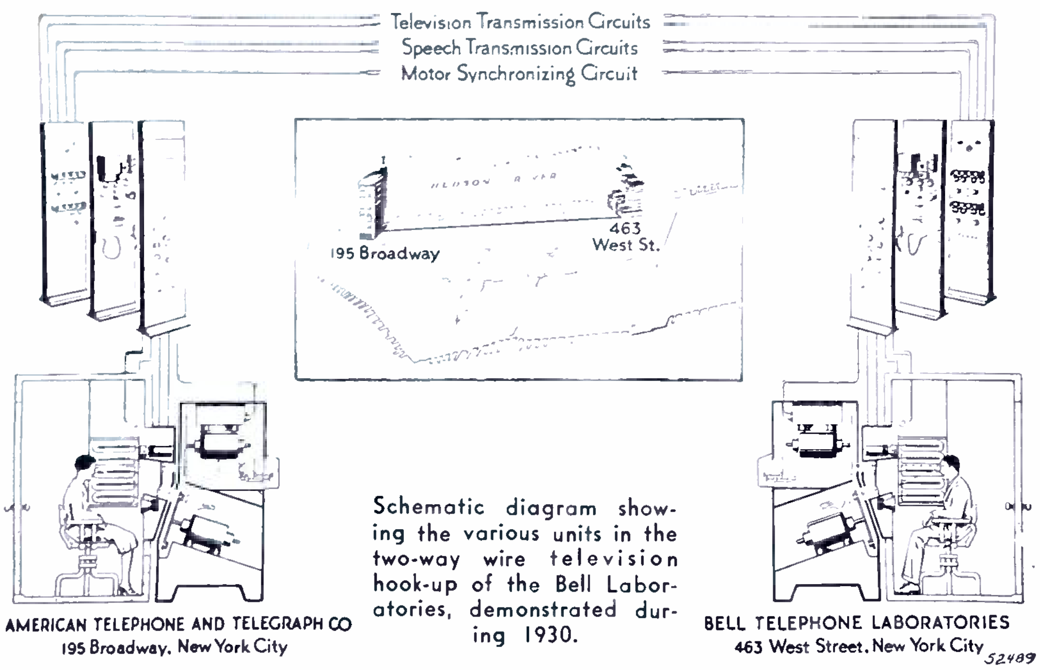
Bell Telephone's Work

All the foregoing remarks apply generally to radio television. They do not take into consideration the fact that the Bell Telephone Laboratories have spent a sum of money said to run into millions of dollars on television experiments from the wire transmission standpoint. As a matter of fact, the television demonstrations staged by the Bell Telephone Laboratories from time to time were generally regarded as the most successful of *all* television efforts.

In October, 1930 the Bell Telephone engineers demonstrated a remarkable two-way television system between 195 Broadway and 463 West Street, New York, N. Y., a distance of a few miles. A person stepped into a small booth quite like an ordinary telephone booth and carried on a conversation with a person at the other end of the line, at the same time seeing his image clearly on a small screen directly in front of him. Likewise, the person at the other end was able to see the first person's image. The system was positively magical!

TWO-WAY TELEVISION SYSTEM

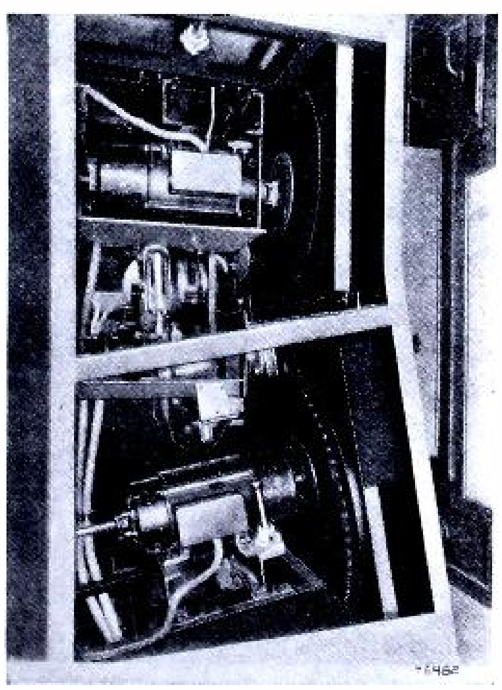
DEVELOPED BY BELL TELEPHONE LABORATORIES



Schematic diagram showing the various units in the two-way wire television hook-up of the Bell Laboratories, demonstrated during 1930.

Of course, what the Bell Telephone Laboratories and the American Telephone and Telegraph Company undoubtedly are striving for is commercial two-way television as an auxiliary to its regular telephone service, which is universally regarded as the best in the world. Eventually, it may be possible for telephone subscribers to see each other as well as talk to each other, paying for this privilege just as they now pay for long-distance calls and other special telephone services. Just when this service will materialize is just as much a matter of conjecture as the advent of radio television.

What makes this particularly interesting from the short-wave standpoint is that television can be transmitted only on the short waves. From all appearances, the extremely short waves, below 10 meters, will be used, but many problems still remain unsolved.



The two scanning discs located behind the Bell Laboratories television booth. By means of the upper one, a beam of light from a powerful incandescent lamp is caused to "scan" the face of the person in the booth, the beam being reflected into the photoelectric cells shown in the lower right illustration on the preceding page.

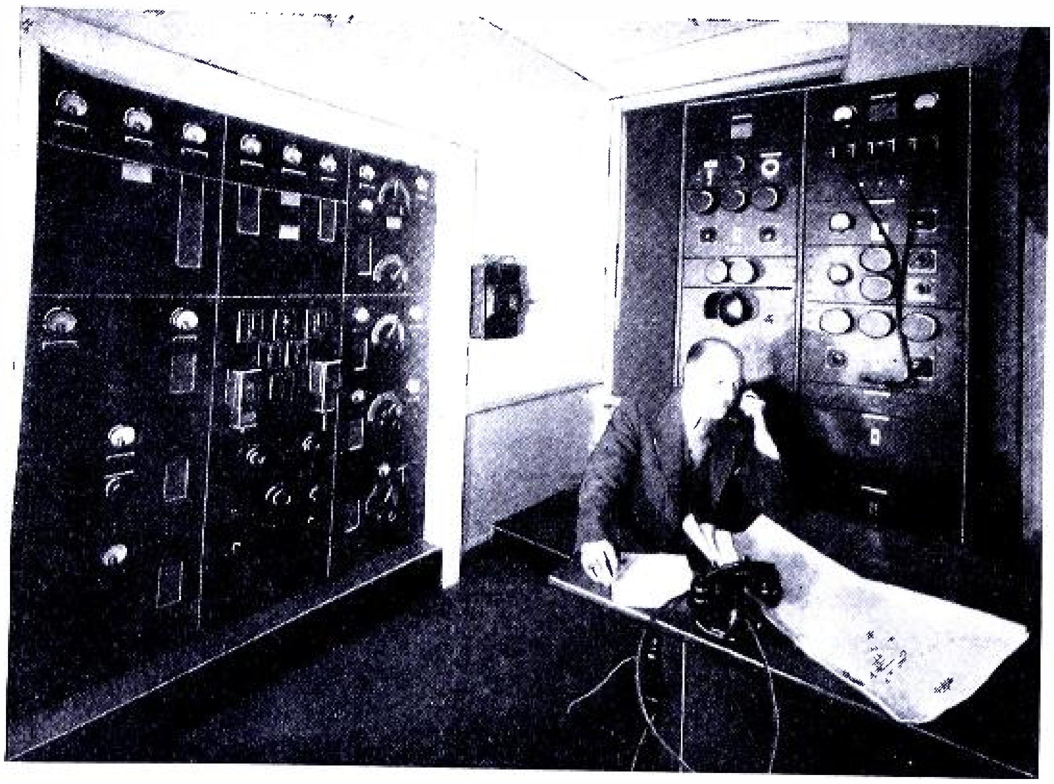
Technical Considerations

Consider the simple case of a stationary picture consisting of alternate black and white lines on which the scanning beam passes from jet-black lines to white lines, successively. Such an object will require the greatest possible frequency band. If the picture is to be scanned sixteen times a second with a 60-line scanning system, and if it be further assumed that the picture is square, then the total number of elements sent over the system will be 60 x 60 x 16, or 57,600 elements. This corresponds to a frequency of 28.8 kc.

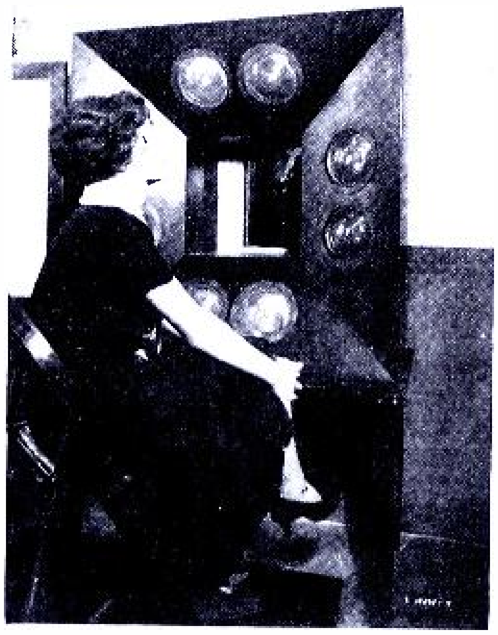
It is quite clear from this simple calculation that if a still picture is to be transmitted, the band width required for each station is 57.6 kc. Unfortunately, however, very few people will be satisfied with looking at still pictures, and no one believes that, except for experimental work, "stills" will be used.

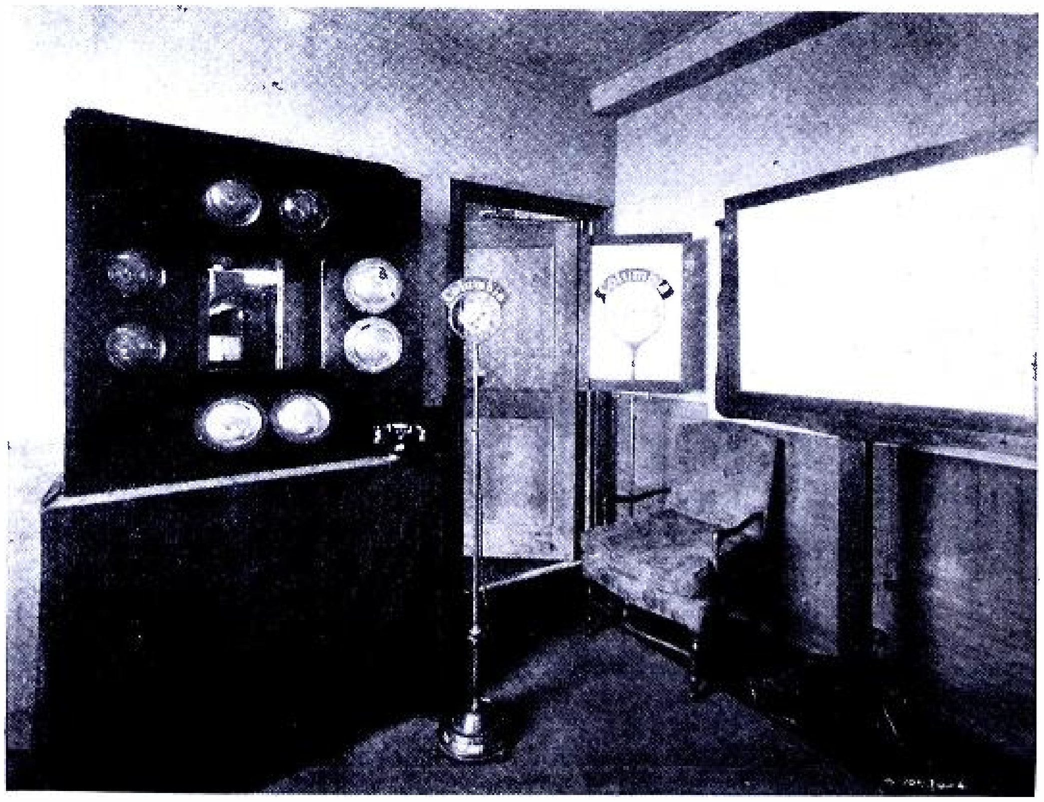
The modern television transmitter produces moving pictures of exactly the same type as ordinarily seen on the screen, and it is with the problems connected with this form of transmission that television engineers must cope.

Consider the frequency band required by motion pictures being transmitted by television with sound accompaniment. The size of a single "frame" on a reel of motion picture film is such as to have a ratio of about 4 to 3, that is it is 33 per cent wider than it is high. Even if a 60-line scanning system were used, the band width required would be 128 kc. Now, a 60-line scanning system gives good picture detail, but in all probability, at least 120 lines will be required for public acceptance. The same picture scanned 120 times requires a picture communication band 512 kc. wide.



Above: The power and transmitting room of W2XAB, the experimental visual broadcasting station of the Columbia Broadcasting System, located at 485 Madison Avenue, New York. Much interesting work was done by this station during 1931, but it is no longer on the air. Edwin K. Cohan, chief engineer of CBS, is at the supervisor's desk. Right: The artist's position in front of the photoelectric cell frame. Directly behind the square opening, in an adjoining room, is the scanning apparatus. Below, right: A general view of the W2XAB television studio. The large white screen was used as a background for the performers, to give the transmitted images desirable contrast.





It needs but a meagre comparison with ordinary broadcast problems to conclude that, with 120-line scanning systems, no more than two television stations could be included in the entire broadcast band between 550 and 1500 kc.! The only possible way in which the required frequency channels may be secured without mutual interference is by utilizing the very short wavelengths in the neighborhood of six meters (50 megacycles). In other words, when television steals around the corner, it is certain to be located right in short-wave fans' own front yard.

The sound systems which must accompany these television transmissions also require a definite channel, and they are distinct and separate from the picture channels. A typical case outlined by Beers states that the tuning range of the picture receiver was limited to 35-to-55 mc. and the sound receiver from 55-to-75 mc. Aside from the frequency differences in each channel, the main point is that two complete channels are required for the picture and the sound.

Cathode-Ray Tube

There seems to be little doubt that the cathode-ray tube will play an important rôle in the commercial television receiver. This tube not only obviates the necessity for a cumbersome rotating disc and allows of convenient mechanical design, but also permits automatic synchronization between the transmitter and the receiver. As stated previously, motion pictures will undoubtedly be transmitted by television stations. In the transmitter itself the scanning system must cover the picture completely for every frame transmitted. Since ordinary motion picture film now in use requires the passage of 24 frames per second for a good image, it is quite clear that the beam in the cathode ray tube in the receiver must not only follow the individual scanning of the elements of each frame, but at the same time must keep in synchronism with each change of picture frame. In other words, there must be a synchronizing system to provide for the lining up of each horizontal line during the scanning of each frame and another synchronizing system for the lining up of each frame. These synchronizing signals are sent out by the transmitter in the form of impulses which are picked up by the receiver and are utilized so as to give automatic synchronization.

Synchronizing Problems

In a 120-line scanning system, therefore, one impulse is required at the end of each line. Furthermore, if there are 24 frames per second, the frequency of the picture synchronizing signal is 120 x 24, or 2,880 impulses per second. The vertical synchronizing signal, which automatically keeps the picture in frame, requires 24 impulses per second, since each impulse is necessary for each picture frame.

An important point arises here. It might seem that the synchronizing signals would cause distortion of the signal, and this would be so were it not for a very ingenious solution devised by engineers of the RCA Victor Co. This solution makes use of the fact that although the beam at the transmitter can return to its starting position after each line in almost zero time, the cathode ray beam at the receiver actually requires time. In fact, 10 per cent of the picture to be transmitted must be added to the time of scanning at the transmitter in order to allow sufficient time for the cathode-ray beam at the receiver to return to its starting position. In other words, during 10 per cent of the time that the transmitter is in operation, no picture is being scanned. It is during this small interval of time that the synchronizing signals are "sneaked" in.

Although many of these technical considerations are of importance only to the design engineer, nevertheless they do point out very definitely that many of the old difficulties which hampered commercial television have been solved very satisfactorily.

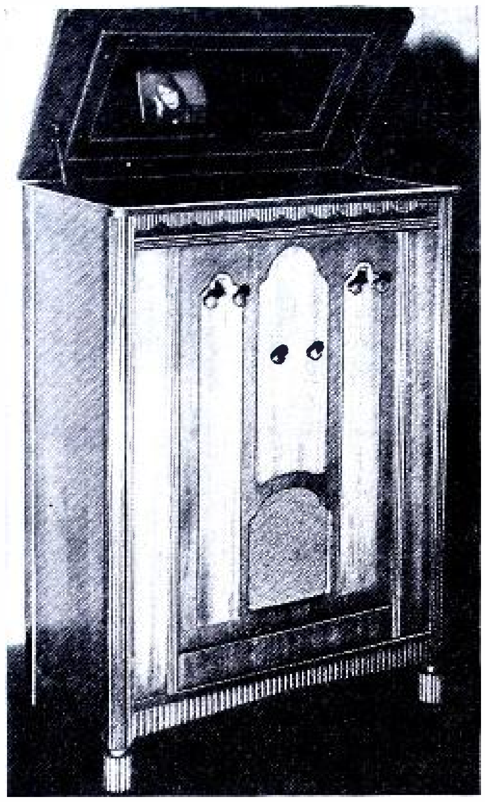
RCA's Work

In the December, 1933, issue of the PROCEEDINGS OF THE INSTITUTE OF RADIO ENGINEERS a comprehensive description of experimental television receivers is given. In this description, G. L. Beers points out that the superheterodyne circuit was selected for the receiver. The design of this circuit is such as to provide flat-top response in both the r.f. and i.f. circuits. An important point is noted in connection with the design of the i.f. transformers which is well worthy of consideration. These i.f. transformers have a response curve which is much wider than ordinarily required, in order to provide ample response when the oscillator changes frequency because of temperature changes, variations in tube capacity, etc. The entire receiver is completely shielded in every respect and it would be extremely difficult for the layman to tell the difference between it and his own broadcast set. The audio amplifiers used in these receivers are practically flat from 20 cycles to about 400,000 cycles per second. This amplifier, of course, is used in the picture receiver; the one used for the reception of the musical accompaniment has the usual flat characteristic between about 100 and 4,000 cycles.

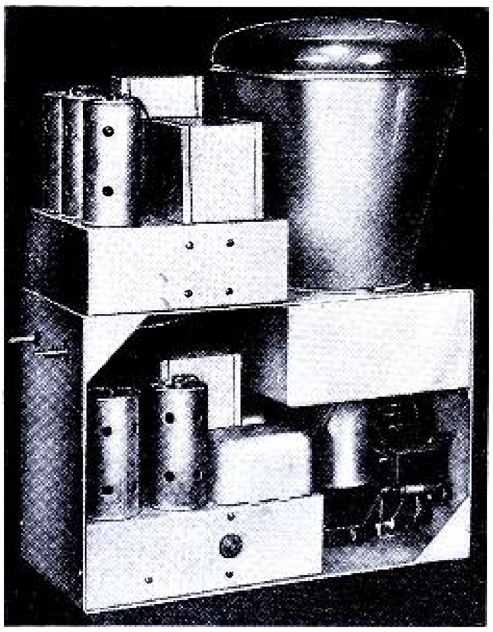
In many of the tests conducted by the RCA Victor Co. atop the Empire State Building in New York, it was found that the only form of interference originated from ignition systems of airplanes and automobiles; otherwise, reception was practically perfect. A very peculiar effect was noted in connection with this interference. It was found that if it was strong enough, it actually threw the system out of synchronism! The effect, therefore, was somewhat similar to the early days of sound pictures when the voice either preceded or followed the picture slightly.

Of course, much work must yet be accomplished. For instance, at the present time there is no adequate standardization by which television receiver performance can be measured. As pointed out by E. W. Engstrom, "Expression of the degree of satisfaction provided by a television image has been bounded on the one hand by the optimism or the conservatism of the observer, and on the other hand by the practical limitations which prevent, for the moment, an increase of picture details, picture steadiness, picture illumination, picture contrast——"

The purpose of this article is not to emphasize the fact that television receivers are ready for distribution to impatient customers, but rather to point out in a general way the advances that have been made and to show that it is not unreasonable to suppose that we can really expect television in the near future. How near that "near" is, is something we cannot venture to guess.



Photograph of a completed experimental television receiver built by the RCA Victor Co., for experimental purposes. This receiver contains a power unit, a cathode ray television tube unit, two receivers—one for pictures and one for sound signals—and a loudspeaker.



Arrangement of the television receiver built for special tests by the RCA Victor Co. One of the most encouraging things about this receiver is its resemblance to a modern broadcast receiver. How far off is commercial television?

Need for Standardization

There is need for standardization of performance of television receivers, just as there are standards by which broadcast receivers are measured. In the broadcast receiver, sensitivity, selectivity, and fidelity are definitely measurable by standard tests, so that an intelligent comparison between competitive sets may be made. However, these tests have a significance only to engineers versed in radio terminology, and serve a highly useful purpose.

The problem in television is a bit different. The same three characteristics may be used, but there is need for additional standards to take care of the scanning system. There seems to be little doubt that the three previously-mentioned characteristics will be measured under static conditions—without the scanning system, so that for real, overall performance the scanning system must be included as part of the test, regardless of whether this system uses a cathode-ray tube or a disc.

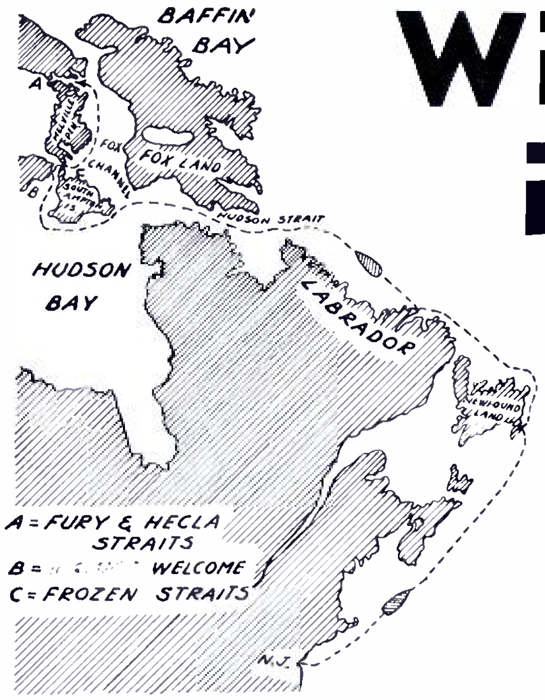
But here is where the trouble arises. The "goodness" of a television system may be arbitrarily defined as the quantity of information contained per unit area of the picture; so that if the scanning system is to be included in the test, some measure of the quantity of information contained in the image must be devised. This, it seems to us, is one of the first problems to be tackled by television standardization committees.

Merely saying that the detail looks good or looks bad is qualitative, and depends to a large extent upon the training of the observer and the acuteness of his vision. A comparison between a standard image and the image obtained from the receiver must be interpreted quantitatively.

Until such standardization is realized—and it may be long after television is accepted by the public—radio stores selling different television receiver would do well to use the same image for all the sets, so that a prospective purchaser may choose a receiver giving detail suitable to him.

What Price Television

Every time a layman talks about television, he mentions price. "What will the first models sell for?" he asks. The answer is usually a shrug of the shoulders and a sly attempt to change the topic. From the standpoint of economics, the price must be what the public is willing to pay. Between fifty and one-hundred dollars is our guess, for a medium quality receiver. Remember, television-receiver manufacturers are—or, rather, will be—in business to make money.



With Bob Bartlett in the Uncharted Arctic Regions

This article describes for the first time the radio aspects of the latest Arctic adventure of the famous captain of the "S. S. Morrissey" and his party of scientific specialists, who made many interesting discoveries.

By Lewis Winner

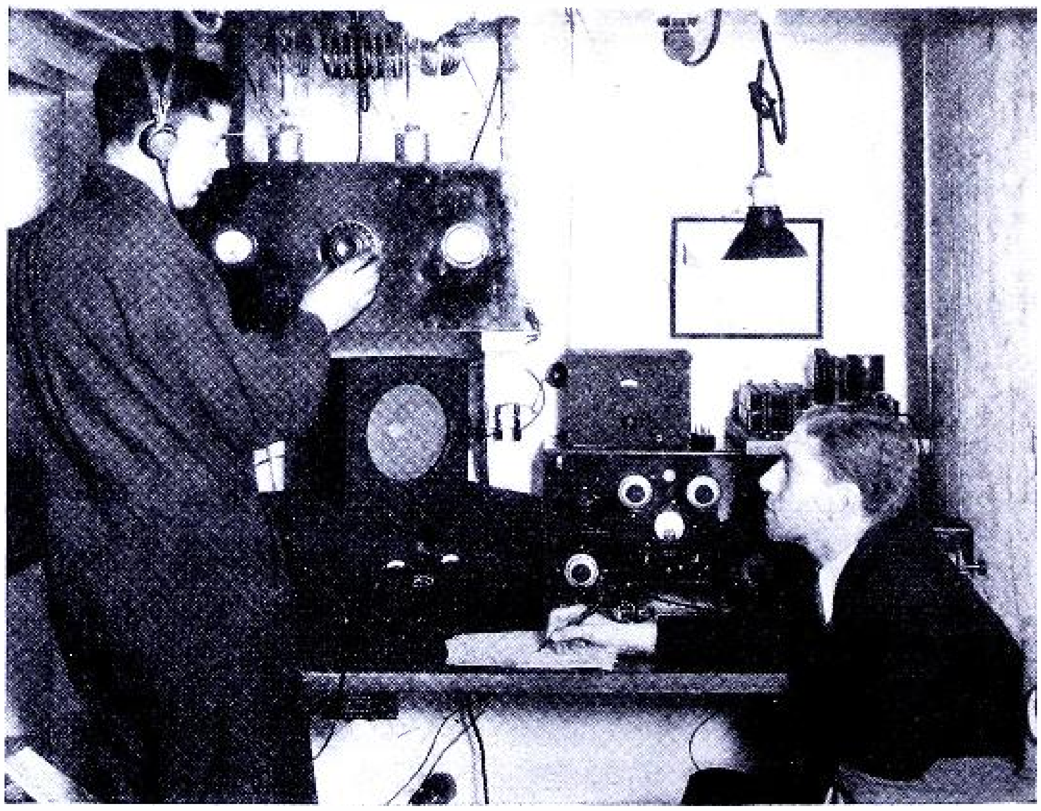
ON June eighteenth, 1933, at 8 a. m., the *S.S. Morrissey*, historic 100-foot exploration schooner captained by R. A. (Bob) Bartlett of Peary fame, slipped her moorings in the MacWilliams Shipyards, Port Richmond, Staten Island, and set sail on a three-month trek to an Arctic region, unvisited by man since 1823, to re-chart this area and engage in other scientific research. The multitude of discoveries made by Captain Bartlett and his scientific specialists is stirring, especially those concerning radio.

To acquaint you with the type of persons engaged in this expedition, I have noted them herewith with a brief explanation as to their work. Professor Jack Angel of McGill University of Montreal, topographical genius, mapped out a section of the Arctic region heretofore uncharted. Strange and rare birds were brought back by Dr. Robert Dove of the Dalhassie University at Halifax. Ethnological discoveries were made by Junius Bird of Rye, New York, assisted by Bob Moe of Brooklyn, New York, who also acted as radio operator and correspondingly made some unusual findings with which we shall concern ourselves shortly. A. D. Norcross, New York sportsman, who has gone along with Captain Bartlett for years on these Arctic trips, also made major discoveries. A photographic study of the entire voyage was made by Pyrman Smith of Pathé News.

Call Letters VOQH

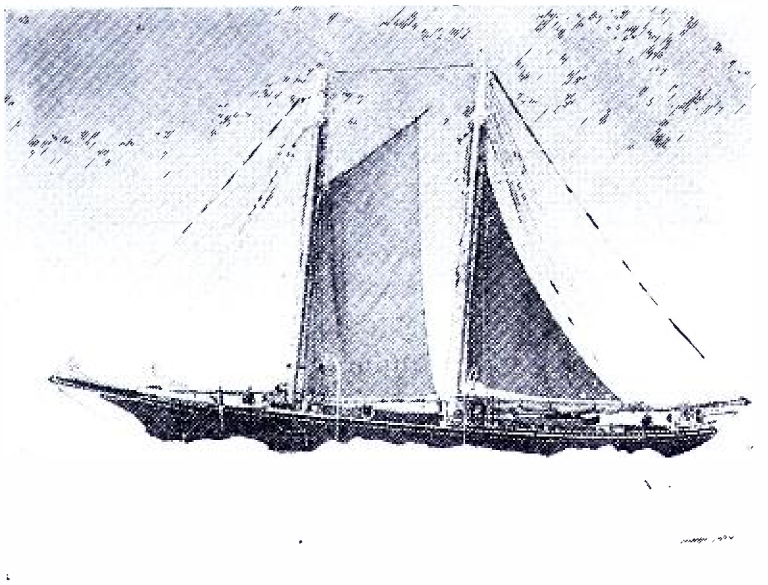
As stated, Bob Moe, who operates station W2UN in New York, operated the *Morrissey* radio station, which had the call letters VOQH. A veteran operator assisted by precision equipment, Mr. Moe was able to collate the most comprehensive and interesting data I have ever studied on reception in the Arctic regions, especially during the summer months. So that you may have as accurate a picture as possible of the conditions which existed during this trip, I will take you, graphically, of course, along the route of the *Morrissey*.

From New York the *Morrissey* went to Brigus, New Foundland, where she spent about a week, held up by bad weather. A few miles each day were covered until Hopedale, Labrador, was reached. The *Morrissey* then went south-west to Turnavick, a fishing station on the old Bartlett family island. She continued north, still making slow progress because of the long nights, which necessitated the ship being tied to ice pans. These pans consisted of solid ice in combination with large chunks of broken up ice. The *Morrissey* continued through the Hudson Straits, where the ice again held up the party. Bad currents also delayed the voyage. After breaking out of the ice, she proceeded to South Hampton Island, through Sir Thomas Rowes Welcome into the Fox Channel. She then made her way to the Fox Basin, where the ship was frozen in for three weeks. After the ice loosened up, the *Morrissey* proceeded northwest to White Island, and finally up to Fury and Hecla Straits, the point of destination. Fury and Hecla represent the names of two boats which went up to this region during 1821 to 1823 looking for the Northwest passage. These ships were commanded by Parry and Lyon, who spent the winter in these parts. The anchoring of the *Morrissey* in this part represented the first time this had been done since 1823. This is the area



The radio "shack" of the S. S. Morrissey. Operator Moe is at the left, tuning the short-wave transmitter; the author of this article is at the right. Under the transmitter is the Hammarlund Pro short-wave receiver; to the right is an old Kennedy long-wave set.

Capt. Bob Bartlett and A. D. Norcross (with the glasses) in the chart room of the S. S. Morrissey, plotting the schooner's position.



The picturesque S. S. Morrissey under sail in Arctic waters. This picture was taken shortly before the vessel was frozen into the ice.

that Captain Bartlett went up to re-chart.

The *Morrissey* was again iced in here for three more weeks. After the ice broke up she retraced her steps back home, making only one exception and that being that she went about in the opposite direction around South Hampton Island.

We shall now concern ourselves with the equipment used in the radio room. The transmitter used consisted of two 204A tubes in push-pull, self excited with a tuned grid, tuned plate circuit. Power was supplied by a bank of 110-volt Exide batteries which turned a generator and fed a step-up transformer to supply 3000 volts to the tubes. The 7500-kc. and 14,128-kc. channels were used. The antenna used was the Zeppelin feed type, seventy-five feet long outside.

The receiver used was a Hammarlund battery type high-frequency model known as the "Pro." There are seven tubes in this model. Two type 78 tubes are used in "air-tuned" i.f. channels, and two 78 tubes are used as electron coupled oscillators, (one is a standard oscillator in the input, and the other is a high-frequency oscillator for c.w. work and also for locating phone stations). Two 77 tubes are used as detectors and a 42 is used in the audio side. The precision design of this receiver provided consistent reception regardless of the conditions which were met, providing world-wide contact at all times, which certainly was important.

Through the efforts of the *New York Times* and W2KJ, an amateur station owned by J. and S. A. Ross of Brooklyn, New York, the contacts were accomplished.

The 40-meter channel was used for receiving and transmitting approximately as far up as Fox Channel. This frequency provided excellent results.

The following, told to me by Mr. Moe and taken from his log book, will indicate more accurately what results were obtained.

"July 20th to August 14th. The West Coast stations came in best from midnight on. New York was poor. In the earlier part of the evening, however, New York started to come in satisfactorily.

"When Fox Channel was reached, the 40-meter channel became useless. I then had to shift to the 20-meter band, which provided excellent results.

"Incidentally, while in Labrador W8XK, the Pittsburgh relay broadcasting station on 17 meters, was heard consistently supplying us with very interesting news bulletins.

"On the 20-meter band, in Fox Channel, I contacted 4's, 5's and 6's with ease. As we went further north off White Island, I was able to contact 2's, 3's, 5's 7's and 9's, but no 6's. The Canadian stations came in exceedingly well.

"As we proceeded to a northerly area, (August 26th), only the 1's, 2's, 8's and 9's were contacted. Beginning September 7th, the 2's and 1's died out completely. I could only hear the North and Middle West—Cleveland to Minneapolis and Kentucky on the south. At this time the *Morrissey* was at the entrance to the most northern point, or at Fury and Hecla Straits."

The expedition started on the return voyage on September 8th. All but the 2's began coming back on 20 meters. In fact, in order to get messages to New York they had to be relayed through Ann Arbor, Michigan. Mr. Moe kept to the 20-meter schedule until September 20th, when he reached Labrador again.

The 40-meter channel was then again put into use. Even at this

(*Continued on page* 42)

A. D. Norcross in a native "cayuk" or canoe. This is a light affair that can be readily manipulated through the treacherous ice floes. The members of the expedition became quite adept at handling these.

Operator Moe entertains some company with musical programs picked up by means of the short-wave receiver. The natives appear to be greatly amused.

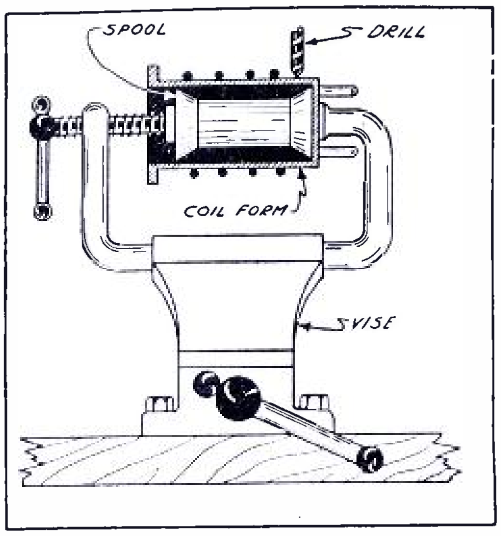
Short Wave Short Cuts

PRIZE WINNER

Drilling Tube Bases

By Donald Bottolfson

EVERY short-wave experimenter who attempts to wind coils on burned out tube bases has had the experience of the molded composition breaking in the vise. This trouble can be overcome by using the scheme shown in the diagram. Simply insert a common spool in the tube base to be drilled and fasten it tightly with a small clamp. Then insert the clamp in the vise and you have a very solid base for drilling.

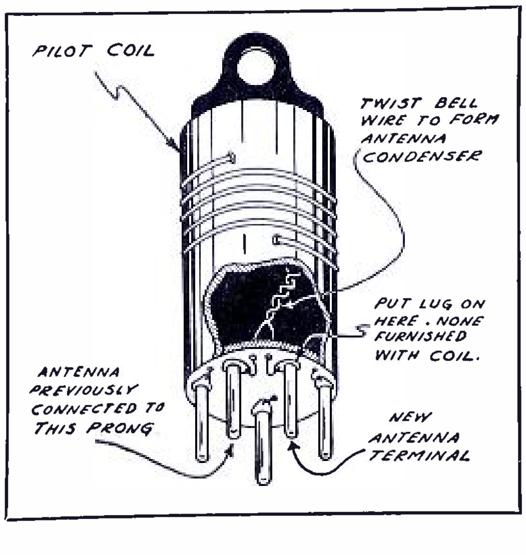


Automatic Antenna Adjustment

By Arthur Darling

IT has become quite common practice to employ one series antenna condenser which, in some cases, necessitates adjustment every time a coil is changed. It is not necessary to tolerate these adjustments if five-pin coils are used.

A short piece of bell wire is soldered to the unused coil pin. Another piece of bell wire is soldered to the grid end of the grid coil. The antenna wire then connects to the fifth or extra pin. A few twists are made in the bell wire. After the coil is placed in circuit, the twists are varied until dead spots are removed from the dial.



If one such condenser is used with each coil, it is evident that condenser adjustment becomes automatic with the insertion of each coil.

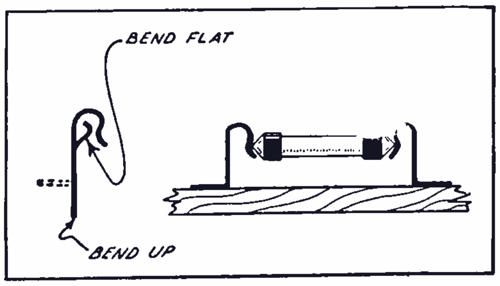
Reducing Insulator Capacity

The capacity effect between the ends of small aerial insulators, while not important at low broadcast frequencies, becomes appreciable on the very high frequencies (short waves). Since a number of small insulators is usually cheaper than a single long one, it is a good idea to use two or three in a row, joined by short pieces of wire. The overall capacity effect is thus lowered considerably.

Grid Leak Clips

By Geo. Donald Hendricks

TWO Fahnestock spring binding posts salvaged from old "B" batteries may be made into an excellent grid leak holder, as shown in the sketch. Bend down the part of the spring marked "A", then bend up the body of the post to form an "L" shaped support. Mount the two clips the desired distance apart by means of wood or machine screws. This same mounting is also very convenient for supporting small radio frequency chokes which are wound on forms resembling grid leaks.



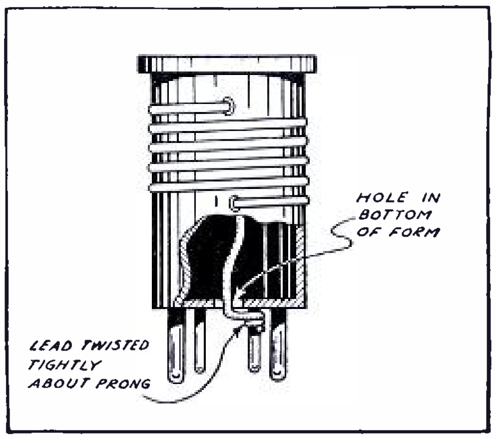
Tracing Noise

BEFORE condemning a receiver for being noisy, make sure that the noise is in the set, and is not due to outside disturbances. Disconnect the aerial and ground, turn up the volume control to maximum, and listen. The set may be surprisingly quiet. If it is, the noise obviously is external and you can do nothing about it, except to try an isolated antenna with a good transposed feeder lead-in.

Indoor Aerials

It is just as important to insulate an indoor aerial as an outdoor one. However, the insulators need not be as heavy, as they carry comparatively little strain and are not subject to rain and snow. Long pieces of bakelite or isolantite, taken from old variable condensers, make good insulators for the purpose, as they are light and thin and have excellent dielectric properties.

Incidently, it makes no difference whether the wire is insulated or not. Any size between No. 20 and No. 14 is OK.



Temporary Coil Connections

By Bob Hunteman

IT is very irritating to have wound a short-wave coil on a standard form and have all leads nicely soldered to the prongs only to find you could have put on one more turn or one less turn on the tickler coil.

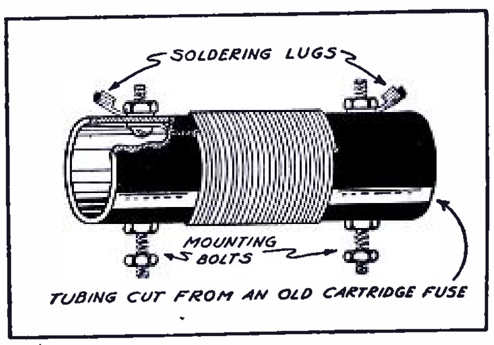
By merely bringing the leads through a hole (already in some forms) punched or drilled in the bottom of the coil forms, the leads can be twisted tightly and compactly around the outside of the prongs, a few turns forming a good connection, and the coils may be used in a conventional tube socket and tried in the set. When the coil has proven correctly wound, the leads may then be soldered in the conventional way.

Using Old Cartridge Fuses

By Robert A. Binkey

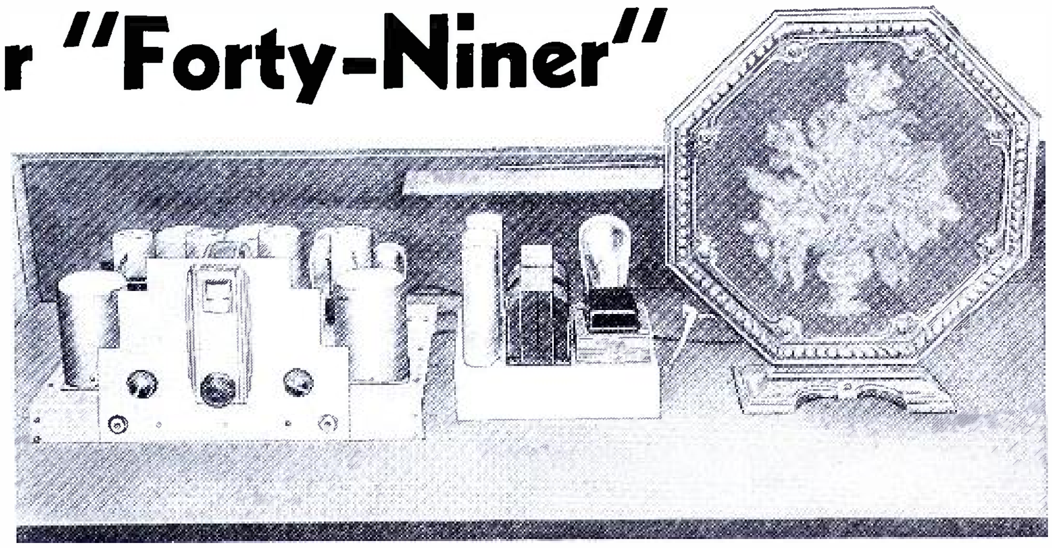
BURNED out fuses of the cartridge type make excellent forms for short-wave radio-frequency choke coils. The tubing is usually of fibre or some other composition and is a good insulator.

Of course, the inside of the fuse should be cleaned out, and the metal end caps removed. The ends of the tubing may be drilled to take terminal and mounting bolts, or one of the metal end caps may be drilled to accommodate a single mounting screw. The choke may thus be mounted in a vertical position.



The Worcester "Forty-Niner"

Summary: *Here is a description of a novel receiver designed exclusively for broadcast reception in the 49-meter band. It has no switches, plug-in coils, or interchangeable drawers, since it covers only the one band. You merely flip the switch and tune, exactly as in a conventional broadcast receiver.*



The specialized receiver, the power unit, and a loudspeaker, ready to go.

By J. A. Worcester, Jr.

THERE are undoubtedly many readers of this magazine who find no appreciable entertainment value in the various amateur, airport, police and commercial phone bands and are interested only in short-wave broadcast reception. For these readers the receiver described in this article, designed for exclusive reception in the 49-meter broadcast band, is presented. This band embraces many of the most important U. S. and Canadian stations, as well as important stations in South America, Europe and Africa, and for all-around results is considered superior to the 25- and 19-meter bands.

Choosing a Circuit

The choice of a suitable circuit for this purpose presented something of a problem. The superheterodyne was soon dismissed because of its high cost and complicated construction. The conventional radio frequency, regenerative detector circuit was finally adopted as combining most satisfactorily the requirements of ease of construction, low cost and low noise level.

Since the frequency band covered by this receiver extends only from 5.5 to 6.5 megacycles (46.15-54.55 meters), it is entirely feasible to employ untuned r.f. transformers in the form of closely coupled tuned circuits with a coefficient of coupling just sufficient to provide satisfactory amplication of the above band. Two stages of this type of amplification are included with an individual gain control so that the overall amplification can be advanced to the maximum value consistent with satisfactory "apparent selectivity" and noise level.

There are numerous advantages which result from covering a comparatively narrow band of frequencies to the exclusion of others. For one thing, it is possible to design an antenna system of the correct dimensions to give maximum results at the band employed. This procedure also eliminates any possibility of "dead spots." There is also an economic consideration, since for any given receiver sensitivity, it is cheaper to build a receiver to cover a narrow band of frequencies than one to cover the whole short-wave range. Finally, tuning is much simpler than with the usual short-wave receiver; in fact, it is no more difficult than an ordinary broadcast set.

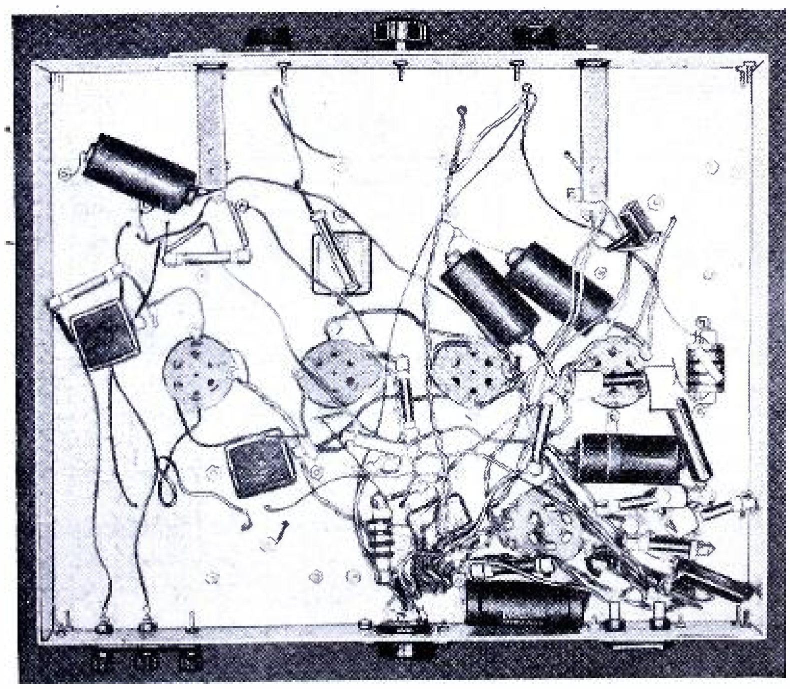
The appearance of the completed receiver as well as the location of the various parts can be noted from the photographs. As can be seen, the receiver looks more like a modern broadcast receiver than the customary short-wave set.

The circuit, as shown in Fig. 1, consists of a tuned input, followed by two untuned radio frequency stages feeding into a third tuned detector stage. The detector is regenerative and is followed by two stages of resistance coupled a.f. amplification. The tubes employed are 58's in the r.f. amplifier stages, V1, V2, V3, a 57 detector, V4, and a 56, V5, and a 2A5, V6, in the audio frequency amplifier.

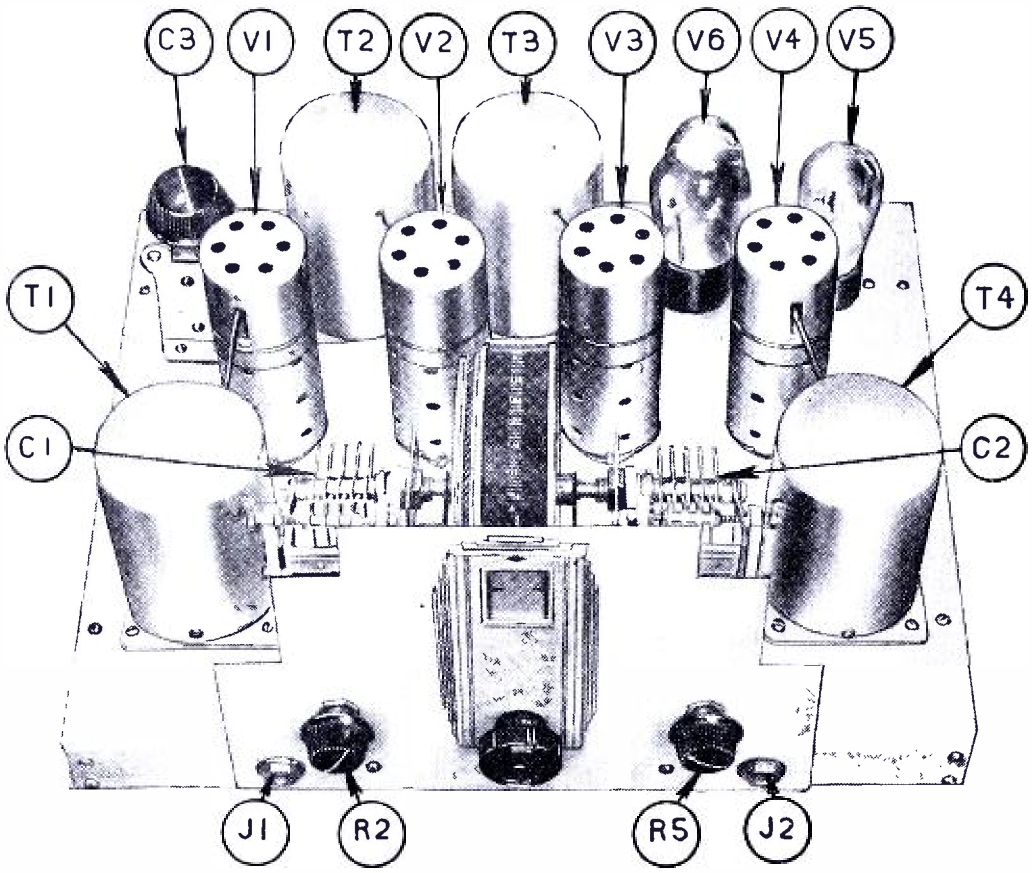
Unusual Features

The following features may be worthy of comment. The antenna input is designed for use with a doublet antenna. The two tuned circuits, which are ganged together, are lined up by means of the 20-mmf. Hammarlund condenser C3 in parallel with the winding L1. The bias on the first r.f. tube is fixed so that the first r.f. stage gives maximum amplification at all times. This results in a higher signal-to-noise ratio than would be obtained if the bias of this tube varied with the two succeeding stages. The amplification of the two untuned stages is varied by means of a variable resistor, R2, in the cathode circuit.

In order to prevent possible oscillation in the r.f. amplifier, the screen grid and plate circuit returns should be made exactly as indicated in the diagram. For instance, the three screen leads are brought to a common junction which is bypassed to ground by the condenser C5. In order to prevent common coupling, the condenser should be connected directly to the junction point of these three leads. The same procedure should be followed when bypassing the plate and cathode returns. Regeneration is controlled in the usual manner by varying the screen grid voltage by means of the potentiometer, R5. In order to prevent "motor boating" in the a.f.



Under-view of the receiver. None of the parts is labeled, since their placement may be easily determined while wiring the receiver. Each of them is connected as close to its respective destination as possible. Although the wiring looks a bit "messy," the receiver works to perfection, and should find much favor among those listeners who fear the complexities of interchangeable coils.



Top view of the receiver which clearly shows all the major items used.

amplifier, decoupling resistors R7 and R11 in conjunction with condensers C11 and C14 are employed.

When building the set it is first necessary to procure the panel and chassis, which can be bought ready made if desired. The panel is made from 1/16″ aluminum sheet 7″ x 9″; the subpanel, also of aluminum, has dimensions of 11″ x 14″ x 1½″. The location of the various parts can easily be noted from the photographs. The drum dial, potentiometers, and phone jacks are mounted on the front panel. On top of the subpanel are mounted the tuning condenser C1, C2, the Hammarlund trimmer C3 and the coils. The tuning condensers are mounted by aluminum brackets 3½″ high and 1½″ wide. The trimmer is also mounted on an aluminum bracket 1¾″ high by 1¼″ wide.

At the rear of the subpanel are mounted the five-prong Connectorald socket, the triple binding post assembly and the twin speaker jack.

Underneath the chassis are mounted the sockets, chokes, condensers, and resistors. The condensers and resistors are mounted directly by their pigtails, as is also the National choke.

Coil Data

The coils are, of course, the heart of this set and should be constructed carefully. Unless facilities are available for spacing turns accurately, it would probably be preferable to buy these coils ready made.

The tuned input and detector coils, T1, T4, are identical, as are also the two untuned transformers, T2, T3. Since the latter are the simplest to make, their construction will be discussed first. All the coils are wound on 1″ diameter bakelite forms 3″ long. Windings L4 and L5 each consist of 43 turns of No. 24 D.S.C. wire wound without spacing. The windings are separated by 1/16″ and are in the same direction. The outside lead of L4 goes to the plate and of L5 to the grid. The finished coil is mounted in the National coil shield by means of a ¾″ double angle. Coil T3 is identical in construction.

The input coil, T1, consists of three windings L1, L2 and L3. Winding L2 consists of 40 turns of No. 26 D.S.C. wound 30 pitch. The outside lead of this winding goes to the grid. Interwound with this winding, starting from the grounded end, is L1, which consists of 26 turns of No. 35 D.S.C. Winding L3 consists of 8 turns of No. 35 D.S.C. close wound. This winding is wound in the same direction as L2 and is separated about ¼″ from the grounded end of same. The outside lead of this winding goes to the plate. Coils L8, L9, L10 are identical in construction except that a grid leak and grid condenser are contained in the shield can. In order to prevent possible grounds, the inner container of the shield is lined with light cardboard.

For best results on the 49-meter band a doublet 78 feet in length should be used. The writer employed the Lynch short-wave kit with entire satisfaction. Although it is possible to use an ordinary antenna by grounding one of the extra terminals, it is almost foolish not to take advantage of the benefits to be derived from the use of a doublet having the correct dimensions.

The only adjustment necessary is the lining up of the two tuned stages by means of the trimmer C3. This is adjusted until the background hiss or the volume of a weak signal is a maximum.

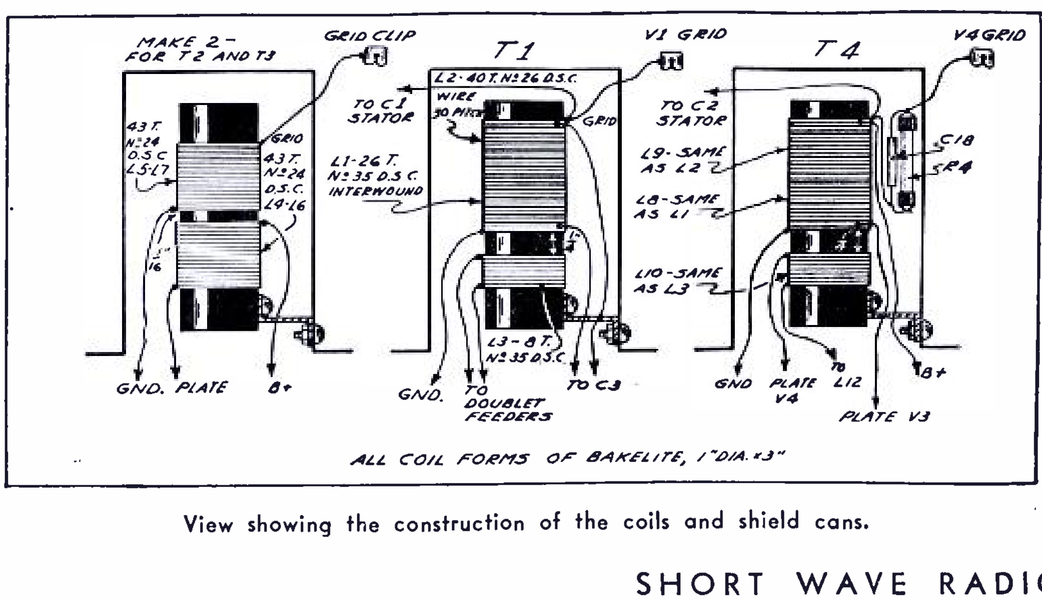
Results Obtained

As to results obtained, the writer during a month of testing has received GSA, DJC, RV59 and OXY in Europe, as well as nearly all the American, Canadian, and South American stations listed in this band. All these stations were received with satisfactory loudspeaker volume. RV59 in Moscow is a particularly interesting station in that it is possible to get the schedule from week to week from a rather extensive talk in English given during each broadcast. By following the schedule it is possible to receive this station consistently.

At the low frequency (high wavelength) end of the dial it is possible to receive 54-meter airport stations. Harmonics of broadcast stations are quite plentiful in this band also, as are third harmonics of 160-meter phone amateurs.

Parts Required

T1, T4—Tuned r.f. transformers. See text.
T2, T3—Untuned r.f. transformers. See text.
C1, C2—National SEU—25 variable condensers, 25 mmf., one clockwise rotation; one counter-clockwise.
C3—Hammarlund 20-mmf. variable condenser, MC-20-S.
C4, C6—Polymet .01-mf. molded mica condenser.



View showing the construction of the coils and shield cans.

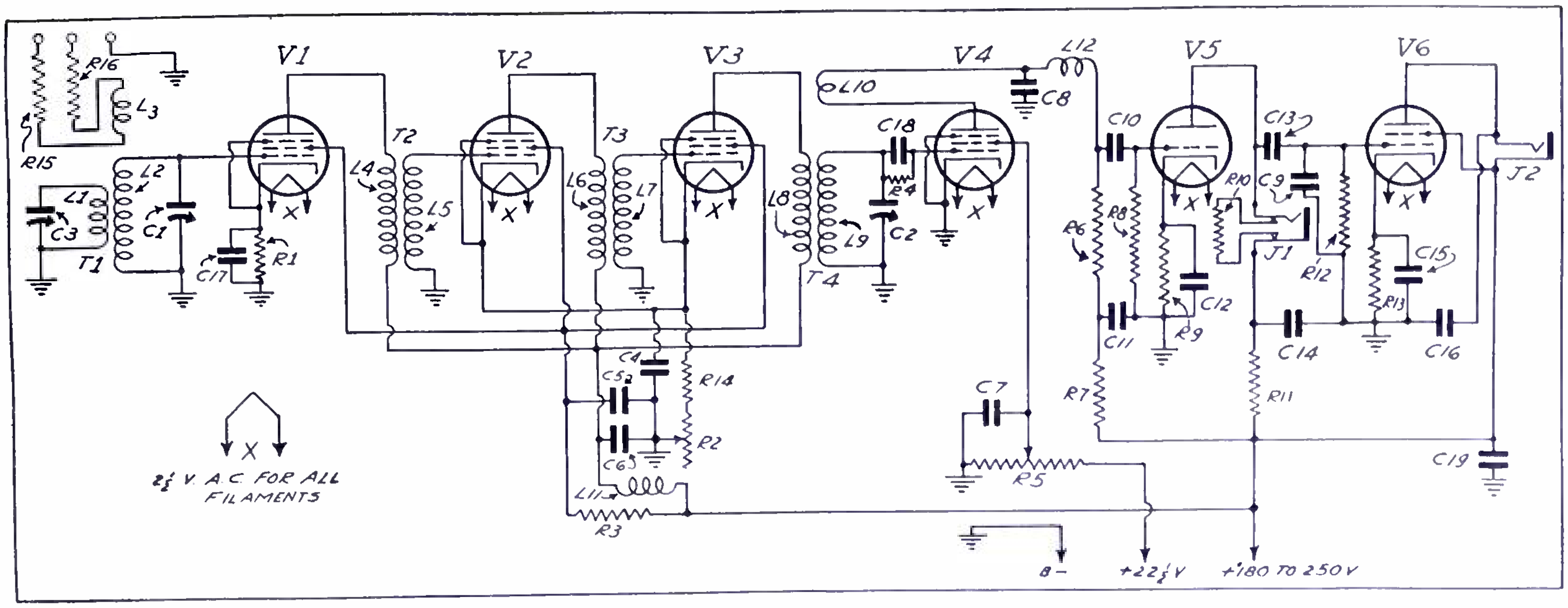


Fig. 1—Schematic circuit and List of Parts of the specialized 49-meter broadcast receiver. Its simplicity is evident.

C5, C17—Polymet .005-mf. molded mica condenser.
C7, C11, C14—Cornell-Dubilier .5-mf. cartridge condenser, 400 d.c. w.v.
C12, C19—Cornell-Dubilier .2—.2 dual cartridge condenser, 400 d.c. w.v.
C10, C13—Cornell-Dubilier .01-mf. cartridge condenser 400 d.c.w.v.
C8, C9—Solar .0005-mf. molded mica condensers.
C15—Aerovox 25-mf. dry electrolytic tubular condenser, 25 d.c. w.v.
C16—Aerovox, .004-mf. molded mica condenser.
C18—Solar .0001-mf. molded mica condenser.
R1—Lynch 500-ohm metallized pigtail resistor.
R2, R5—Centralab "Elf" 50,000-ohm potentiometers.
R3, R11—Lynch 50,000-ohm metallized pigtail resistors.
R4—Lynch 3-meg. metallized grid leak.
R6, R8, R10, R12—Lynch 250,000-ohm metallized pigtail resistors.
R7—Lynch 2000-ohm metallized resistor.
R11—Lynch 100,000-ohm metallized resistor.
R13—Lynch 400-ohm metallized resistor.
R14—Lynch 250-ohm metallized resistor.
R15, R16—Lynch 150-ohm metallized resistor.
L12—Hammarlund Isolantite r.f. choke, CH-8, 8 millihenries.
L11—National Isolantite r.f. choke type 100, 2.5 millihenries.
1—National type VHCE drum dial.
4—National type J-30 coils shields.
4—National type 24 grid clips.
4—Hammarlund type TS-50 tube shields.
3—type 58 tube.
1—type 57 tube.
1—type 56 tube.
1—type 2A5 tube.
5—Eby six-prong laminated wafer sockets.
1—Eby five-prong laminated wafer socket.
1—Double circuit jack.
1—Single circuit jack.
1—Eby triple binding post assembly.
1—Eby molded speaker jack.
1—Alden five-prong battery connector and socket.
1—9" x 7" aluminum front panel.
1—11" x 14" x 1½" aluminum subpanel.
1—Lynch short-wave antenna kit.

Some Unique Tube Characteristics

UNTIL the advent of the graphite anode, the distinguishing mark of a thoroughly evacuated transmitting tube was a glass envelope with silvery deposits over more or less of its inside surface. The latest graphite anode tubes, however, are crystal clear. No deposits are in evidence. An explanation is in order, and it is forthcoming from Victor O. Allen, Assistant Chief Engineer of the Electronics Division of Hygrade Sylvania Corporation, under whose guidance the graphite anode was recently perfected.

"Gas, the arch enemy of tube operation and life, now has a keeper as well as a getter," states Mr. Allen. "For years past plenty has been said regarding getters which, during the pumping out of a tube, act as a chemical broom in sweeping up the gases driven out of metal pores by the bombardment heat. Were it not for the use of some sort of getter, the pumping time would have to be increased many times, and in the case of the large transmitting tubes, this operation might prove entirely impractical, especially from the economic standpoint. Hence the use of getters. Also the fact that we have been taught to look for that silver lining as a badge of good tube housekeeping.

"It is usually the practice to leave some of the getter material, usually magnesium, barium or the like, in the tube to absorb further amounts of gases which are released from the tube elements during their operation, particularly during heavy overloads. The getter then becomes a keeper, as it were, being charged with absorbing further gases and maintaining the high vacuum essential for proper operation.

"In our own transmitting tube activities we have found that by treating the graphite anode properly during exhaust, it becomes a sponge for those gases released during the life of the tube. This sponge or keeper action of graphite is most pronounced, so that we find it no longer necessary to employ a deposit material on the glass envelope of our tubes to serve as keeper. Our graphite anode tube envelopes are crystal clear, without deposit of any kind. This feature is advantageous, as there is no possibility of the getter-keeper material—in this case the solid, one-piece graphite anode, free from impurities and amorphous carbon or surface carbon dust—getting on insulation between tube elements to cause disastrous leakage effects and reducing heat radiation through the glass envelope."

(See the Jan. '34 issue—*Tech. Div.*)

MANY inquiries are received relative to the blue glow which is present in a number of tubes. Most of these inquiries are based on the misunderstanding of the different types of glow that may be present in a tube. There are three different types of blue haze that may appear while tubes are in operation: Fluorescent glow; mercury-vapor haze and gas.

The fluorescent glow is usually of violet color, and is noticeable around the inside surface of the glass bulb. This glow is a phenomenon caused by electronic bombardment taking place within the tube. This glow changes with the intensity of the signal and may at times become quite brilliant. Fluorescent glow has absolutely no effect on the operation of a receiver. In fact, tubes with this characteristic are particularly good as regards gas content.

Mercury-vapor haze is a blue glow which is noticeable between the plate and filament in types 82 and 83 rectifier tubes. These are the only types of receiving tubes in which this type of haze appears. The perfect operation of the types 82 and 83 is dependent upon a mercury vapor which comes from free mercury that has been placed in the bulb during

(*Continued on page 43*)

How Radio Receiver Sensitivity Is Rated

SUMMARY: *One of the most confusing things radio fans have had to contend with is the matter of rating receiver sensitivity. To say a set has an amplification of so-many "times" is pretty meaningless, because the theoretical amplification some circuits are supposed to possess is rarely achieved in actual practice. To simplify things, engineers have agreed on a standard means of determining over-all receiver performance, and this is described in the article below.*

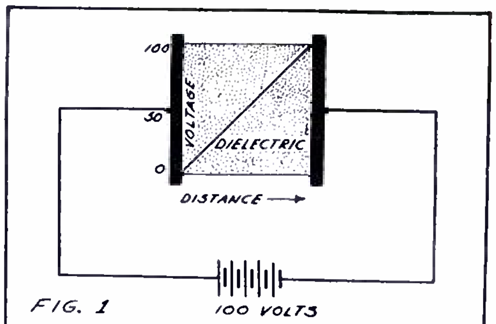


FIG. 1

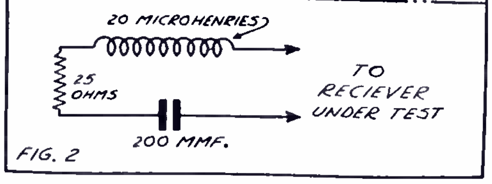


FIG. 2

THE invasion of all-wave receivers into the short-wave field has been accompanied by a host of technical terms which although old to the broadcast radio man, are relatively new to the short-wave fan. Many of the new-fangled ideas incorporated in the costlier short-wave sets are already familiar to short-wave listeners; but many technical terms of extreme importance are little understood by the average listener, who is forced to wade through them when attempting to justify the purchase of a new receiver. It is the purpose of this discussion to explain accurately the technical meaning of several important terms used to compare radio receiver performance.

Microvolts Per Meter

The first, and probably the most confusing, term used in the comparison of radio-set performance is *microvolts per meter*. Furthermore, this term has a significance that is slightly different from what one would ordinarily think the higher the rating in microvolts per meter, the less sensitive the receiver! Let us start from scratch and see what this business is all about.

The one thing we all know is that radio waves are sent out by transmitters, and that these waves travel in all directions until they strike metal, or a conducting object, like an aerial; when this occurs, the aerial absorbs a bit of the energy from the wave, and the latter is converted into usable sound by the radio set and loudspeaker.

This radio wave may be thought of as being energy, and, furthermore, this energy may be thought of as continually changing, the rate of change being equal to the frequency of the wave. (Parenthetically, it may be mentioned that the radio wave may not only be *thought* of as energy—it *is* energy, just as heat is energy.) Now, electrical energy may exist in only two forms: electrostatic and magnetic, the former existing between the plates of a condenser when it is charged, and the latter surrounding a wire carrying current. A radio wave is composed of both types.

An important point arises here: per unit volume of the medium through which the wave travels, and at any instant, the amount of energy in magnetic form is exactly equal to the amount of energy in electrostatic form, so that the *total* energy of the radio wave at any instant is equal to twice the energy of either component. Furthermore, the amount of energy in either form varies continually, at the frequency of the currents generated at the transmitter. The picture to be formed, therefore, is that of a wave of two components, both equal in magnitude at any instant, and both varying in magnitude from zero to a maximum. When this wave strikes an antenna, a voltage is induced in the antenna, and it is this voltage which is amplified, rectified, and converted into sound by the loudspeaker. A good measure of the sensitivity of a receiver, therefore, is to determine what antenna voltage is required to deliver a *fixed* output. The greater the voltage required to deliver this fixed output, the less sensitive the receiver; conversely, the lower the voltage required for the fixed output, the more sensitive the receiver.

Measured At Antenna

The measurement of the sensitivity of a radio set, therefore, requires the measurement of the strength of the wave *at the receiving antenna*, and in order that everyone make the measurement in the same manner, a standardized procedure has been adopted. Since, as pointed out previously, the amounts of energy in the magnetic and electric fields are identical, it makes no difference which is chosen for the measurement. However, because the electrostatic component lends itself to measurement and standardization more readily than the magnetic component, it was picked for the job. Although it is realized that the total energy of the wave is twice that of the electric component alone, we need not worry, for the simple reason that we are not interested in the energy in the wave *per se*, but in the sensitivity of the receiver.

Now, the "fly in the ointment" regarding the measurement of the wave at the receiver is that the voltage induced in the receiving antenna is a function of the height of the antenna—the higher the antenna, the greater the voltage induced. In order to make the measurements standard for all types of antenna installations, the voltage induced in the antenna is specified "per unit height of the antenna." Since the wavelength is measured in meters, it is natural that the height of the antenna be measured in meters; furthermore, since the voltage induced in the aerial is measured in microvolts (the one-millionth part of the volt), the sensitivity of the receiver is specified in microvolts per meter, which means the number of microvolts per meter of height of the antenna.

The Electrostatic Component of the Wave

If a battery be connected across the terminals of a condenser, a current flows until the condenser is fully charged, at which time the voltage across the condenser is equal to that of the battery. Every condenser has a dielectric which is substantially homogeneous, so that the voltage drop in the dielectric from one plate to the other (in a two-plate condenser) is uniform, as shown in Fig. 1. Here the thickness of the dielectric has been exaggerated for simplicity; but the straight line shows that the voltage at any point in the dielectric, measured from the positive plate, depends directly upon the distance of that point from the positive plate. With a given dielectric, the potential is greater as the distance from the positive plate increases.

Few practical radio men realize that a receiving aerial is a condenser, the air between the wire or wires and the ground being the dielectric. Since the wave front of the radio wave is very high—much higher than the aerial—the potential of that place in space in which the aerial is located with respect to ground, is greater the greater the height of the aerial, just as in the case of the condenser cited in Fig 1. Hence, the electrostatic component of the wave affords a direct means of determining the voltage induced in an antenna system.

Microvolts Absolute

We have seen that the actual voltage induced in an aerial is dependent upon the strength of the wave and the height of the antenna in meters. When receivers are tested in the laboratory, where engineers have little or no knowledge of the type of antenna which will be used with the receiver in practice, some sort of a standard antenna must be devised so that no matter in what locality the engineering work is done, there will be a common basis for receiver rating. For this reason, the antenna circuit of the receiver under test in the laboratory is connected to a standard dummy antenna consisting of a 25-ohm resistor, a 20 microhenry inductor, and a 200 mmf. capacitor in series.

The voltage from the standard oscillator, modulated 30 per cent at a frequency of 400 cycles, is coupled to this dummy antenna, and the voltage required to maintain an output power of .05 watt (50 milliwatts) is measured. This power is to be consumed by a resistor of the same value as will be used by the output transformer and loudspeaker in practice. It is clear, then, that the greater the input voltage required to maintain the 50 milliwatts output, the less sensitive the receiver, and *vice versa*.

When the 50 milliwatts are obtained, the voltage in the dummy antenna (Fig. 2) is measured, and since it is usually in microvolts, it represents the sensitivity of the receiver in microvolts absolute.

Mechanical vs. Electrical Antenna Height

A man may erect an antenna 100 feet in the air, but because of surrounding objects and because of the presence of the masts, etc., the effective height—that height actually contributing to signal strength—may be only 25 feet. The actual physical height, therefore, is by no means the effective height. Engineers have made a very complete survey of the effective height of the average listener's antenna and have found it to be but 4 meters—about 13 feet!

The result, therefore, is interesting. If a manufacturer states the sensitivity of his receiver is microvolts absolute, then merely divide by 4 to obtain the sensitivity in microvolts per meter.

The absolute measurement is that actual voltage in the antenna circuit required for 50 milliwatts output, and is an excellent basis for receiver comparison because of the standardization of the dummy antenna; but microvolts per meter is useful when the real effective height is known from measurement.

by
Louis Martin

Byrd Expedition Notes

AT 10 p.m., E.S.T., on Saturday nights, the Columbia Broadcasting System has been rebroadcasting special programs originating on the *S. S. Jacob Ruppert*, Rear Admiral Richard E. Byrd's main supply vessel, while the latter has been on the high seas bound for Little America. These programs have been transmitted through KJTY, the short-wave transmitter on board the vessel. This same transmitter will be set up at the Expedition's permanent base, where it will again be used for regular relay broadcasting purposes. A complete description of this project appears on pages 4, 5, and 6 of the January, 1934 issue of SHORT WAVE RADIO.

In addition to the scheduled 10 o'clock rebroadcasts over the Columbia Broadcasting System's regular chain, KJTY has been running numerous tests, some of hours' duration, with New York. Edwin K. Cohan, Technical Director of CBS, has on occasion talked directly to John Dyer, KJTY engineer, merely by addressing a microphone in his office at 485 Madison Avenue, New York. His voice was transmitted through W2XBJ, one of the short-wave experimental telephone stations of RCA Communications, located at Rocky Point, L. I. On board the ship, Dyer picked up this station directly. However, the signals from KJTY were relayed to New York by way of either Buenos Aires, San Francisco, or Koko Head, Hawaii, again over the experimental radiophone facilities of RCA. Mr. Cohan has been able to hear KJTY directly, but for rebroadcasting purposes the relay system has been used.

Reception of KJTY's signals has invariably been accompanied by peculiar fading, swinging, and rushing sounds such as might be made by ocean waves. Many listeners have gotten the impression that the microphone is out on deck, and that KJTY is deliberately broadcasting the roar of the ocean. This, however, is not at all the case, as all the programs from KJTY originate in a sound-proof studio on board the ship. The irregularities in transmission are due, in most part, to the fact that the ship rolls a great deal in the heavy seas. When the transmitter is set up at its permanent base, this trouble undoubtedly will disappear.

Inasmuch as the KJTY transmitter is crystal-controlled and is highly stable, the shifting is not a frequency change, but is more probably an amplitude variation. Listeners who encounter this trouble are advised not to retune their receivers, but to leave them alone; the signals will swing back periodically. Short-wave transmission is tricky enough from fixed stations, and becomes more so from mobile stations.

Note

In addition to the radio equipment described on page 6 of the January issue, four Silver Masterpiece II's were taken on the Byrd Expedition. These are being used for short-wave broadcast reception and emergency communication purposes.

Secrecy of Messages

In connection with reception of the KJTY transmissions to American test stations, Mr. Cohan emphasizes an important point that is quite generally overlooked by radio listeners. This concerns the secrecy provision in the Radio Act of 1927, the federal law covering radio communication. We are quoting this part of the law in full:

"Sec. 27. No person receiving or assisting in receiving any radio communication shall divulge or publish the contents, substance, purport, effect, or meaning thereof except through authorized channels of transmission or reception to any person other than the addressee, his agent, or attorney, or to a telephone, telegraph, cable, or radio station employed or authorized to forward such radio communication to its destination, or to proper accounting or distributing officers of the various communicating centers over which the radio communication may be passed, or to the master of a ship under whom he is serving, or in response to a subpoena issued by a court of competent jurisdiction, or on demand of other lawful authority; and no person not being authorized by the sender shall intercept any message and divulge or publish the contents, substance, purport, effect, or meaning of such intercepted message to any person; and no person not being entitled thereto shall receive or assist in receiving any radio communication and use the same or any information therein contained for his own benefit or for the benefit of another not entitled thereto; and no person having received such intercepted radio communication or having become acquainted with the contents, substance, purport, effect, or meaning of the same or any part thereof, knowing that such information was so obtained, shall divulge or publish the contents, substance, purport, effect, or meaning of the same or any

(*Continued on page 42*)

The "Uni-Shielded Short-Wave Three"

SUMMARY: *In spite of the development of large, super-sensitive receivers like the superheterodyne, many people want small, simple sets that are easy to construct, simple to tune and economical to operate. The "Uni-Shielded Three" more than fills the bill, and we recommend it heartily.*

The author demonstrates the method of tuning the "Uni-Shielded Three."

By H. L. Shortt*

WHILE the "Uni-Shielded Short-Wave Three" has been designed especially for the short-wave novice, it is really capable of satisfying the most discriminating short-wave fan. Its outstanding features are high r.f. sensitivity, simplified circuit and mechanical design, smooth regeneration control, ease of tuning, use of low-current drain two-volt tubes, specially designed short-wave coils, antenna tuning control, all-pentode operation, unusually thorough by-passing, newly developed self-shielded chassis design of high efficiency, and, last but not least, low cost. These and other features will be explained in detail in the latter part of this article.

The circuit consists of a stage of r.f., using a type 34 pentode V1, a regenerative detector also using a 34 pentode V2, and a single audio stage using a 33 pentode power output tube, V3. Since these three pentodes are all two-volt filament tubes, the A supply of this receiver may be two ordinary bell-ringing type 1½-volt dry cells, an Air Cell A battery, or one cell of a 6-volt storage battery, or any standard storage battery. Of course, the correct voltage reducing resistor will have to be used with each particular type of A supply to bring the voltage down to the required 2-volt value. For example, a .7-ohm resistor will have to be used in series with an Air Cell battery or with a single cell of a storage battery, a 3-ohm resistor will be needed in series if two 1½-volt dry cells are used, etc. The total filament current is only .38 ampere and this drain is so light that even the 1½-volt dry cells should last a long time without requiring replacement. Three 45-volt B batteries are required and 13½ volts of C battery. Only .02 ampere is drawn from the B batteries, hence this set is extremely economical in operation.

* Chief Engineer, Wholesale Radio Service Co., Inc.

The Circuit

Analyzing the circuit, the first feature to attract attention is the trimmer condenser C1. This permits adjustment for various length aerials, so that the set will work just as well on a long aerial as on a short one. The antenna tuning condenser also provides an extra adjustment when tuning in weak, distant stations, although it is not ordinarily used for this purpose. It will be noted that the antenna is connected through C1, directly to the r.f. tube V1. That is to say, the signal is impressed directly upon the grid of V1, dispensing with the antenna coil or coupler.

Tuning is accomplished by means of a .00014 mf. variable condenser C6 shunted across a plate impedance coil L1. The latter constitutes the longer winding G of a special four-prong, plug-in coil. The shorter winding of this coil, T, serves as a tickler, being connected in series with the plate of the detector tube V2. The regenerative action thus obtained is very strong.

Regeneration is controlled in the conventional (that is, for screen-grid tubes) manner, by varying the screen-grid voltage of the detector. The potentiometer R4 is used for this purpose. This method of control is smooth and effective.

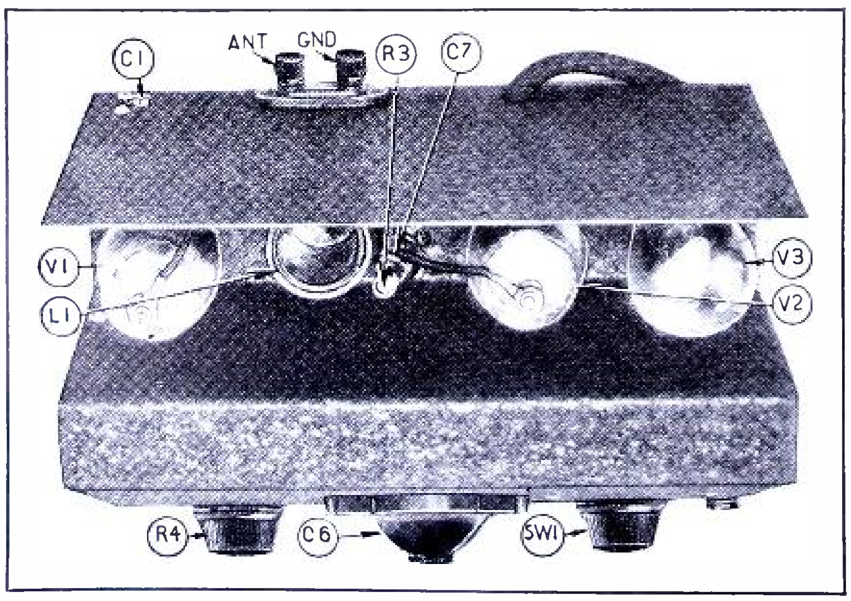
The short-wave plug-in coil is of special design. Four of these coils are used to cover the band from 15 to 200 meters (20,000 to 1500 kc.). A feature of the coils is the band spread effect attained through proper design and the use of shielding.

Values of .0001 mf. for the grid condenser C7 and 10 megohms for the grid leak R3 have been found to give best results. However, in some cases it may be desirable to use a smaller grid leak such as a 5 or even a 3 megohms.

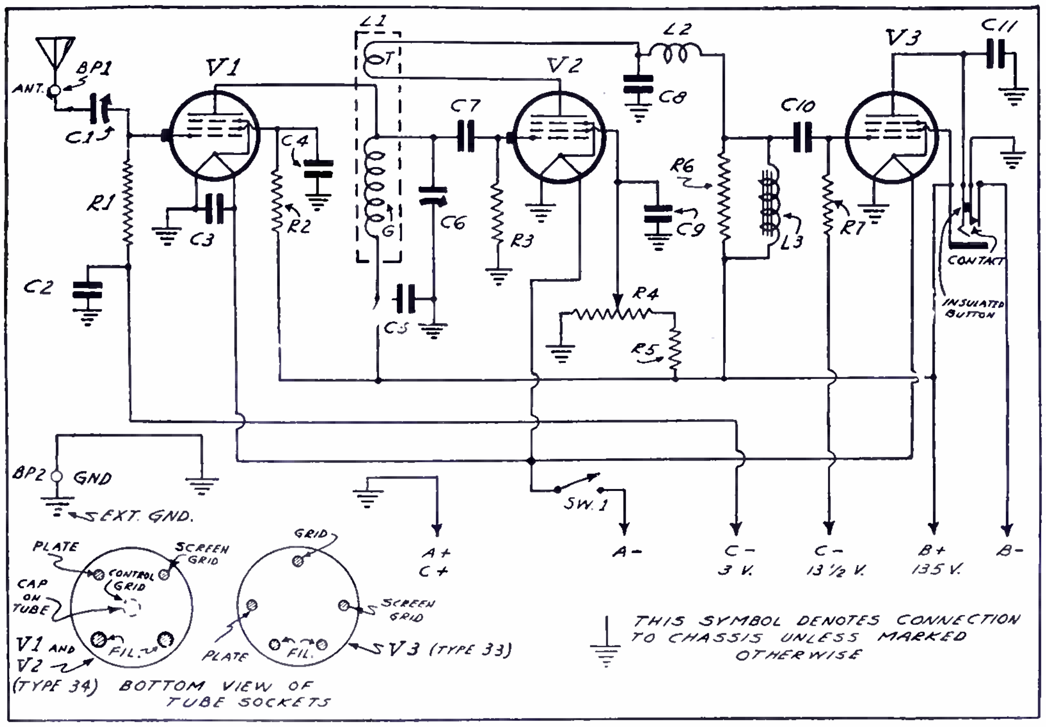
The 2½ mh. r.f. choke, L2, serves to block off r.f. currents from the audio circuit. These currents are bypassed through the .00025 mf. mica condenser C8. Values both of the r.f. choke and of the bypass condenser have been calculated carefully for high frequency reception and should be adhered to for best results.

The use of an audio plate choke at L3 adds immensely to the efficiency of the Uni-Shielded Three, permitting a higher plate voltage on the detector and thus increasing the sensitivity to an amazing extent.

Since the output amplifier pentode V3 uses a C battery for negative grid bias, a grid resistor R7, having a value of 500,000 ohms, is used.

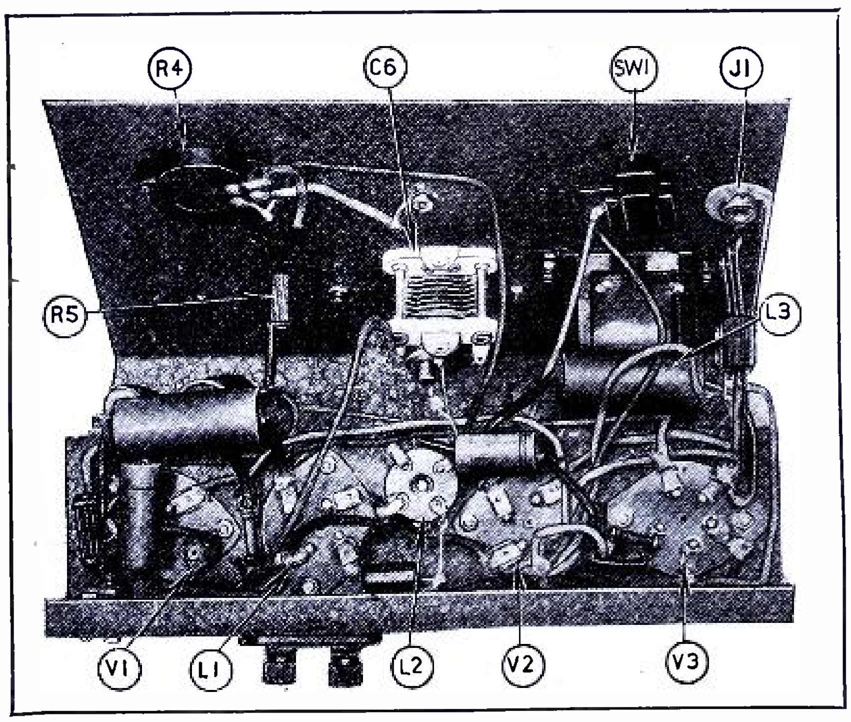


The unique chassis construction of the Uni-Shielded Three is evident in this top view. The R. F. tube V1, the plug-in coil L1, detector tube V2 and output tube V3 are in a straight line, permitting short, direct connections between the parts on the underside of the set. The chassis is self-braced and is quite rigid.



Complete schematic wiring diagram of the Uni-Shielded Three. To simplify wiring, bottom views of the tube sockets are shown. Note particularly in the diagram how the B circuit is broken with the phone plug out of the earphone jack in the V3 plate circuit.

C1—0-30 mmf. antenna tuning condenser, Trutest.
C2—.1 mf., 400-volt Trutest cartridge condenser.
C3—.1 mf., 200-volt Trutest cartridge condenser.
C4—.1 mf., 400-volt Trutest cartridge condenser.
C5—.25 mf., 400-volt Trutest cartridge condenser.
C6—.00014 mmf. Trutest variable condenser.
C7—.0001 mf. Aerovox mica condenser.
C8—.00025 mf. Aerovox mica condenser.
C9—.1 mf., 400-volt Trutest cartridge condenser.
C10—.01 mf., 200-volt Trutest cartridge condenser.
C11—.001 mf., Aerovox mica condenser.
R1—100,000 ohm, 1/4 watt Trutest carbon resistor.
R2—40,000 ohm, 1/2 watt Trutest Carbon resistor.
R3—10 megohm, 1 watt Trutest carbon resistor.
R4—50,000 ohm "Elf" potentiometer.
R5—50,000 ohm, 1/2 watt, Trutest carbon resistor.
R6—50,000 ohm, 1/2 watt, Trutest carbon resistor.
R7—500,000 ohm, 1/4 watt Trutest carbon resistor.
J1—Carter 103 open circuit three-spring jack.
BP1, BP2—Eby twin binding-post, ant. and gnd.
L1—Special short-wave, 4-prong shielded Trutest plug-in coil, wound on bakelite form, 1 1/4" dia.
L2—1 1/2 millihenry Trutest r.f. choke.
L3—200 henry plate choke.
V1—2-volt pentode, type 34.
V2—2-volt pentode, type 34.
V3—2-volt pentode, type 33.
SW1—G. E. rotary switch with bakelite knob.
1—Bakelite knob for potentiometer R4.
1—Kurtz-Kasch vernier dial.
1—Six-conductor battery cable.
1—Roll Corwico braidite solid core hook-up wire.
2—Screen-grid clips.
1—Trutest 5-prong wafer socket.
3—Trutest 4-prong wafer sockets.
1—Phone plug.
1—Pr. Frost DX special phones.
3—45-volt B batteries.
3—4 1/2-volt C batteries.
2—1 1/2-volt A cells, or Eveready air cell A battery.
1—Special metal chassis.



The "works" of the Uni-Shielded Short-Wave Three. The straight-in-line arrangement of the tube and coil sockets, makes for easy wiring. The cylindrical objects are the various bypass condensers, and are held in place by their own connecting wires. It is important to have the earphone jack J1 thoroughly insulated from the front panel, as the latter forms the B minus side of the circuit.

The conventional .01 mf. coupling condenser, C10, is employed between the detector and the audio stage. The 33 output tube has an undistorted power output of 700 milliwatts. This tube is capable of producing considerably greater power output than three-electrode power amplifiers of the same current drain. Furthermore, the 33 has greater amplification than is possible in a three-electrode amplifier, without serious sacrifice in power output. The power-handling ability of the 33 tube is made possible by the addition of both a suppressor and a screen between the grid and plate. The suppressor is placed next to the plate and is connected inside the tube to the filament.

The .001 mf. condenser C11 improves tone quality since it bypasses certain of the harsh or scratchy higher audio frequencies which are often especially noticeable with pentode output tubes. The triple spring open circuit jack J1 permits earphones or loudspeaker to be plugged into the output circuit as desired. When the plug is inserted in the jack, this also automatically closes a second circuit between B minus and the chassis. The jack is insulated from the chassis.

Unique Chassis Design

The Uni-Shielded Short-Wave Three derives its name from its unique chassis design. The chassis, panel, and shielding are in one piece, as shown in the photographs. In effect, this results in a sloping panel of pleasing appearance, a "U" shaped shielded well for the three tubes and the plug-in coil and also effective shielding for the parts beneath the chassis. This design dispenses with extra shielding and, moreover, is efficient, rugged, compact, and economical. The chassis will readily slide into a metal or wood carrying case and presents a neat, attractive appearance.

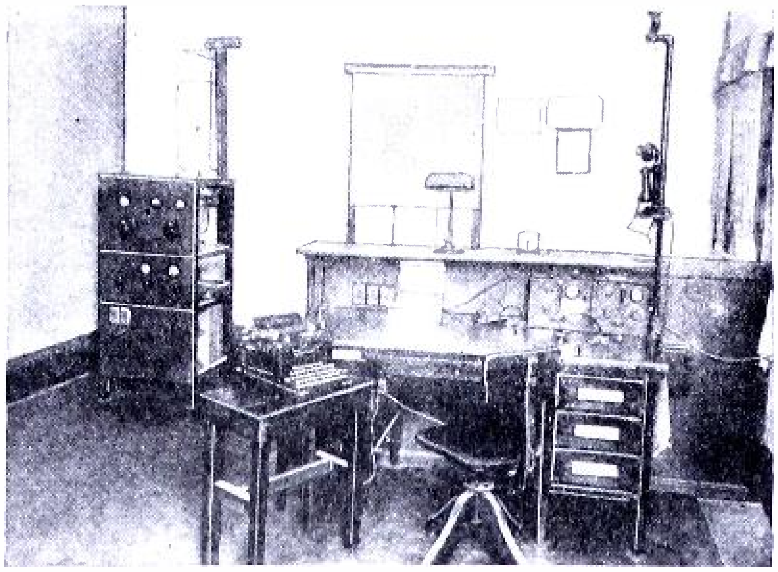
While the Uni-Shielded Three has sufficient power to operate a loudspeaker on many stations, it was purposely designed to have high r.f. sensitivity so as to bring in the hard-to-get foreign stations on earphones. In other words, instead of increasing expense and complicating the circuit by the addition of audio stages, the designer concentrated on producing a simplified circuit, actually capable of bringing in extreme DX with sufficient power to be heard readily on a good pair of earphones. With the ordinary three-tube short-wave receiver, this condition is generally reversed, as most such receivers are designed with a "showy" audio system, but with a relatively weak r.f. circuit which falls down badly when it comes to bringing in real distance.

The Uni-Shielded Three is easy to operate, since it is perfectly stabilized and more than amply bypassed. Naturally, a certain amount of skill and experience is needed to bring in

(*Continued on page 40*)

The Army Amateur Radio System

Unique organization sponsored by the Signal Corps performs patriotic and valuable service for the country; membership is voluntary and activities non-military



Army Amateur Net Control Station, WLQ-W3SN, of the Third Corps Area located at Fort G. G. Meade, Md. (This station was transferred to Baltimore during the latter part of December).

By Capt. Garland C. Black
(Signal Corps, U. S. Army)

FOR centuries past man has been exploring the earth and not until recently has he devoted his efforts to the stratosphere, up above the earth's surface. Parallel to this we find that the broadcast listener has been exploring the radio waves between 550 and 1,500 kilocycles, always searching for new and more distant stations, until today he has extended the search up above 1,500 kilocycles.

What is there up above 1,500? This is a question many a listener asks himself as he reads the advertisements expounding the wonders open to the owner of a short-wave receiver. Let us see to what that part of the radio spectrum is allotted. If one consults the frequency allocations as set forth in the rules and regulations of the Federal Radio Commission, it is found that some of these higher frequencies are set aside for the following services: aviation, police, government, general communication, visual broadcast, experimental, and amateur communication.

Many of these services are already familiar fields to thousands of listeners. Particularly is this true of the police systems, airway systems, and the amateur phones, not to mention the visual broadcast or television. Some of the other services, such as the amateur bands where code is used, are not so well known. However, these channels are extremely interesting to those who are "in the know."

Amateur Activities

Let us consider some of the activities of these amateur radio stations. But first what is an amateur station? The term "amateur station" means a station used by a person, holding a valid license issued by the Federal Radio Commission, who is interested in radio technique solely with a personal aim and without pecuniary interest. There are several bands of frequencies allotted for amateur radio communication, the more popular ones being from 1,715 to 2,000 kc., 3,500 to 4,000 kc., 7,000 to 7,300 kc., and 14,000 to 14,400 kc. These are commonly referred to as the 160-, 80-, 40-, and 20-meter bands, respectively.

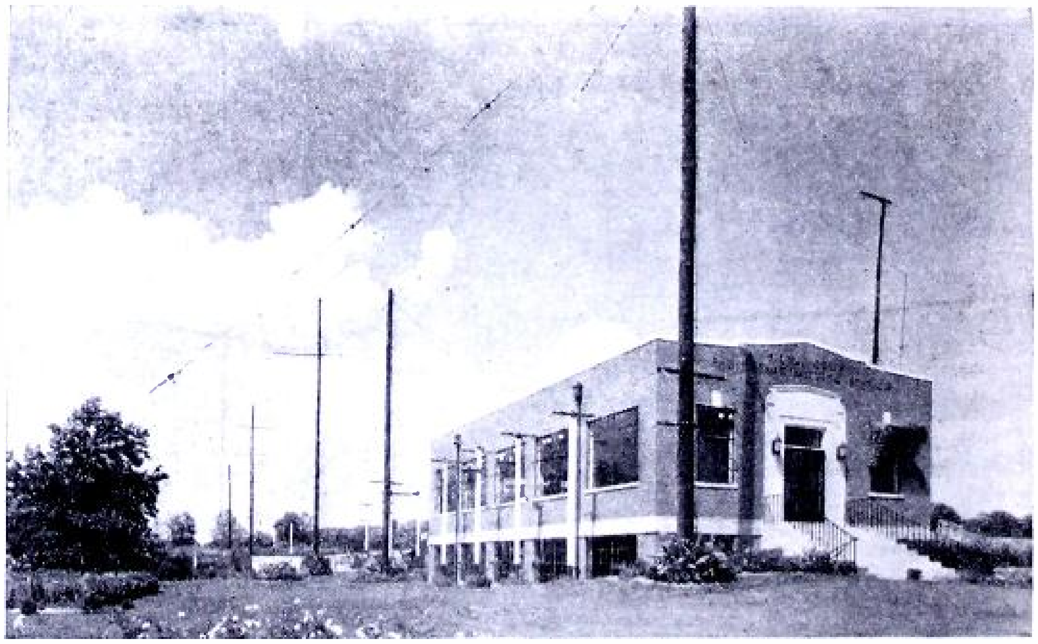
The number of amateur stations has increased rapidly since the World War until now the number is probably in excess of 10,000. These stations carry on communication among themselves and not only do the operators derive considerable pleasure from their contacts, but they also have done a great deal to advance the art of radio communication. Amateurs as a group are very resourceful and ingenious. They have achieved prominence by furnishing communication from certain areas in the United States during times of disaster when other means of communication have been interrupted. They have their own local, sectional, and national organizations, the most prominent being the American Radio Relay League, formed by Hiram Percy Maxim in 1914, and which today is the largest amateur organization in the world.

Purpose of the A.A.R.S.

A number of years ago the Chief Signal Officer of the United States Army conceived the idea that it would be desirable to bring about an affiliation between the United States Army Signal Corps and the civilian radio transmitting amateurs of the United States. This affiliation was desired for the following purposes:

(1) To provide an additional channel of radio communication throughout the continental limits of the United States that could, in time of disaster or emergency, be used as a substitute for telephone and telegraph lines destroyed by earthquake, fire, flood, ice, tornado, riot, or insurrection.

(2) To place at the disposal of representatives of the American National Red Cross and military commanders, including the National



WAR, the U. S. Army Signal Corps station at Fort Meyer, Va. This building also houses the transmitters used by the Army Amateur Radio System under the calls WLM and W3CXL. (Photo by U. S. Army Signal Corps.)

Guard, such amateur radio communication channels as might be developed under this plan.

(3) To provide civilian radio operators with a knowledge of the Army methods of radio procedure and methods of technique essential to operate such a radio network.

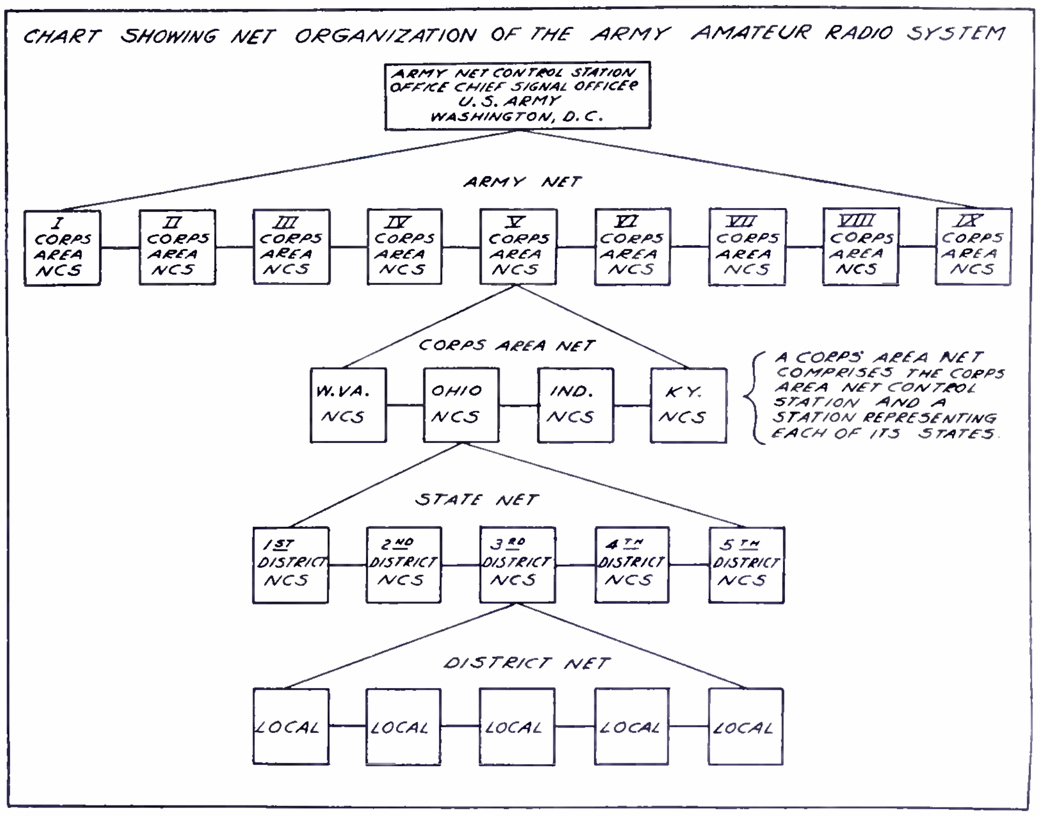
(4) To establish contact with a considerable number of civilian amateur radio operators for the purpose of acquainting them with the Signal Corps and its activities, and securing their aid in experimental work, tests, etc.

(5) To render such encouragement and assistance as might be desirable to firmly establish and perpetuate the American Amateur.

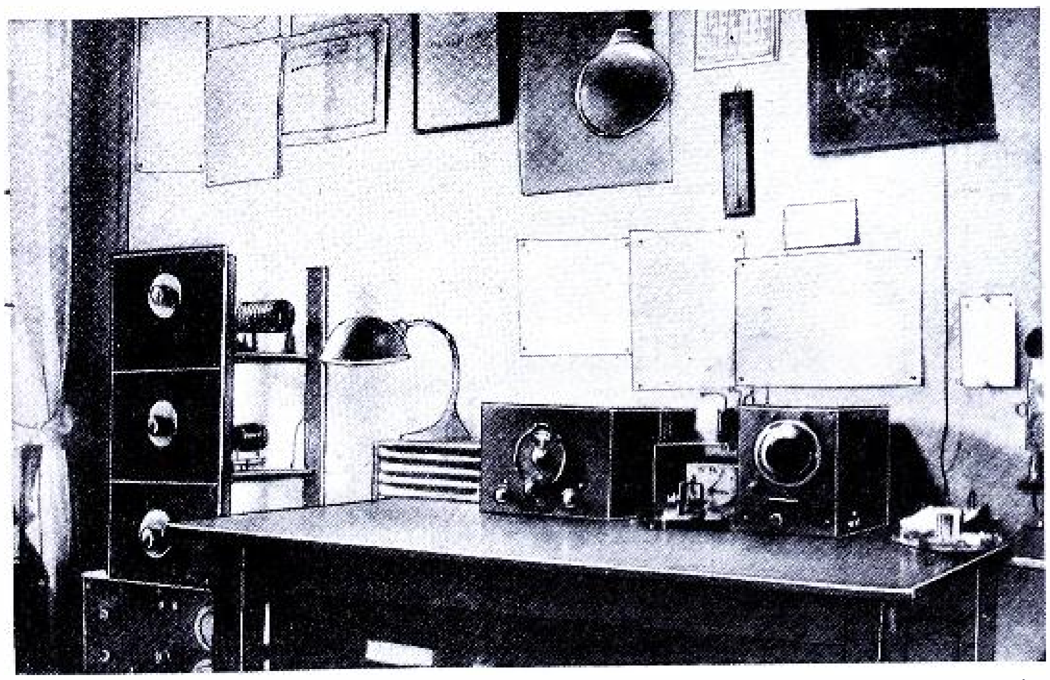
From the very beginning the work met with a wholesome response from the amateurs. This affiliation is known as the ARMY AMATEUR RADIO SYSTEM. Its membership averages about 1,000 active amateurs. No attempt is made to enlarge upon this figure, as this number of amateur radio stations, strategically located throughout the continental United States, is sufficient to provide the desired radio network for establishing the emergency communication channels.

The members of the Army Amateur Radio System do not receive any additional pay or compensation as a result of their affiliation with the Signal Corps, nor are they carried as members of any military reserve or other organization. The work is purely voluntary on their part and what benefits they derive from their activity is solely the pleasure that can be obtained through handling traffic under such a scheme and by knowing that they are rendering a service to their country.

Because of the fact that the system is organized and its operation supervised by the Signal Corps, it is natural to find the organization primarily based upon the military organization of the United States



which divides the country into nine geographical sections known as Army corps areas. The Chief Signal Officer of the Army administers the operation of the system as a whole. The direct operation and administration of the system within each corps area is conducted by the corps area signal officer. This decentralization results in a closer relationship between the amateurs and a representative of the Chief Signal Officer, and permits of desirable variations in the organization due to the inherent differences between the various sections of the country. Obviously it would be impracticable for all of these stations to operate one with another without some definite scheme for operation. This is achieved by assigning the stations to groups, each of which operates on a definite frequency at a prescribed time, and also arranging for key stations within each group to work with other groups. The groups are known as "nets." The following nets are organized: an Army net, nine corps area nets, forty-eight state nets, five district nets for each state, and where necessary, local nets for the districts.



Army Amateur Net Control Station, WLT-W9DOU, of the Sixth Corps Area located in the residence of the Radio Aide, 1st Lieut. C. W. Roth, Sig.-Res., Oak Park, Ill.

Make-up of the Net

The Army net comprises the station in the office of the Chief Signal Officer and a station representing each corps area headquarters. Each corps area net comprises the station representing the corps area headquarters and a station representing the state organization of each state within the corps area. Each state net comprises the state control station and a station representing each of the five districts within the state. Each district net comprises the district station and stations located throughout the district. When this number of stations is too great for all to operate within one net, local nets are organized. In this manner, stations located throughout our entire country are tied into one large network so that a message from any part of the country can be transmitted to any other part by being relayed from its local or district net through its state net, corps area net to the Army net and then to the specified other corps area net, to the proper state net and district net on to the designated local station.

In order to place this system at the disposal of the Red Cross, each Red Cross chapter is assigned to an Army Amateur station and the branches of these chapters are also assigned to stations. This permits each Red Cross chapter or branch to have one or more of these radio stations at its disposal as a means of providing it with communication during times of

(*Continued on page* 41)

Mr. Brennan, standing before his transmitter, a moderately priced, low power affair.

How to Get Started on an Amateur Phone Set

SUMMARY: *This is the first of a series of two unusually complete constructional articles describing the step-by-step procedure in building a high quality phone transmitter. QSA5, R9 has been the report received by the author in practically every one of the phone contacts made with other "hams." Simplicity of construction, ease of adjustment and operation and moderation in the price of the parts employed are only a few of the outstanding features.*

By John B. Brennan, Jr.

FOR ages, it seems, I have been talking about getting busy on the construction of that "ultimate" transmitter; but, somehow or other, the time slipped by, and I had nothing to show for my thoughts. It was high time, then, that I formulated some definite idea as to what the transmitter should be. There followed days and days of scouting through all available literature for designs which, as nearly as possible, would coincide with my whims and fancies, to say nothing of my pocketbook.

To my way of thinking, a transmitter has to meet some definite requirements. They are: (1)—highest possible performance in terms of reliable distance-covering ability commensurate with moderate cost; (2)—ease of construction and adjustment; and (3)—consistency and stability of operation. It is safe to add that the transmitter whose construction is described here admirably meets every one of these requirements.

In an unbiased consideration of transmitter circuit designs it is probably true that only rarely does an absolutely new type of circuit make its acquaintance with radio experimenters. Usually, the so-called revolutionary circuits have their newness embodied not so much in circuit innovations as in improvements in parts and layout. In contradistinction, then, to most descriptions of circuit brain-children, the modest description of a reliable "day-in and day-out" phone transmitter which follows makes no spectacular claim to fame. There is one exception—in spite of its ripe old age of sixteen months, it is still one of the popularly accepted rigs used by "hams."

Exercising my prerogative to indulge in a number of worthwhile mechanical, electrical, and constructional changes over the original design of the transmitter, which made its initial appearance in July of 1932, I am presenting herewith the design and constructional details of a complete 160-meter amateur phone transmitter installation. This design, it is felt, will appeal to a host of amateurs who have just entered or re-entered the game or who, like myself, have put off the time of getting on the air until some such occasion as this tempted them sufficiently.

Obtaining a License

Before entering into a description of the actual design features of the complete transmitter, it is well, perhaps, to settle a number of questions which are sure to arise in the minds of those who are not now licensed amateur radio operators, but who, at one time or another, have seriously considered taking

List of Parts for the Transmitter

Symbol	Quantity	ITEM	Type	Value
C1	1	Cardwell Standard Variable Cond.	123-B	.0005 mf.
C6—C10—C13	3	Cardwell Midway Variable Cond.	406-B	.00025 mf.
C8	1	Cardwell Midway Variable Cond.	402-B	50 mmf.
C-12	1	Cardwell Midway Variable Cond.	404-B	100 mmf.
C2—C4—C7	3	Aerovox Mica Fixed Condensers	1450	.005 mf.
C3—C5—C9	3	Aerovox Mica Fixed Condensers	1450	.00025 mf.
C11	1	Aerovox Mica Fixed Condensers	1450	.001 mf.
R1—R3—R5—R6	4	Electrad Center-tap Fila. Resistors		20 ohms
R2	1	Aerovox Resistor	1 watt	50,000 ohms
R4	1	Aerovox Resistor	2 watt	1000 ohms
R7	1	Electrad Potentiometer	R1-203	0-500,000 ohms
R8—R9	2	Electrad Tapped Voltage Divider	D-200	20,000 ohms
T1	1	Acratest Microphone Transformer	2625	200-0-200 ohms
T2	1	National Audio Transformer	A100	4-1 ratio
T3	1	National Class B Input Transformer	B1	
T4	1	National Class B Output Trans.	B0	variable
T5—T6	2	Acratest Power Transformers	6758	
V1—V2—V3—V4				
V6—V7—V8	7	Eveready-Raytheon Tubes	46	
V5	1	Eveready-Raytheon Tube	56	
V9—V10	2	Eveready-Raytheon Rectifier Tubes	82	
L1—L2—L3—L4	4	Inductors wound as described in text (or supplied in kit form by the Insuline Corp. of America)		
L5—L6	2	Audio Chokes	4714	30-Henry, 150 ma.
C14—15—C16—17	2	Aerovox Electrolytic Filter Cond.	E5 doubles	8-8 mf.
	8	Five-Prong Insuline Co. Sockets		
	2	Four-Prong Insuline Co. Sockets		
	4	Dials 4 inches dia.		
	5	R. F. Transmitting Chokes as per winding details in Fig 3		
	2	Stand-off Insulators		
M1	1	Weston 0-5 Amp. Thermo-Couple Ammeter		
M2	1	Weston Type 301, 0-200 milliammeter		
	36	Fahnestock Clips		
	4	Insuline Corp. Panels 1/8 inch thick, 17 3/4 inches long by 8 inches wide		
	1	Universal Double Button Microphone		
	1	A.C. Line Switch		
	4	Breadboards 12" by 16"		
		Lumber for frame as shown in Fig 2		

Although this is his initial contribution to SHORT WAVE RADIO, John B. Brennan (W2DJU) is by no means unknown to radio amateurs and experimenters. For a number of years he was technical editor of RADIO BROADCAST, and then later, technical editor and finally managing editor of RADIO NEWS.

The transmitter described here is the one he has built for himself. From a look at his log book we can assure those who attempt to duplicate his rig that they will have a transmitter of which they will be rightly proud.

Next month's installment will conclude the description of this particular transmitter, but by no means will terminate the articles coming from the pen of Mr. Brennan.

this important step in the future.

Anyone who is a citizen of the United States, native born or naturalized, may apply for the amateur operator's examination.

There are three classes of amateur operator licenses. Class C applies to those who reside more than 125 miles from any one of the numerous cities where examination places have been set up. To these people written examinations are given in their own homes after they first demonstrate before some local amateur radio operator their ability to pass a code test.

The Class B license applies to all newcomers in the game who live within the 125 mile radius of one of the examination centers. Those falling in this category must present themselves at the examination centers and pass a code test administered by one of the examining inspectors. Then they are given the written part of the examination. This embraces such items as questions on regulations of the Federal Radio Commission, transmitter and receiver design, and theory and operation of transmitters and receivers.

The Class A license, carrying so-called unlimited privileges, applies only to those previously licensed amateur operators who have held one of the above licenses for a year or more and who pass a rather extensive written examination covering a wide variety of questions on theory and practice of telegraph and phone transmitters.

The Class A license allows an amateur to operate a c.w. station in any one or all of the various frequency bands set aside by the Federal Radio Commission for amateur use. It also permits the operation of phone stations in any one of the phone channels.

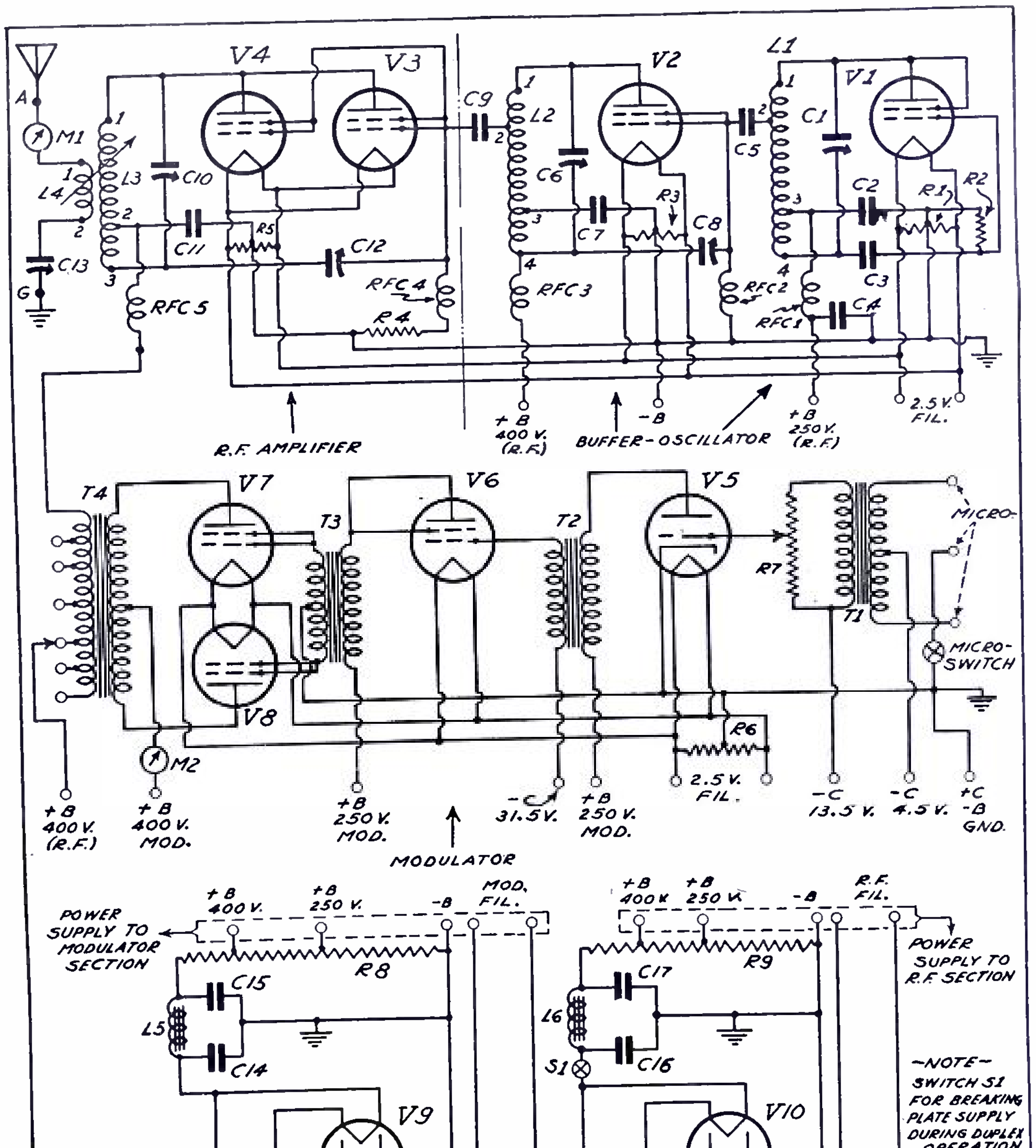
Class A privileges allow phone operation in *all* of the following frequency bands:

1800 kc. to 2000 kc. ("160 meters")
*3900 kc. to 4000 kc. ("75 meters")
*14,150 kc. to 14,250 kc. ("20 meters")
28,000 kc. to 28,500 kc. ("10 meters")
56,000 kc. to 60,000 kc. ("5 meters")
400,000 kc. to 401,000 kc. ("¾ meter")

Class B and C privileges extend to phone operation in all of the above bands excepting the two marked with an asterisk*. *These two bands are for the exclusive use of holders of Class A licenses.*

From the above it will be seen that before an amateur can engage in phone operation in the 75-meter (3900-4000 kc.) band, the band most prominently associated with amateur phone work, he must first hold a Class B or C license for at least a year. Then he becomes eligible for the Class A examination.

For this reason the transmitter description which follows concerns itself with a 160-meter outfit—one which will prove satisfactory for use by Class A, B and C license holders, and with alterations in coil winding, for operation in the 3900-4000 kc. band.



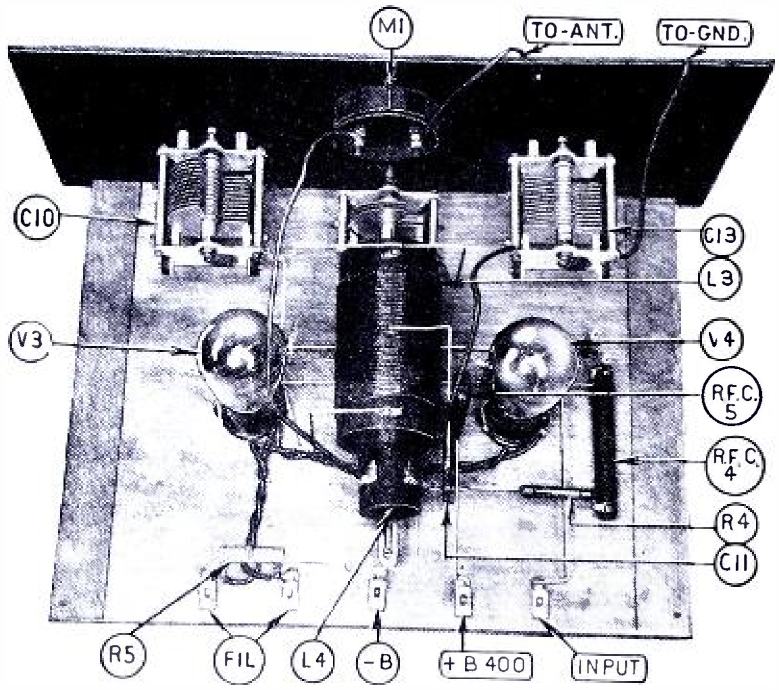
Here is the complete wiring diagram of the entire transmitter. At the top is shown the r.f. section comprising the oscillator-buffer and final amplifier stages. Below is the complete audio channel employing Class B modulation. At the bottom are shown the dual power supplies, one for each of the above.

The Circuit

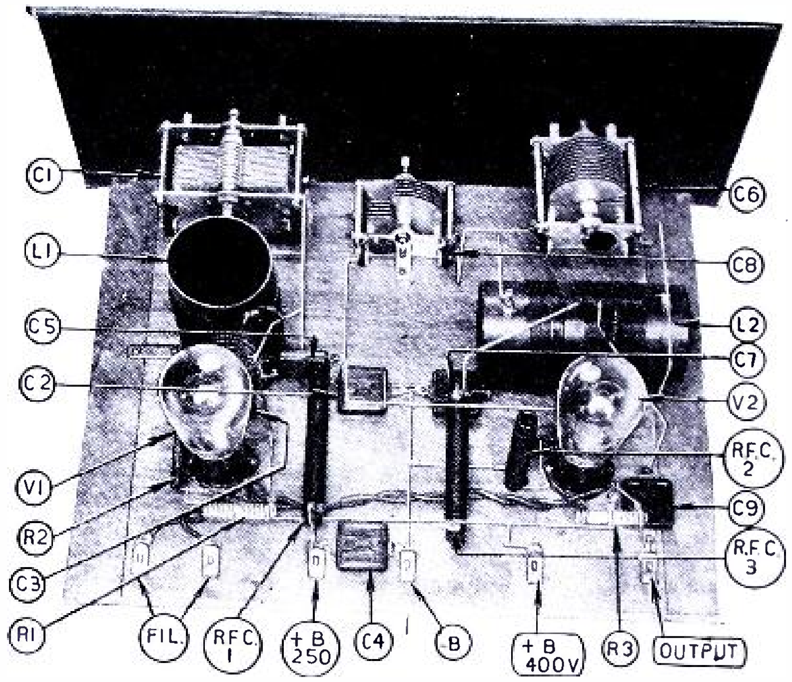
The circuit of the complete transmitter, as built and operated by me, and which has rendered satisfactory service to scores of other "hams" throughout the country is shown in all its details in Fig. 1.

It will be seen that, essentially, the transmitter consists of three main units, as follows: (1) the r.f. section, comprising the master oscillator, the intermediate or buffer r.f. stage and the final r.f. modulated amplifier; (2) the audio channel, comprising the microphone, speech amplifier, and Class B modulator stage; and (3) the dual power supply comprising an individual power supply unit for each of the aforementioned units.

To supply to the antenna a steady c.w. signal, free from frequency modulation, the circuit shown has been found extremely satisfactory. Stability of frequency is assured



A top view of the final r.f. amplifier stage.



A top view of the oscillator buffer stages.

by the fact that the oscillator is separated from the final r.f. amplifier stage by a buffer stage, which also functions to furnish the requisite input excitation to the final amplifier stage.

Oscillator, buffer, and final amplifier all use type 46 tubes. In the oscillator stage the outer grid cathode terminal on socket) is connected to the plate in a series-fed Hartley circuit. In the buffer and final amplifier stages the two grids are tied together, as shown in the circuit diagram.

Referring to the circuit diagram, the variable condensers C1, C6 and C10 tune their respective circuits to the operating frequency, while in the buffer and final amplifier stages the condensers C8 and C12, respectively, furnish the requisite neutralizing mediums. The antenna is tuned to resonance with the tank circuit of the final r.f. amplifier by means of the series tuning condenser, C13.

Take particular note of the fact that only 250 volts is applied to the plate of the oscillator. This lower-than-usual plate potential is purposely applied to guard against an erratic oscillatory condition. In the buffer and final amplifier stages the plate potential, under operating conditions, is 400 volts.

Coupling from one stage to another is obtained by the capacitors C5 and C9.

It has been found advisable to shunt the filament terminals of each of the r.f. tubes with its own center-tap resistor, the mid-point of which is grounded. Thus each stage is assured of having short, direct returns to ground and unwanted coupling between stages is prevented.

The Audio Channel

In the audio arrangement shown, employing Class B amplification in the modulator stage, approximately 20 watts of audio power is delivered, an amount sufficient to fully modulate an r.f. input of about 40 watts.

The circuit, as can be seen, is perfectly straightforward, and consists of a microphone stage employing a type 56 tube, transformer coupled to a 46 Class A driver, operated at a plate potential of 250 volts. This stage feeds into a pair of 46's in push-pull, Class B, which in turn furnish the audio power to the r.f. amplifier.

Class B transformers, originally designed for use with type 10 tubes, were found to work quite satisfactorily at the voltage values indicated for the 46's.

Volume, or gain control, is furnished by means of a 0-500,000-ohm potentiometer R7, shunted across the secondary of the microphone transformer T1. A 200-ma. meter M2 connected in series with the plate supply to the 46 modulator tubes functions as an excellent volume level indicator.

The Power Supplies

For furnishing the requisite plate and filament potential to the tubes in the transmitter, two power supplies, identical in every respect, are employed. One of them furnishes all the plate and filament supply required by the audio channel, while the other is used solely to furnish the same kind of supply to the r.f. channel.

The primaries of the two power transformers are connected in parallel and, through a series line switch, to the 110-volt a.c. supply. This line switch, at first, controlled the entire operation of the transmitter. The one drawback to this arrangement was the fact that in coming back at a station which had been successfully contacted, it took some time—a matter of seconds—before my station again got on the air, due to the thermal lag of the heater of the 56 tube.

This condition was overcome by inserting an additional switch in series with the plate supply to the voltage divider of the r.f. power supply so that while the heater and filament supply to all the tubes was uninterrupted, the plate supply to the r.f. tubes might be broken during listening periods.

The power transformer secondary is rated at an output of 350 volts either side of its center-tap. Several filament windings are provided, but the two which interest us most are the 2.5-volt, 3.5-ampere winding suitable for furnishing filament supply to the type 82 rectifier tubes and the 2.5-volt, 9-ampere winding for furnishing filament supply to the tubes in the transmitter proper. In the r.f. channel the filament consumption is on the order of 7 amperes, while for the audio channel it is 6.25 amperes, both these figures being well within the 9-ampere rating of the filament windings of the power transformers.

Heavy duty chokes, capable of passing 150 milliamperes and rated at 30 henries, are employed in the filter section, together with electrolytic condensers having two 8 mf., sections in each can. Purely for safety's sake and better regulation of the power supply, the voltage divider resistors R8 and R9 are of the 75-watt type and have a resistance of 20,000 ohms, each one being supplied with two variable taps for picking off the intermediate voltages. Under proper load conditions

Under normal operating conditions the various tubes will impose a drain on the power supply as follows:
Oscillator, 15 ma.
Buffer amplifier, 15 ma.
Final r.f. amplifier, 100 ma.
Speech Amplifier, 5 ma.
Interstage audio amplifier, 20 ma.
Class B Modulator, 10 to 20 ma. without speech. 100 ma. peaks with speech.

the taps are arranged to provide 400 and 250 volts. Proper load conditions can be determined with the aid of the milliammeter which temporarily may be connected in the plate supply circuits to the various tubes.

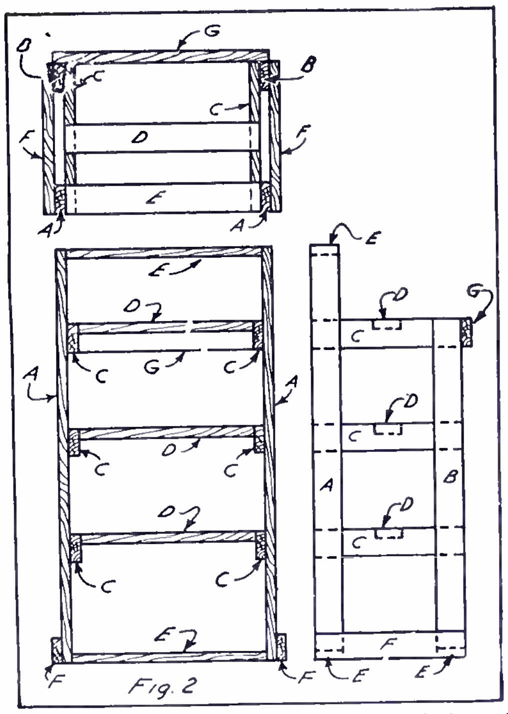
Constructional Details

Originally the transmitter was laid out in breadboard fashion, but it decidedly was not an object of art in this condition. Later, its constructional features were revamped with a marked improvement, not only in appearance but in operation and ease of adjustment.

A wooden rack, such as that shown in Fig. 2, was built to take four removable slide-in shelves. Then, for the shelves, four 12″ by 16″ breadboards were procured from a house-furnishing store and disposed of in the following manner: the shelf sliding in at the bottom of the rack contains both power supplies; the one immediately above it houses all the audio apparatus; next above this one comes the oscillator-buffer stages; and finally at the top is the final r.f. amplifier shelf.

Referring again to Fig. 2 it will be seen that one size of lumber is used throughout in the construction of the rack. The lumber is clear pine, free from knots, and is ⅞-inch thick by two inches wide. The front uprights are 36 inches long and the rear uprights 24 inches long. The front and rear uprights are joined together laterally by four pieces on each side, these pieces being 12 inches long. Five cross-members stretching the full width of the rack join the side assemblies together. These are 16 inches long.

To each of the breadboard bases is fastened a bakelite panel, each of the four panels being 8 inches wide by 17¾ inches long. In the original construction I used veneer panels, and, from a transmitting standpoint, with some measure of success. However, I made the error of painting these panels with a paint which proved to be highly conductive and I obtained a swell grid leak action. Although I don't know exactly, I'm sure many good amperes which should have gone antenna-wards were dissipated in the paint on the panels. Therefore, with all possible haste I changed over to bakelite panels.



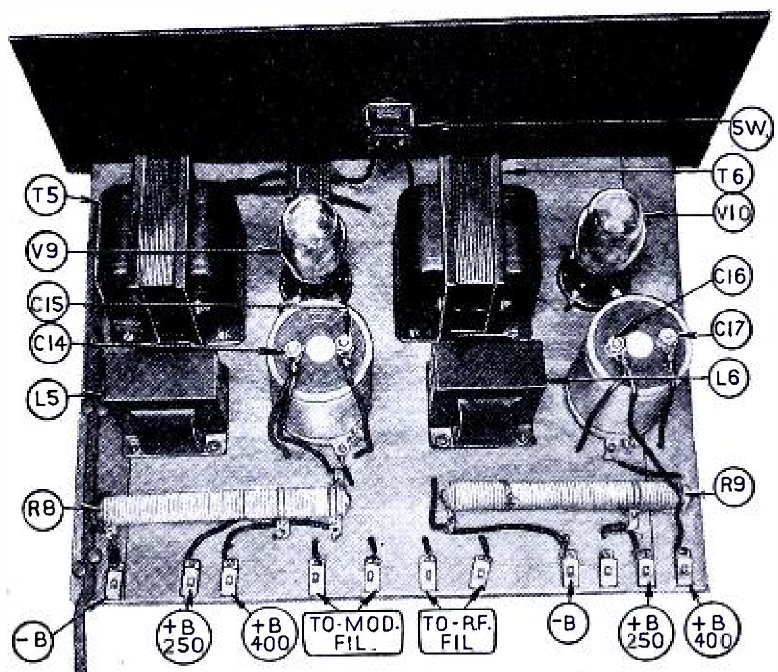
The rack for supporting the four shelves is constructed as shown here. All lumber, ⅞″ by 2″ dressed. Items A, 2 pcs. 36″ long; B, 2 pcs. 24″ long; C, 6 pcs. 12″ long; D, 3 pcs. 16″ long; E, 3 pcs. 16″ long; F, 2 pcs. 12″ long; and G, 1 pc. 17¾″ long. All lumber clear pine.

I found that there was a distinct advantage to be gained by the use of the shelf and rack method of construction. First, it was highly convenient to mount and wire the parts on one baseboard at a time. Then, as each shelf was completed it was slid into place in the rack. Secondly, when it came time to make slight adjustments, it was decidedly convenient to be able to remove only that shelf with which I was concerned at the moment, without having to disturb the wiring or connections to the remaining shelves.

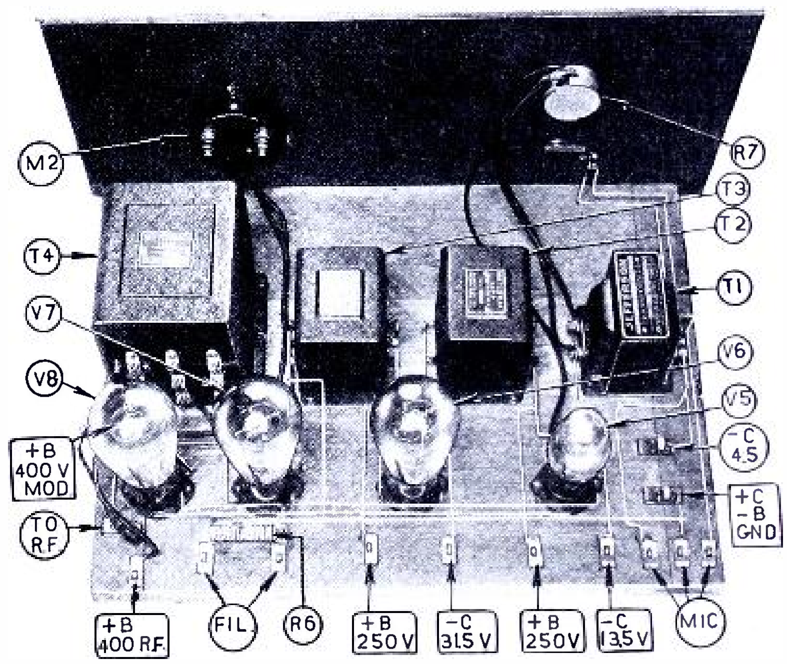
The several accompanying photographs show quite plainly the layout of the parts on the four shelves. Beginning at the top shelf, the tank tuning condenser C10 is mounted at the right of the panel, while the antenna tuning condenser C13 is to the left. Midway between these two, and lower down on the panel, is the neutralizing condenser, C12. Directly above it is located the antenna ammeter, M1. On the shelf itself, the tank inductor, L3, is located directly behind the neutralizing condenser, while the two 46 tubes, V3 and V4, are mounted either side of it. Other parts are located as indicated. The antenna coupling coil L4 is mounted on a brass strip which is slotted so as to permit the coil to be slid back and forth for variable coupling between it and the tank inductor L3. Plate, input and filament connections are brought to Fahnestock clips arranged along the rear of the baseboard.

The next lower shelf assembly is as follows: on the panel the oscillator tuning condenser, C1, is at the right and the buffer stage tuning condenser, C6, at the left. The neutralizing condenser C8 is located between them. Directly behind the oscillator tuning condenser is the oscillator inductor L1, while behind it is the oscillator tube, V1. The buffer inductor L2, and the tube V2 are likewise located behind the tuning condenser, C6. Other parts employed are located as indicated.

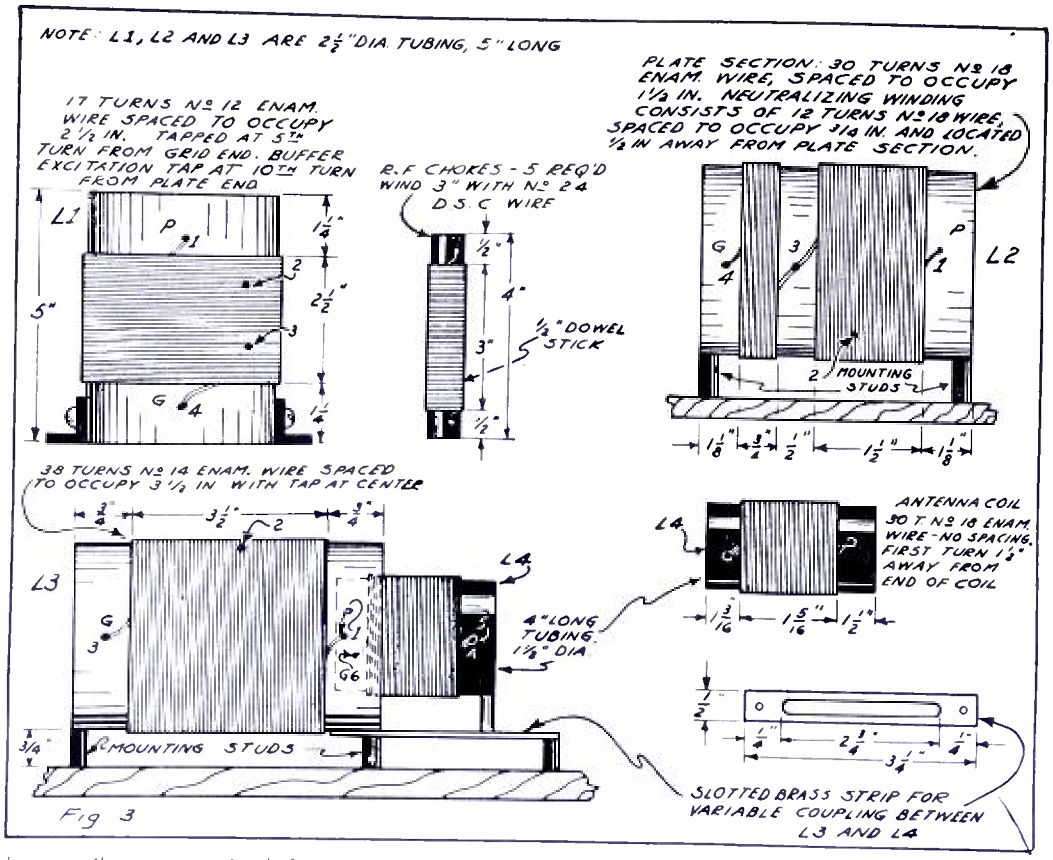
Next below this panel and shelf is the audio channel, and, when viewed from the front, as the others are, the microphone switch and gain control are located at the left of the panel while the volume level indicator meter is to the right. On the baseboard, from left to right, are located in order the microphone transformer T1, the interstage coupling transformer T2, the Class B input transformer T3, and the output Class B transformer T4. Behind the transformers are located the several audio tubes, as shown, while the Fahnestock clip connectors are



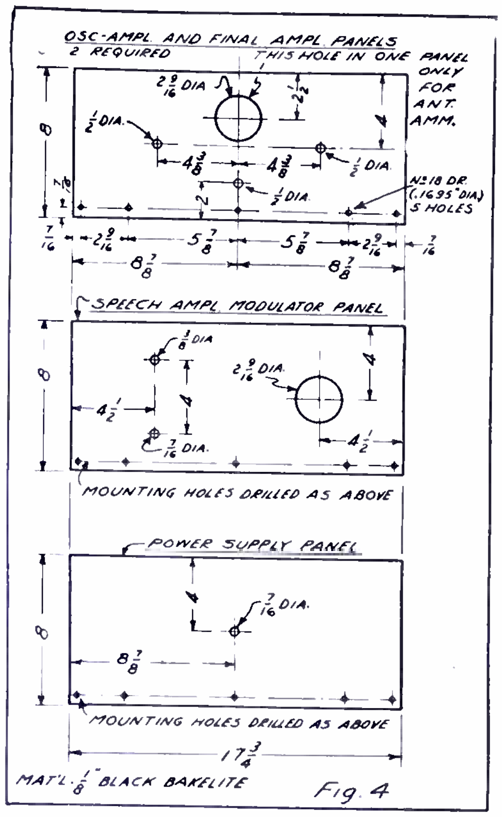
A top view of the dual power supplies.



A top view of the audio channel.



Four coils are required for the transmitter. Complete winding details together with the space sizes of the windings are given. Also is shown the method of mounting the antenna coupling coil, L4, on its slotted brass strip.



The several panels are laid out for drilling as shown above.

disposed along the rear edge of the baseboard.

The last and lowest shelf in the rack contains the dual power supply. Only the line switch is mounted on the panel, in the center. Along the front edge of the baseboard are the rectifier V10, power transformer T6, rectifier V9 and power transformer T5. Behind them are the filter units C16-C17-L6 and C14-C15-L5. The two voltage divider resistors R8 and R9, together with the Fahnestock clips for voltage supply, are located along the rear of the baseboard.

Only on this shelf alone was it found advisable to run the connecting wires underneath the baseboard. This was necessary because the power apparatus available at the time the transmitter was rebuilt was of the sub-panel construction type. If other parts allowing wiring above the baseboard are available, they may readily be used providing they meet the voltage requirements as outlined previously.

The circuit diagram Fig. 1 shows how the various shelves are interconnected. In a following article, full instructions for adjusting the transmitter preparatory to putting it on the air will be given, together with data on various types of antenna which may be found desirable for 160-meter operation.

One thing more. The coils employed were home-made and full details for winding them are given in Fig. 3. For those who wish to purchase their coil kit all ready for winding without the attendant trouble of drilling holes and purchasing an oversupply of wire, arrangements have been made with the firm mentioned in the list of parts to furnish a complete kit.

Aerial Kinks

THE twin problems of how to use two or more aerials with one short-wave receiver and two or more short-wave receivers with one aerial frequently arise.

The first is easy of solution. Simply take all the lead-ins from the respective aerials and connect them to the aerial binding post of the receiver. This sounds like terribly obvious advice, but many people seem to have the idea that special coupling coils are needed. The use of a number of aerials, running in different directions, is advantageous in some locations. At some experimental short-wave receiving stations three or four independent aerials, separated as much as several miles but feeding into a common receiver, have been found to compensate to a large extent for fading effects. The same signal may be fading when it hits one aerial but not another, and therefore good reception is sometimes obtained when a single aerial is useless.

To use more than one receiver with only one aerial, merely make connection between the sets and the aerial through small condensers. If the receivers are of the straight regenerative type, and already have antenna "trimmers" for the purpose of eliminating dead spots, no additional condensers are needed. The coupling condensers in any case may be of the "postage stamp" variety, with screw adjustment. The capacity is not at all critical and can readily be determined by experiment.

It is even possible to make the required loose coupling to the single antenna merely by wrapping a few turns of insulated wire from the set's aerial binding post around the lead-in wire. The capacity between the two wires is usually sufficient for a good transfer of energy.

Incidentally, the same trick can be applied effectively to an aerial already being used with a broadcast receiver. Many short-wave fans save themselves the expense of an extra aerial this way.

License Exams

PROSPECTIVE radio amateurs living in the southwest will be interested to learn that examinations for all classes of operator licenses will be held at 9 a.m., C.S.T., at the following points:

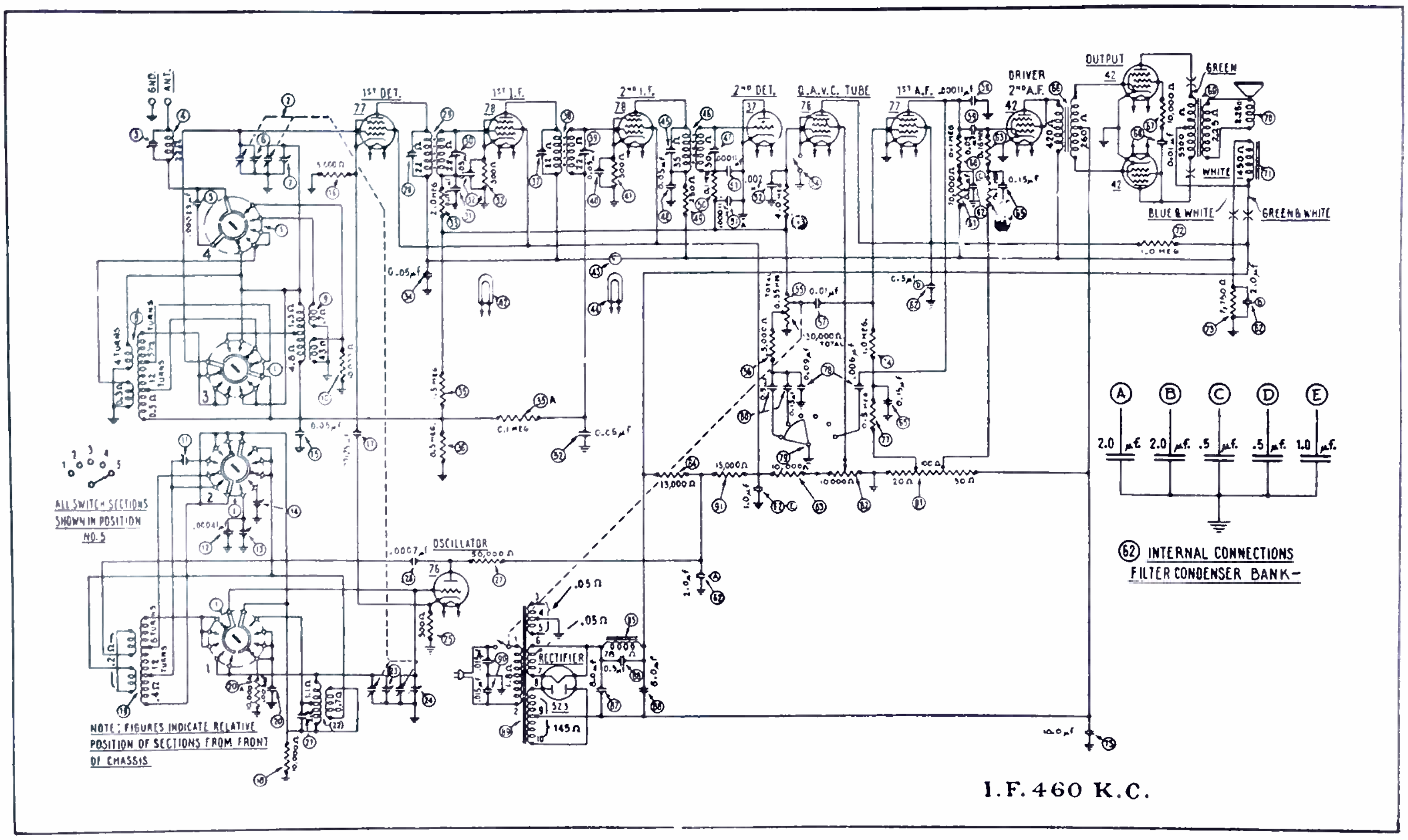
Oklahoma City, Okla., Civil Service Room Post Office Building. Examination days: February 2nd, May 4th, August 3rd, November 2nd.

San Antonio, Tex., Civil Service Room, Post Office Building. Examination days: March 2nd, June 1st, September 7th, December 7th.

Dallas, Tex., 464 Federal Bldg. Examination days: every Tuesday and Friday except when one of these days is a National holiday or when an examination is being held in San Antonio or Oklahoma City, as shown in the foregoing schedule.

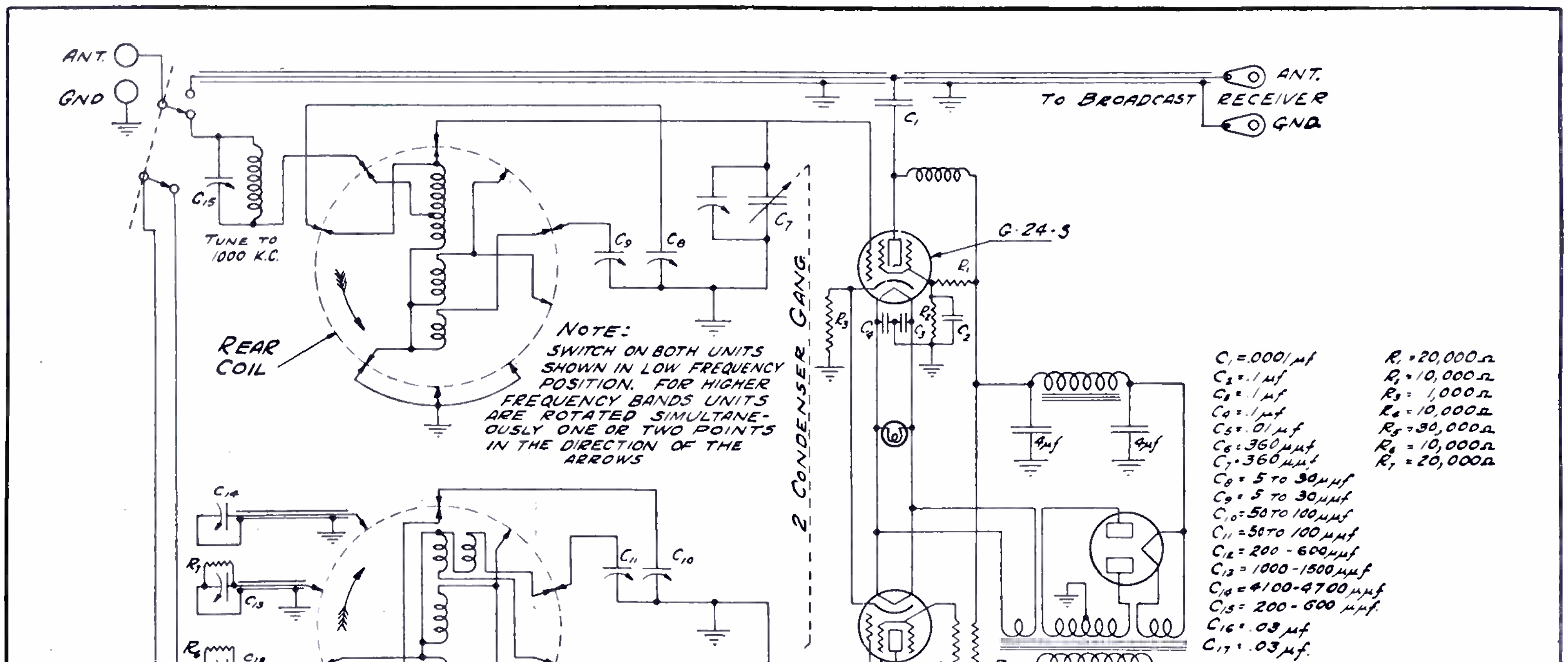
It is requested that each applicant notify the Federal Radio Commission, Division of Field Operations, 464 Federal Building, Dallas, Tex., in advance.

Philco Model 16 All-Wave Receiver



The Philco Model 16 all-wave receiver is an eleven-tube outfit of advanced design. All the tubes are of the 6.3-volt a.c. type, which seem to be replacing the 2.5-volt type in many sets. The combined output of the oscillator (76) and the first detector (77) feeds into a two-stage intermediate-frequency amplifier tuned to 460 kc. and using 78's. Quiet automatic volume control is provided by a 78.

Majestic Model 10 Short-Wave Converter



The Majestic Model 10 short-wave converter is a two-tube-plus-rectifier unit, completely self-contained and self-powered. When used with a broadcast receiver of the t.r.f. type, the combination becomes a superheterodyne; when used with an existing broadcast super, the combination is a sort of double super. The aerial change-over switch on the converter also acts as power switch for the receiver.

Single Side-Band Phone Signals

SUMMARY: *There are many people who, while tuning for signals, some across some that sound "neither here nor there." The voice is clear, but unintelligible. In some cases, the carrier disappears entirely when the voice stops; in other cases, the carrier remains.*

The article below discusses the general principles of single side-band transmission, and shows how they may be helpful to the transmitting phone amateur in minimizing interference on the 80- and 160-meter bands, which are now very badly overcrowded.

By Hy Levy

MANY listeners are not aware of the fact that transatlantic telephone communication is carried on by short-wave radio. In tuning over a band you may run across some speech that sounds as though it was being run through a meat grinder. You recognize the fact that it is speech, but it is impossible to understand any of it. The reason is very simple: if a person uses the telephone to speak to anyone in Europe, in all probability that person demands privacy. To insure privacy, the telephone company literally scrambles the speech before it goes over the air, and then unscrambles it again at the other end. This method is technically known as "inverted speech." Another method used to make the voice unrecognizable is to remove the carrier and/or one side band, which introduces a pile of distortion. It is this second, and rather unknown, method that will be simply analyzed here, since it offers a solution to the problem of amateur phone interference.

It is a simple matter to determine the difference between scrambled and single side-band transatlantic phone: if, during a short time that there is no speech, a carrier can be heard, then scrambled, or inverted, speech is being used; if the carrier cannot be heard, then single side-band phone is being used.

The 80 and 160 meter bands consist of frequency ranges of 3900 to 4000 kilocycles and 1800 to 2000 kilocycles, respectively. This means a frequency range difference of 100 kilocycles in the 80-meter band and 200 kilocycles in the 160-meter band. Now, if 10 kilocycles is sufficient separation between adjacent channels, there are available in the 80 meter band

$$\frac{4000-3900}{10},$$

or 10 channels; and in the 160 meter band,

$$\frac{2000-1800}{10}$$

or 20 channels. All told, there are 30 separate channels in these two bands with thousands of amateurs trying to occupy them at one time.

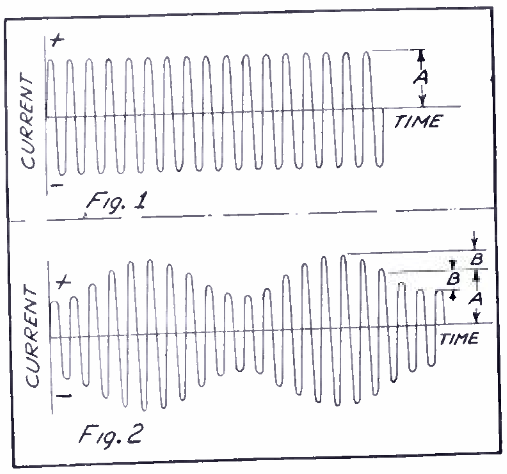
If we were to express, as a ratio, the number of stations working in these bands of frequencies to the number of channels available, or, in other words, the number of stations per channel, the ratio would be great in favor of the number of stations.

There are three methods of transmission used in present day communications:

1. The most common method of sending out transmitted waves, consisting of a carrier frequency and two side bands.
2. Transmitting the carrier frequency and only one side band (either one).
3. Suppressing the carrier and one side band (either one) and transmitting the remaining side band only.

The first is the well-known method used in radio broadcasting; the second is used mostly in carrier telephony; and the third, in carrier telephony and trans-oceanic communications. Considering the third method only, as it is the one we are interested in at present, it can be said that the method of suppressed-carrier single side-band transmission is by no means new. It has been used extensively in radio and telephony with a great deal of success for the past fifteen years, especially in carrier telephone systems and trans-oceanic communications. Single side-band transmission has a large number of advantages over ordinary methods of transmission, and also has certain disadvantages—if they could be called disadvantages—as will be seen in the following enumeration of both the advantages and so-called disadvantages of single side-band transmission. The advantages are:

1. There is a power saving of approximately 5/6 of the power required in the ordinary method of carrier transmission. This is so, because the carrier in ordinary methods of transmission represents about 2/3 of the radiated power, and the other 1/3 is present in the two side bands—each side band has 1/6 of the total power. If the carrier is suppressed, 4/6 of the power is immediately saved, and if one side band is also suppressed, another 1/6 of the power is done away with. In all, then, 4/6 plus 1/6, or 5/6, of the original power is saved. The remaining side band, therefore, can be radiated the same distance (or area) at a somewhat reduced intensity *with but 1/6 of the power necessary to transmit over the same distance using the carrier method of transmission.*
2. The channel width is cut in half, because only the one side band is transmitted, whereas the carrier method occupies the whole channel, since both side bands are transmitted. This makes it possible to have two stations on each channel with no interference between them; or, better still, if conditions allow, only one station need occupy each cannel, and by each transmitting either the upper or lower side band, practically no interference is set up.



This illustration shows, from top to bottom, an unmodulated and a modulated carrier, respectively. The percent modulation is the ratio B/A.

The so-called disadvantages are:

1. The necessity for extremely high-precision, tested apparatus, such as balanced modulators, local oscillators, and highly-selective filter circuits, which are needed for making this method of transmission effective.
2. The necessity for a separate, or local, oscillator of definite frequency and amplitude which is necessary for complete demodulation and recognition of the original signals at the receiving station.

However, it can be seen that if the apparatus mentioned above is obtained, or built, and meets the circuit requirements, the above disadvantages actually become advantages, as they make for a successful transmitter, creating no interference, and thereby answering the problems to be discussed here.

The method of suppressed-carrier, single side-band transmission is a subject that has not been discussed or written about to any great extent in the last few years. It would be advisable, then, to discuss briefly, and in order, the general theory of modulation, the production of side bands, and the principles of suppressed-carrier single

(*Continued on page* 39)

Grid-Bias Resistor Chart

TYPE	PLATE SUPPLY	SCREEN VOLTS	GRID VOLTS	GRID RESISTOR IN OHMS
1A6 (C)	180	67.5	-3.0 MIN.	810
2A3 (A)	250	—	-45	750
2A5 (A)	250	250	-16.5	407
2A6 (A) TRIODE	250	—	-1.35	3375
2A7 (C)	250	100	-3.0	526
2B7 (A) PENT. R.F.	100 250	100 125	-3.0 -3.0	400 265
2B7 (A) PENT. A.F.	250	50	-4.5	6925
6A4 (A) ALSO LA	100 180	100 180	-6.5 -12.0	613 480
6A7 (C)	250	100	-3.0	526
6B7 (A) PENT R.F.	100 250	100 125	-3.0 -3.0	4000 2650
6B7 (A) PENT A.F.	250	50	-4.5	6900
6F7 (A) TRIODE PENT AS AMPL.	100 250	— 100	-3.0 -3.0	857 375
6F7 PENT. AS MIXER	250	100	-10.0	2940
00A (D)	45	TO — FILAMENT		
01A (A)	90 135	— —	-4.5 -9.0	1800 3000
10 (A)	350 425	— —	-31.0 -39.0	1938 2165
WD-11, WX-12 (A)	90 135	— —	-4.5 -10.5	1800 3500
12A (A)	90 180	— —	-4.5 -13.5	900 1750
19 (B)	135 135	— —	0 -3.0	ZERO SEE TUBE CHART
120 (A)	90 135	— —	-16.5 -22.5	5500 3465
22 (A) RF	135 135	45 67.5	-1.5 -1.5	650 300
24A (A) R.F.	180 250	90 90	-3.0 -3.0	525 525
24A DET.	275	20 TO 45	-5.0 APPROX.	50,000
26 (A)	90 180	— —	-7.0 -14.5	2410 2320
27 (A)	135 250	— —	-9.0 -21.0	2000 406
27 DET.	250	—	-30.0	30,000
30 (A)	90 135 180	— — —	-4.5 -9.0 -13.5	1800 3000 4350
31 (A)	135 180	— —	-22.5 -30.0	2810 2940
32 (A) R.F.	135 180	67.5 67.5	-3.0 -3.0	1430 1430
32 DET.	180	67.5	-6.0 APPROX.	30,000
33 (A)	135	135	-13.5	770
34 (A) R.F.	135 180	67.5 67.5	-3.0 MIN.	790 790
35 (A) R.F.	180 250	90 90	-3.0 MIN.	341 333
36 (A) R.F.	100 180 250	55 90 90	-1.5 -3.0 -3.0	833 970 613
36 DET.	100 250	55 90	-5.0 -8.0	50,000 80,000
37 (A)	90 180 250	— — —	-6.0 -13.5 -18.0	2400 3140 2900
37 DET.	90 250	— —	-10.0 -28.0	50,000 140,000
38 (A)	100 180 250	100 180 250	-9.0 -18.0 -25.0	1100 1100 970
39-44 (A) R.F.	90 180 250	90 90 90	-3.0 MIN.	416 416 416
40 (A)	135 180	— —	-1.5 -3.0	7,500 15,000
41 (A)	100 180 250	100 180 250	-7.0 -13.5 -18.0	660 626 477
42 (A)	250	250	-16.5	407
43 (A)	100 135	100 135	-15.0 -20.0	625 487
45 (A)	180 250 275	180 250 275	-31.5 -50.0 -56.0	1015 1470 1500
46 (A)	250	—	-33.0	1500
46 (B)	300 400	— —	0 0	ZERO ZERO
47 (A)	250	250	-16.5	446
48 (A)	95 125	95 100	-20.0 -22.5	358 980
49 (A)	135	—	-20.0	350
49 (B)	180	—	0	ZERO
50 (A)	300 400 450	— — —	-54.0 -70.0 -84.0	1540 1270 1525
53 (B)	250 300	— —	0 0	ZERO ZERO
55 (A)	135 180 250	— — —	-10.5 -13.5 -20.0	3100 2250 2500
56 (A) 56 DET.	250 250	— —	-13.5 -20.0	2700 100,000
57 (A) R.F.	250	100	-3.0	1200
57 DET.	250	100	-3.9	4000
58 (A) R.F.	250	100	-3.0 MIN.	294
59 (A) TRIODE	250	—	-28.0	1080
59 (A) PENT.	250	250	-18.0	410
59 (B) TRIODE	300 400	— —	0 0	ZERO ZERO
71A (A)	90 180	— —	-19.0 -43.0	1900 2150
75 (A)	250	—	-1.35	3370
77 (A) R.F.	100 250	60 100	-1.5 -3.0	715 1035
77 DET.	250	50	-19.5	3000
78 (A) R.F.	90 180 250 250	90 75 100 125	-3.0 MIN.	435 600 333 222
79 (B)	180 250	— —	0 0	ZERO ZERO
85 (A) TRIODE	135 180 250	— — —	-10.5 -13.5 -20.0	2840 2250 2500
89 (A) TRIODE	160 180 250	— — —	-20.0 -22.5 -31.0	1175 1120 970
89 (A) PENT.	100 180 250	100 180 250	-10.0 -18.0 -25.0	900 780 665
89 (B) TRIODE	180	—	0	ZERO
UV-199, UX-199 (A)	90	—	-4.5	1800
864 (A)	90 135	— —	-4.5 -9.0	1550 2565

THE chart above was computed for experimenters who want a convenient reference for the determination of the proper grid-bias resistor for most of the tubes in common use today. The value of the bias resistor is given, not only for each tube, but for each different plate voltage recommended for each tube. To facilitate the use of the chart, the corresponding value of screen voltage is stated.

There are several abbreviations to be noted. The first is that some tubes may be used for a variety of purposes, and each purpose requires a different value of grid-bias resistor; an abbreviation—the letter in parentheses—has been used to designate the use of the tube:

(A) means class A amplifier.
(B) means class B amplifier.
(C) means converter—first detector in supers.
(D) means detector.

Aside from these general classifications, there are several tubes that may be connected so that they are triodes class A, pentodes class A, or triodes class B. These uses may be easily distinguished because of the wording, "triode, pent., or triode." Whether or not the triode is used as a class A or class B amplifier is represented by (A) or (B), respectively. For example, consider the type 89 tube: the values of grid-bias resistors corresponding to the various plate voltages preceded by the notation, "(A) triode," mean that when the type 89 power tube is connected for use as a triode class A amplifier, the values of grid-bias resistors are as shown alongside the corresponding values of plate voltage.

Then, too, there are other tubes which cannot be used—rather, are not recommended for use—in audio circuits. Such tubes are designated "(A) r.f."

A glance at the values of resistors recomemnded will show that their sizes are odd, and cannot be purchased in the open market. The values given are exactly those computed. Purchase resistors as close to those specified as possible.—*L.M.*

Where Does Noise Come From?

SUMMARY: *This masterly article describes the various causes and sources of noise in radio receivers, and pays particular attention to the little-known thermal agitation and "shot" effects. Since noise in short-wave reception has become the main limiting factor in set design, the information given herewith should be of timely interest and appeal.*

IT is well known that extraneous noise in the output of a radio receiver may be caused in several different ways. A few of these are:

(1) Atmospheric static
(2) Power supply noise
(3) Man-made static
(4) Poor connections
(5) Defective or poor quality parts

There are, however, other noise sources which persistently remain after the above sources have been eliminated. These become evident as a steady hissing sound when the receiver sensitivity is high. When an attempt is made to eliminate these sources of noise, it is found that a certain minimum remains which approaches the value predicted theoretically as due to thermal agitation and "shot" effect.

Thermal-agitation noise is supposed to be due to the random movements of electrons within a conductor. It has no particular frequency, but consists of a series of pulses.

Shot-effect noise is produced by the emission of electrons. Electricity is not an infinitely fine grained fluid, but consists of discrete particles, that is, electrons. From the theory of emission it can be predicted that a certain noise current is present in the electron current. This noise current consists of a series of pulses similar to the thermal-agitation effect.

On a purely theoretical basis, relations have been derived for calculating both the thermal-agitation voltage and the shot-effect voltage. Measurements show agreement between calculated and measured values.

Figure 1 shows a block diagram representing a receiver. Assume a standard signal applied to the receiver input. When the signal voltage is increased from zero, the a.f. output volts increase first as the square of the input voltage, then linearly with input voltage. This is true for diodes as well as other types of detectors. The range of square-law increase will depend on the type of detector. For a diode operated with a large input signal, the square-law range may be entirely negligible. In more modern receivers there is sufficient a.f. gain between the diode detector and the tube so that the output will be according to the square law at the 50-milliwatt output level. In general, we may say then, that at the initial noise level, a detector will follow the square law.

Frequently, a receiver has no noticeable noise until a carrier is tuned in. Figure 2 shows how the noise-output voltage and the a.f. output voltage increase as the carrier voltage is increased.

In the square-law range, the noise-output volts increase linearly, while the a.f. output increases according to the square law. In the linear range the noise-output volts are constant, while the a.f. output volts increase linearly.

The laws of increase of noise and a.f. voltage are different. As the signal is increased, both carrier volts and sideband volts increase proportionately. The noise-input volts existing independent of signal appear as a constant sideband voltage. In both instances the output is proportional to the product of the carrier voltage and the sideband voltage.

As the detection becomes linear the output is no longer proportional to the product of the voltages, but is directly proportional to the smaller of the two voltages and is independent of the magnitude of the larger voltage. Since the carrier is the larger voltage, increasing it does not increase the noise-output voltage. The increase in a.f. output voltage results because the sideband voltage is increased.

It is interesting to note that the ratio of noise-output volts to a.f. volts varies inversely as the signal-input voltage throughout the square law and linear range of operation.

It is evident that as the signal is increased, the noise will become a negligible factor and that as the signal is decreased the noise will eventually become greater than the a.f. output. This latter condition may occur at an inaudible level.

The noise voltage usually originates either in the grid circuit or in the plate circuit of the first tube. Under conditions of very low gain in these circuits, the second tube may also contribute to the noise.

Since the noise is a series of pulses it excites the associated circuits in the frequency range to which they respond. It is amplified by the succeeding stages provided they are in tune with the initial circuit either directly or through the medium of a frequency converter. For example, if the noise originates as a band of radio frequencies, it is changed by the converter just as any other signal is changed to the corresponding band of intermediate frequencies. Thus, the noise voltage appears at the detector input and also in the a.f. output, although it may be inaudible until sufficient carrier voltage is supplied at the detector input.

Effect of Circuit Constants

Refer to Figure 1 and suppose the input to the first tube is short-circuited so that only plate-circuit noise is amplified. Then, by adjusting Gain II the noise-voltage input to the detector may be made any value either large or small. Changing the plate-load impedance Z, has the same effect as changing Gain II. Both noise and signal are changed in the same ratio. Cutting the frequency band width either in the i.f. or a.f. stages gives a satisfactory apparent reduction in noise, since the ear is most sensitive to high frequencies. Of course, the higher a.f. components of the signal are reduced at the same time.

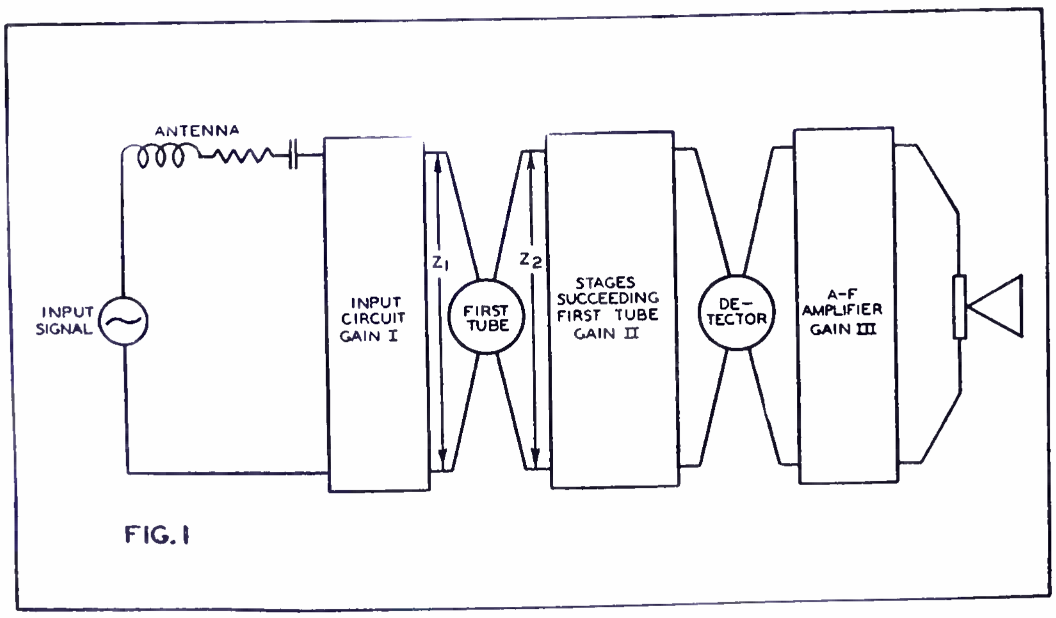


FIG. I

Block diagram of a typical receiver, arranged for purposes of noise analysis. High gain in the initial amplifier stages reduces the noise level. Z_1 and Z_2 are the respective input and output impedances of the first tube.

If the noise-volts input to the detector is low enough so that the detector becomes linear before the noise voltage reaches the audible level (approx. 0.1 volt across 4,000 ohms), no amount of increase in signal will produce audible noise. This is evident by referring to the curves of Fig. 2.

Theory shows that the shot voltage increases in proportion to the square root of the plate current of a tube. The variation of plate-circuit noise voltage with plate current is found to change in proportion to the square root of the plate current and to be almost independent of the plate, screen and grid voltage, and of whether or not the tube has oscillator-input voltage on it.

High gain in the first tube gives low output noise for any receiver sensitivity. For example, in a superheterodyne receiver, a first detector tube gives less gain for the same plate current than an amplifier tube. *Hence, for a given sensitivity, a set which uses a first detector in the first tube position will have more noise than a similar set which uses an amplifier.*

When gain is controlled in the first tube, the gain decreases faster than the square root of the plate current. That is, noise and gain are both decreased, but the gain is decreased more than the noise is decreased. *It would be advantageous then, as regards noise, to secure this decrease in gain in the succeeding stages.*

If the first tube can be operated at a fixed bias with small signal input, the lowest noise will be obtained by choosing a tube with high gain and low plate current, and by operating this tube at the highest value of plate current permissible. Operating with high plate current increases the gain more than it increases the noise. It is assumed that the plate resistance is not reduced enough to affect the results.

Similarly, if two or more tubes are put in parallel and the plate resistance remains high enough to be negligible, the gain will be increased n times, where n equals the number of tubes in parallel. The plate current is increased n times, also, and the noise is increased by the square root of n. The noise, for the same overall sensitivity, is thus reduced by a factor of one over the square root of n.—*RCA Radiotron Co., Inc.*

RELATIVE NOISE OUTPUT & A-F OUTPUT VS. CARRIER INPUT VOLTS FOR TYPICAL RADIO RECEIVER

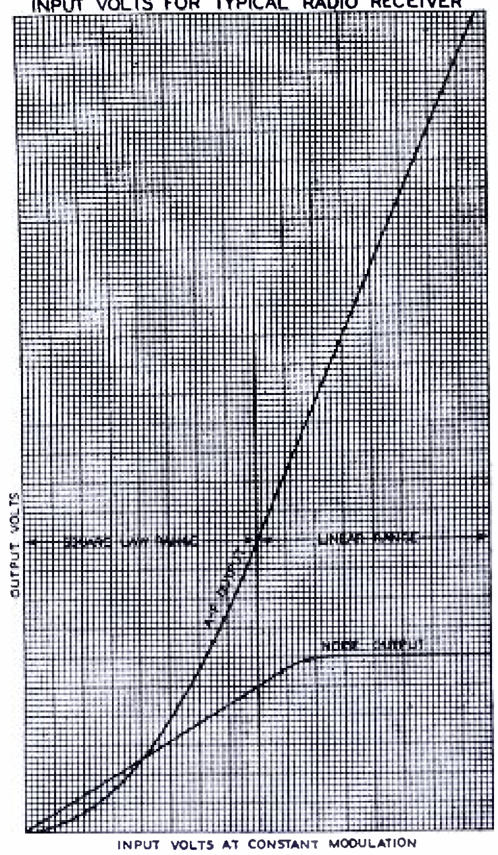


FIG. 2

Hum Elimination in AC-DC Receivers

SUMMARY: *The eight principal causes of hum in a.c.-d.c. receivers are described herein, and many practical suggestions for their cure are offered. Of course, the information given applies just as fully to straight a.c. short-wave receivers, many of which suffer from the very hum troubles mentioned.*

Mysterious "modulation hum", which is present only when signals are being received, is disclosed as a result of inadequate filtering.

THE continued popularity of the AC-DC receiver intensifies the necessity of more elaborate precautions to eliminate hum difficulties which arise in connection with the design and production of these receivers.

Hum may be divided into two classes: that which is present when no signal is being received and that which is apparent with an impressed signal.

The principal sources of hum when no signal is being received are:

(1) Unbalance in power supply to receiver.

(2) Insufficient filtering of rectified power.

(3) Heater cathode leakage.

(4) Inadequate by-passing of cathode resistors.

(5) Incorrect cathode resistor in detector-oscillator circuit.

(6) Coupling from oscillator to input of 2nd detector.

The principal sources of hum with signal tuned in:

(1) Reradiation from rectifier.

(2) Overloading of input stage with strong signal.

Hum caused by unbalance of the power line may be checked by reversing the line plug. If any difference in hum is noted, this indicates an unbalanced condition. This may usually be cured by employing a dual condenser, of about 0.1 mf. for each section, between each side of the line and the chassis.

Insufficient filtering is one of the most frequent sources of hum because of the limited space which can be used for filters in some sets. If a 12Z3 rectifier is employed the value of inductance or capacities should be increased if possible. If a 25Z5 is used as a half-wave rectifier with both cathodes in parallel, some improvement may be noted by separating the field of the speaker from the rest of the filter system. Under this condition one cathode supplies speaker excitation while the other supplies plate voltage for the tubes in the circuit. An advantage of this system is that the excitation and plate voltage may be adjusted independently by changing values of filter condensers.

The heater cathode leakage should be kept at a minimum in order to help reduce hum. Further reduction may be effected by making certain that the tubes most subject to hum have their heaters connected into the voltage supply in such a way as to be nearest the negative plate-supply terminal. Usually it will be found that the best arrangement is the following, starting from the negative plate-supply lead: 2nd detector, detector oscillator, output tube, to be followed by the remaining tubes. The series resistor usually should be connected to the side of the line feeding the rectifier plate or plates, followed by the rectifier heater. By-passing the cathode resistors of both the second detector and output tube with large capacity low voltage electrolytic condensers should aid in reducing hum content.

Many detector-oscillator circuits operate the detector-oscillator tube with a relatively low bias resistor in the cathode circuit (5000 ohms or less). This condition often leads to bad hum conditions since the peak oscillator voltage on the grid of this tube is considerably higher than the grid bias, causing grid current to flow during part of each cycle. Besides introducing hum this gives rise to poor selectivity and gain. It may be necessary to readjust the coupling in order to employ a resistance of the proper value (10,000 ohms).

Most broadcast receivers of this type utilize a 2-gang condenser and a circuit requiring a detector oscillator, an intermediate amplifier at 456 kilocycles, a second detector and an output tube, as well as a rectifier. In most cases the intermediate transformer is of the single-tuned type. With a set of this kind hum is often very troublesome at the low-frequency end of the dial, while it is satisfactory at the high-frequency end. This difficulty is usually due to the fact that sufficient attenuation is not available between the oscillator and the second detector to prevent

(*Continued on page 42*)

How Capt. Hall Obtained a Verification from Mussolini!

By Capt. H. L. Hall

whose reception is the envy of all who know him.

SOME time ago I wrote in an article that 2RO, Rome, Italy, was hard to hear and harder to hear from. Since that statement appeared I have had some "fine business" with them. Here is the story in detail:

Almost two years ago, when I decided to go after "veries" with a vengeance I described a program that I had heard transmitted from 2RO station and requested a verification. After waiting nearly two months, and not receving any reply, I wrote again. Still no answer. In all I wrote nine letters, each time including an international reply coupon. Each letter was written after an interval of about a month and after each letter my anger rose, until July 1933 it reached the "boiling point." At that time 2RO was the easiest of the foregn locals to hear. So one day I wrote down a program I heard and also wrote a letter. To the station? No! To Premier Benito Mussolini. In my letter I told him that I had sent nine letters to this Government-controlled station, also mentioning the reply coupons, and had never received an answer. I also wrote that I was not the only one who had experienced this discourtesy from this station. The letter, to put it plainly, was very "hot." After sending the letter off registered mail, with a return receipt required, I awaited further developments. In the middle of August the return receipt arrived signed, so someone had gotten the letter.

One day in November the mail included a legal looking envelope with "Consul General of Italy" written across the left-hand corner. The enclosed letter was from the Consul General of New York City and requested my presence at his office as he had something to tell me. I went there that same day and saw the Consul himself. He told me that he had a communication from Mussolini. To make a long story short, Il Duce himself had taken my letter and had given it to his secretary for a thorough investigation of conditions at 2RO. Among other things they found that the program I had enclosed was broadcast on that day, so this was a veri from Mussolini!

A Thorough Investigation

But they did not think that sufficient. They made a thorough investigation of why the station had not answered. The station's alibi was that they had never received any of my nine letters. So the Secretary forwarded all data to the Consul here and he was to find out further details from me. I told him that many fans had "black-balled" 2RO as one of the stations that did not answer. He said all information that I had given him would be forwarded to Italy, where the officials in Charge of Foreign Affairs would handle it. Said the Consul, "You will hear from us again."

Indeed I did hear from them again. About three months passed and I got another letter from the Consul and down to the office I went for the second interview. He said, "Premier Mussolini thanks you so much for writing him, because he is interested in just these things. His policy is to investigate the smallest complaints. May I add that he has employed at 2RO an Englishman to answer all correspondence. So tell your friends that 2RO will from now on answer all letters promptly and we are sorry for this misunderstanding."

And you who receive your new 2RO veries can thank Premier Mussolini for them. It is needless to say that when I wrote another letter to the station I received my veri in twenty-one days.

* * *

Bombay, India

BOMBAY! Bombay! Oh, what a place! People often ask me what thrilled me most when I came alongside of it and I always say Bombay. When my ship came within sight of that grand and truly Far Eastern City, I was like a child going to the circus for the first time. The buildings, the native dress of the peoples, and the innumerable religions that are such an interesting study in themselves all intrigued me. I could write pages about my impressions of Bombay.

Right now I correspond with a most interesting high caste gentleman of Bombay who is also a short-wave fan. His name is D. R. D. Wadia and he has initiated his charming wife into the secrets of his hobby. Together they tune and listen to programs from the old and new worlds. Mr. Wadia has heard every continent but North America and it would greatly thrill him to hear a station announcement from America. His "veries" include LSX, HVJ, VK2ME, VQ7LO, G5SW, FYA, PCJ and VU2BF.

Now about his receiver. He has used almost every standard commercially built receiver, but has been getting some of his best catches on an American superhet. He is a most excellent friend and I feel highly honored to list him as one of my correspondents.

Pictures of Mr. Wadia and his wife are reproduced here.

E.I.A.R. ENTE ITALIANO AUDIZIONI RADIOFONICHE ROMA

1RO 2RO

ORARIO TRASMISSIONI

ORA EUROPA CENTRALE (GREENWICH)

Egregio Signore,

Abbiamo verificato il vostro ascolto del giorno

e vi diamo conferma che la Stazione da Voi ricevuta, era 1RO m. 420,8 - 2RO m. 25,4 - 2RO m. 80.

Distinti saluti.

E.I.A.R.

Direzione Centro Radiofonico

Reproduction of the new verification card now sent to listeners who report reception of the popular Italian short wave station 2RO. A knowledge of Italian is necessary for an understanding of the card.

Mail From Readers

THE mail bag has been overflowing with letters from fans from all parts of the United States.

Mr. W. J. Rohrer of York, Pa., wrote of reception of PSK, on 36.65 meters. This is the station that radiates programs for the Radio Club of Brazil and is on 7 to 7.30 p.m. E.S.T. every night. Requests are asked for and a veri promised.

Edward Weppler of West Lafayette, Ind., reports excellent reception of the following: CP5, La Paz, Bolivia on 49.40 meters; HBJ, Bogota, Colombia, on 20.06 meters; KAY and KAX, Manila, P. I., working on 20.03 meters and 15 meters, respectively; LSN, Buenos Aires, on 30.3 meters; YV1BC, Caracas, Venezuela, on 50.20 meters; IRM Rome, Italy, on 30.52 meters, and ZFA, Bermuda on 59.4 meters.

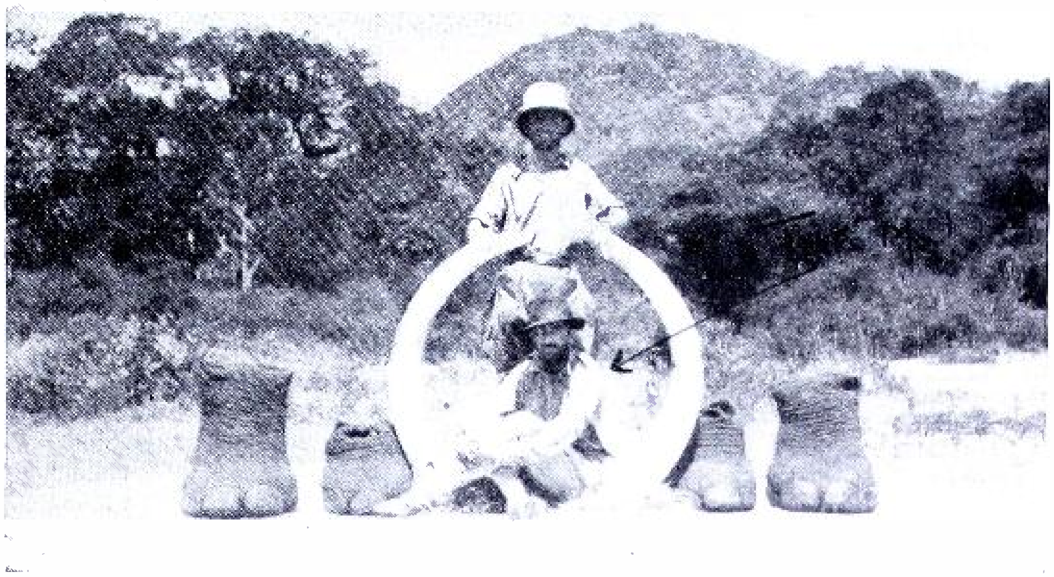
Most of these stations are commercial phone circuits and have no regular schedules and are on the air only when traffic permits.

How to Get Moscow

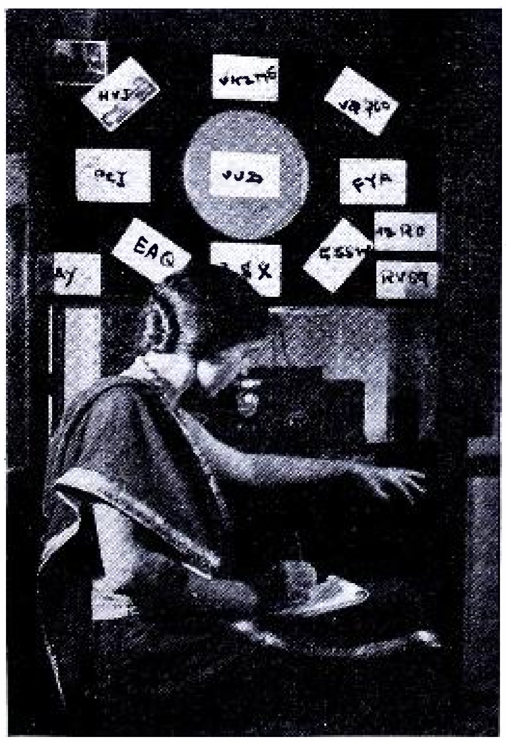
Mr. L. E. Goerner of Oberlin, Ohio, reports the impossibility of receiving Moscow. Maybe he does not have the latest dope on this catch. RV59 is on 50 meters from 4 to 6 p.m. E.S.T., and on Sunday RNE, on 25.00 meters, also transmits the same program. One is likely to hear RNE most any morning testing with America or Germany. RV59 is considered one of the foreign "locals" here in New York. We hear them best from about 4.45 to 6 p.m. It is easy to identify this station, as their broadcasts consist solely of talks in foreign languages. On Sunday, Wednesday and Friday, English is spoken. Station announcements are given at the even half hours and are as follows, "Hillo, Hillo. Here is Moscow." This is said several times by ether a lady or man announcer and the playing of the "International" follows. When writing to this station for a verification the address is "Radio Centre, Solianka 12 Moscow, U.S.S.R." Do *not* write Russia if you expect to have your letter delivered.

Mr. C. E. Schiller, of Muskogee, Okla., writes of regular reception of EAQ, TI4NRH, Pontoise, France; Germany, England, LSL, HRM, VK2ME, several phones and the Byrd Expedition. This fan is using a seven-tube, all-wave super.

Mr. H. N. C. of Poughkeepsie, N. Y., wrote asking about 2RO, Rome, Italy. I think this article will clear up his question. If not fire them along.



Mr. D. R. D. Wadia, short-wave enthusiast of Bombay, is also an accomplished hunter, as this photograph received by Capt. Hall shows. Judging from the size of the tusks and hoofs, that must have been one big elephant!



Mrs. D. R. D. Wadia is also a capable short-wave operator. Here she is listening to an American superheterodyne. On the loudspeaker baffle in the background are some of the verification cards received by Mr. Wadia.

Short Waves in the Evening

Frank Gillelen, Jr., of San Diego, Cal., "razzs" me for saying it is possible to get stations on the low waves in the evenings. I do not know about reception in California but here in New York we heard Germany on 19 meters until 9.30 p.m., France on 25 meters until midnight, England on 79 meters and numerous 20-meter phones until the sun comes up, every night last summer. Let us hear your ideas on this subject.

W. B. Taylor of Harrison, N. J., reports reception of EAQ: Germany, Australia and England.

Guy R. Bigbee, Fort Benning, Georgia, wants to know why I said W2XE blanketed my reception of F3ICD, Saigon, Indo-China. F3ICD has been off the air for almost two years and when I was hearing them W2XE used to come on the air with all its power and drowned out all hope of further reception of this Far Eastern station.

Kenneth Pratt, of Milton, Mass., requests the address of G6RX, the English phone heard on 69.44 meters. It is: Engineer-in-Chief's Office, General Post Office (Radio section) 86 Wood Street, London E.C. 2.

This correspondent also wants to know the call letters of the Japanese station mentioned in a previous article. It is JOGK, a 10 kw. station on Kyushin Island.

* * *

New Catches

NEW catches by the writer were: "Radio Budapest," sending a special program on 43.86 meters, call letters HAT2.

"Radio Kopek," on about 50.00 meters, sending a special broadcast to India from 3.15 to 5.41 p.m., E.S.T.

"Radio Vienna" or UOR2 on Sunday. Full details in next article.

Heard for the past month: Germany, France, Spain, Morocco, Russia, Australia, Dutch East Indies, South America, Canada and Nova Scotia. Try for HC2RL, Guayaquil, Ecuador; Schedule 5.45 to 8 p.m., E.S.T. on Sunday, and 9.15 to 10.45 on Tuesday.

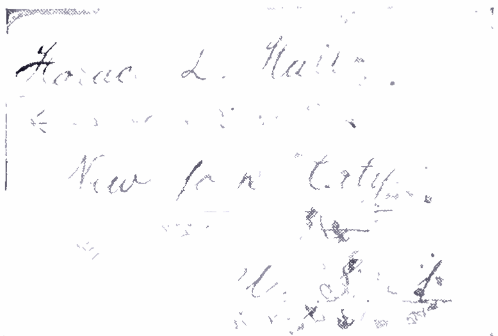
* * *

A Friend in Japan

SIX thousand eight hundred and fifty miles from New York City lives a man who has become one of the best friends I have. His name is Shokichi Yoshimura and he lives in Moji, Japan. He has a collection of "veries" that is astonishing and every letter he writes tells of his new "finds" on the ether waves. We short-wave fans in the United States are principally interested in pulling in stations in foreign countries, but Mr. Yoshimura is thrilled when he catches a United States or South American station. He uses a superheterodyne converter which is attached to a regular broadcast receiver. This converter uses 224's, 227's, and a 280.

He has been an ardent tuner for several years and in his spare time he is also a licensed amateur and a member of the J.A.R.L. This alone

Above: Shokichi Yoshimura and his wife, of Moji, Japan, two more of Capt. Hall's long distance friends. Below: a unique souvenir from Mr. Yoshimura—Capt. Hall's name in English and Japanese.



makes him an important figure, as to acquire an amateur license in Japan is quite difficult and to keep one is still more difficult. The rules and regulations to be complied with in order to be an amateur in Japan are stricter, from an American's viewpoint, than in any other country in the world. Mr. Yoshimura, in other words, is a real ham and short wave enthusiast.

Photographs of his city, which by the way is known as the Holy Place Moji, give one a very vivid picture of the beautiful country Japan really is. I have been to Tokio, which is a seaport city, and it has acquired the customs of the Western world to a large degree. When I was there it was during one of my round-the-world trips as Master of a large ocean-going tramp ship which carries millions of dollars' worth of cargo to the Far East. Among my ports of call were many cities that now have short-wave radio stations and when I tune in these distant places I can close my eyes and vision them.

SEND IN REPORTS

As the United States is a big country, and reception conditions vary markedly in different locations, Capt. Hall would like to receive reports from other short-wave listeners, so that he may collate them for the benefit of all readers. Capt. Hall does all his listening in New York, and he is particularly anxious, therefore, to learn what general results are being obtained on the West Coast. Address your letters to Capt. Hall in care of SHORT WAVE RADIO, 1123 Broadway, New York, N. Y.

Please do not ask Capt. Hall to pass opinion on different makes or kinds of radio receivers.

Suggestions on Tuning

The Matter of Comfort

Many otherwise excellent short-wave receivers have their main tuning knobs too high on the panel, and the operator, in many cases, is forced to twist his hands into strained positions in order to manipulate the controls. To overcome this trouble, it is sometimes advisable to place a couple of books in front of the set, on which the hands may be rested in a normal, comfortable manner.

This sounds like a small matter, but a set of strained wrist and forearm muscles is likely to take all the joy out of foreign-station fishing.

Incidentally, a good kink in this connection is to replace small tuning knobs with man-sized knobs an inch and a half or more in diameter. These avoid cramping of the fingers and give a sort of extra vernier action. The General Radio "jumbo" knob, which is $2\frac{3}{8}$ inches in diameter, is swell for the purpose.

Practically all control shafts are $\frac{1}{4}$ inch in diameter, and installing a new knob is only a matter of one minute's work with a small screwdriver.

* * *

Those Harmonics Again!

Newcomers to the short-wave field are invariably fooled by foreign-language programs broadcast by small stations in big cities like New York, Philadelphia and Chicago. These programs are spuriously scattered into the short-wave regions as unwelcome harmonics of the regular broadcast-band transmitter. Just because you hear someone spouting in German, Italian, Spanish, or Bohemian, don't jump to the conclusion that you have brought in Europe. Wait for a final announcement, which, disappointingly enough, may be in good Americanese!

By the same token, don't attempt to identify legitimate short-wave stations according to the language used by the announcer. Many of the European stations, which are frankly operated for propaganda purposes, put on special programs and announcers for the particular benefit of certain foreign countries. For instance, the Berlin stations DJA and DJC frequently have long talks in Spanish, and even a knowledge of that language will not always enable you to guess the source of the program until it is all over, when an announcement is made in German and then in English.

When PCJ, the Philips Radio station in Eindhoven, Holland, was active a few years ago, it had a versatile announcer, Edward Startz by name, who fluently spoke six or seven tongues. There was never any difficulty about identifying PCJ, for no matter where you lived or were educated you were bound to understand at least one of the announcements! This was probably the reason PCJ was the most popular and widely followed short-wave station on the air. Its present absence from the air waves, reputedly due to political reasons, is certainly lamentable.

* * *

Airplane Call Letters

A number of readers have inquired as to why the operators of airplane radio transmitters never give their call letters, as other stations do. The answer is that mobile craft of this kind have five-letter calls, many of which are real tongue-twisters. By special dispensation of the Federal Radio Commission, the operators are not required to use them when engaged in communication with their ground dispatchers. Planes flying established routes are easily identified by the ground operators according to their numbers and the names of the pilots, and the official call letters, therefore, are not very important.

* * *

Keep a Log

Too many listeners depend upon their memory for dial settings of important foreign stations. Every set owner should maintain a "log" of some kind, if it is only a ten-cent ruled notebook.

Several different methods of listing are possible. Some fans arrange their "catches" according to either wavelength in meters or frequency in kilocycles (depending on how the set dial is calibrated), with different sections for each wave band. Other people arrange the calls according to countries. Another popular method is by the hours of the day. Some methodical set owners who take pride in their international reception have two separate logs, so that they can spot dial settings easily and quickly.

* * *

C. W. Reception

Because some short-wave superheterodynes designed especially for broadcast reception do not incorporate local oscillators, some people have the idea that these sets are not capable of picking up c.w. (continuous wave) telegraph stations.

Theoretically, it should not be possible to receive such stations, but a peculiar heterodyning effect takes place between stations on neighboring frequencies, with the result that strong signals appear in the receiver. Besides, some commercial radio-telegraph stations transmit modulated signals, which are reproduced quite well without the aid of a local oscillator.

* * *

A. V. C. Noise

In some receivers employing automatic volume control, there appears to be excessive noise between stations, because the absence of a carrier causes the sensitivity or gain to rise to maximum automatically.

Best Short Wave Stations

The list of stations below has been compiled directly from the log of Capt. Hall. The column to the left is the wavelength, the letter to the right indicates the type of transmission, and the location and operating time follow. The operating time is liable to change from day to day, so that those listed may only be used as a guide. All times given are E.S.T.

World wide stations that send programs, B, Broadcast; E, Experimental; P, Telephone stations.

Europe

16.30, P, PCK, Kootwijk, Holland, about 6.30 a.m.
16.86, B, GSG, Daventry, England, 7.30 to 8.45 a.m.
16.88, B, PHI, Huizen, Holland, 7 to 9 a.m., irregular.
19.55, B, CTIAA, Lisbon, Portugal, Tuesday and Friday, 4.30 to 7 p.m.
19.68, B, Pontoise, France, 8 to 11 a.m.
19.73, B, DJB, Zeesen, Germany, 8 to 12 a.m.
19.82, B, GSF, Daventry, England, 3 to 5 a.m.
19.84, B, HVJ, Vatican City, Italy, 10 to 10.30 a.m.
25.20, B, Pontoise, France, 11 to 2 p.m.
25.28, B, GSE, Daventry, England, 7.30 to 8.45 a.m. and 4 to 6 p.m.
25.40, B, 2RO, Rome, Italy, 2 to 6 p.m.
25.51, B, DJD, Zeesen, Germany, 2 to 6 p.m.
25.53, B, GSD, Daventry, England, 3 to 5 a.m., and 1.15 to 2.45 p.m.
25.57, B, PHI, Huizen, Holland, 8 to 10 a.m.
25.63, B, Pontoise, France, 3 to 5 and 6 to 8 p.m.
29.04, Ruysselede, Belgium, 1 p.m. on.
30.00, B, EAQ, Madrid, Spain, 5.30 to 7 p.m.
31.27, B, HBL, Geneva, Switzerland, Sat. 5 to 5.45 p.m.
31.30, B, GSC, Daventry, England, 6 to 8 p.m.
31.38, B, DJA, Zeesen, Germany, 2 to 6 p.m.
31.55, B, GSB, Daventry, England, 11 a.m. to 1 p.m., 1.15 to 2.45 p.m., 6 to 8 p.m.
43.86, HAT2, Budapest, Hungary, irregular. No time schedule.
45.38, B, REN, Moscow, Russia, 2 to 6 p.m.
49.50, B, OXY, Skamleback, Denmark, 2 to 6 p.m.
49.59, B, GSA, Daventry, England, 2.45 to 5.45 p.m., 6 to 8 p.m.
49.83, B, DJC, Zeesen, Germany, 7 to 9 p.m.
50.00, B, RV59, Moscow, Russia, 4 to 6 p.m.
50.26, B, HVJ, Vatican City, Italy, very irregular.
60.30, E, G6RX, Rugby, England, 8 to 10 p.m., irregular.
69.44, E, G6RX, Rugby, England, 9 to 11 p.m., irregular.

Asia

16.50, P, PMC, Bandoeng, Java, 3 to 5 p.m., irregular.
19.03, E, JIAA, Kemikawa, Japan, 4.30 a.m., irregular.
20.03, P, KAY, Manila, Phillippine Isl., 5 to 8 a.m.
28.80, P, UIG, Medan, Sumatra, 4 to 5 a.m.
30.40, E, JIAA, Kemikawa, Japan, 5 to 7 a.m.
48.90, B, ZGE, Zula Lumper, Malayan States, Sun., Tues., Fri., 6.30 to 8.30 p.m.
49.10, B, VUC, Calcutta, India, 9.12 a.m. and 2 p.m. to 3 a.m.
71.00, B, RV15, Khabarovsk, Russia, 3 to 9 a.m.

Africa

23.38, B, CNR, Rabat, Morocco, Sun., 7.30 to 9 a.m.
29.58, P, OPM, Leopoldville, Belgian Congo, 9 to 10 a.m.
37.33, B, CNR, Rabat, Morocco, Sun., 3 to 5 p.m.
41.60, B, EAR58, Tenerffe, Canary Isl., 5 to 6 p.m.
48.99, B, Johannesburg, South Africa, 4 to 5 a.m., 12 to 3 p.m., and 8 to 10 a.m.
49.50, B, VQ7LO, Nairobi, Kenya, 11 a.m. to 2 p.m.

North America

16.87, B, W3XAL, Bound Brook, N. J., 10 a.m. to 4 p.m., irregular.
19.56, B, W2XAD, Schenectady, N. Y., Mon., Wed., Fri. and Sun., 4 to 5 p.m.
19.64, B, W2XE, Wayne, N. J., 11 a.m. to 1 p.m.
19.67, B, W1XAL, Boston, Mass., 11 a.m. to 3 p.m., Sun.
19.72, B, W8XK, Pittsburgh, Pa., 10 a.m. to 4 p.m., irregular.
25.27, B, W8XK, Pittsburgh, Pa., 4 to 10 p.m., irregular.
25.36, B, W2XE, Wayne, N. J., 5 to 6 p.m. and 6 to 10 p.m.
25.45, B, W1XAL, Boston, Mass., Sat., 5 to 11 p.m., and Sun. 6 to 8 p.m.
31.28, B, W3XAU, Philadelphia, Pa., 1 to 6 p.m.
31.36, B, W1XAZ, Springfield, Mass., 8 a.m. to mid.
31.48, B, W2XAF, Schenectady, N. Y., 8 to 11 p.m.
46.69, B, W3XL, Bound Brook, N. J., irregular.
48.86, B, W8XK, Pittsburgh, Pa., 4 p.m. to 1 a.m.
49.02, B, W2XE, Wayne, N. J., 6 to 11 p.m.
49.19, B, W3XAL, Bound Brook, N. J., Sat. 4.30 to 12 p.m.
49.18, B, W9XF, Chicago, Ill., 8 to 9.30 p.m.
49.34, B, W9ZAA, Chicago, Ill., 3 to 6 p.m.
49.50, B, W3XAU, Philadelphia, Pa., 8 to 12 p.m., irregular.
49.50, B, W8XAL, Cincinnati, Ohio, 9 to 10 p.m.

South America

19.19, P, OCJ, Lima, Peru, 2 p.m. irregular.
25.73, E, PPQ, Rio de Janeiro, Brazil, 7 p.m., irregular.
27.35, P, OCI, Lima, Peru, 10 p.m., irregular.
28.98, E, LSX, Buenos Aires, Argentina, 8 to 9.30 p.m., irregular.
30.03, E, LSN, Buenos Aires, Argentina, 9 to 10 p.m., irregular.
32.00, B, Ti4NRH, Costa-Rica, 8 to 10 p.m.
31.56, B, YV3BC, Caracas, Venezuela, 9.30 to 10.30 p.m.
36.65, E, PSK, Rio de Janeiro, Brazil, 8 p.m., irregular.
40.55, E, HJ3ABD, Bogota, Colombia, 9 to 11 p.m.
41.55, B, HKE, Bogota, Colombia, Mon. 6 to 7, p.m. and Tues. 8 to 9 p.m.
41.60, B, HJ4ABB, Manizales, Colombia, 9 to 10 p.m.
45.00, B, HC2RL, Quito, Ecuador, Sun. 5 to 7 and Tues. 9 to 11 p.m.
45.31, B, PRADO, Riobamba, Ecuador, Thurs. 9 to 11 p.m.
45.60, B, HJ1ABB, Barranquilla, Colombia, 6 to 10 p.m.
47.00, B, HJ5ABD, Colombia, Thurs., Sat. and Sun., 7 to 9.30 p.m.
48.00, B, HJ3ABF, Bogota, Colombia, 7 to 10.30 p.m.
48.50, B, TGW Guatemala, 6-12 p.m.
48.78, B, YV3BC, Caracas, Venezuela, 6.30 to 10 p.m.
48.95, B, YV11BMO, Maracaibo, Venezuela, 8 to 11 p.m.
50.20, B, YV1BC, Caracas, Venezuela, 5 to 10 p.m., irregular.
50.20, B, HJ4ABE, Tunga, Colombia, 9 to 10.30 p.m.
73.00, B, HCJB, Quito, Ecuador, 7.30 to 9.45 p.m.

Mexico, West Indies, and Yucatan

25.50, P, XDM, Mexico City, Mexico, 8 to 9 p.m., irregular.
26.00, E, XAM, Merida, Yucatan, 6 to 7 p.m. irregular.
32.09, E, XDC, Mexico City, Mexico, 5 to 7 p.m., irregular.
47.50, B, HIZ, Santo Domimgo, 5 to 6 p.m.
47.80, B, HI1A, Dominican Republic, Mon., Wed. and Fri. 12 to 1.30 p.m. Tues., Thurs. and Sat. 7.30 to 9.30 p.m.
50.40, B, HIX, Santo Domingo, Tues. 8 to 10 p.m., and Sun. 2.30 to 4.30 p.m.

Oceanic

31.28, B, VK2ME, Sydney, Australia, Sun. 1 to 3 a.m., 5 to 8.30 a.m., and 9 to 11 a.m.
31.55, B, VK3ME, Melbourne, Australia Wed. 5 to 6.30, Sat. 5 to 7 a.m.

Canada

25.60, B, VE9JR, Winnipeg, Canada, 6 to 10 p.m., irregular.
49.10, B, VE9HX, Halifax, N.S., 8 to 11 p.m., 5 to 10 p.m.
49.22, B, VE9GW, Bowmanville, Canada, 3 to 6 p.m. daily.
49.29, B, VE9BJ, St. John, N. B., 5 to 10 p.m.
49.42, B, VE9CS, Vancouver, B.C., Fri. 12 to 1.30 p.m.
49.96, B, VE9DR, Montreal, Canada, 8 to 10 a.m., Sun 1 to 10 p.m.

NOTE: All times given are approximate and subject to change.

SHORT WAVE RADIO'S

Short-Wave Station List

THE following list, conveniently arranged alphabetically according to call letters, represents practically all the short-wave stations of the world, except amateur, that use voice transmission and are therefore recognizable by listeners who do not know the code. In most cases the frequency in kilocycles, the corresponding wavelength in meters, and the location by city are given; the country of origin, where it is not obvious, may quickly be determined from the preliminary list of international call letter assignments. Amateur and some special experimental calls consist of the assigned prefix, followed by a number and two or three letters.

Stations listed as "experimental" change around a great deal and may use code or voice; definite frequencies cannot be given for them.

No attempt has been made to include operating schedules in this list, as a great majority of the stations are experimental in nature, and have the habit of changing announced programs without warning. Up-to-the-minute information on the best stations of the month is contained in another department in this issue.

For the sake of brevity, a number of abbreviations of operating company names are used. These are RCA, Radio Corporation of America; GPO, General Post Office; BBC, British Broadcasting Corporation; CBS, Columbia Broadcasting System; NBC, National Broadcasting Company; GE, General Electric Company; ATT, American Telegraph & Telephone Co.; MRT, Mackay Radio Telegraph Co; MIT, Mass. Institute of Technology.

List of International Call Assignments

Block of Calls	Country	Amateur Prefix
CAA-CEZ	Chile	CE
CFA-CKZ	Canada	VE
CLA-CMZ	Cuba	CM
CNA-CNZ	Morocco	CN
CPA-CPZ	Bolivia	CP
CQA-CRZ	Portuguese colonies:	
	Cape Verde Ids.	CR4
	Portuguese Guinea	CR5
	Angola	CR6
	Mozambique	CR7
	Portuguese India	CR8
	Macao	CR9
	Timor	CR10
CSA-CUZ	Portugal:	
	Portugal proper	CT1
	Azores	CT2
	Madeira	CT3
CA-CVZ	Rumania	CV
CWA-CXZ	Uruguay	CX
CZA-CZZ	Monaco	CZ
D	Germany	D
EAA-EHZ	Spain	EAR
EIA-EIZ	Irish Free State	EI
ELA-ELZ	Liberia	EL
ESA-ESZ	Esthonia	ES
ETA-ETZ	Ethiopia (Abyssinia)	ET
F	France (including colonies):	
	France proper	F
	French Indo-China	FI
	Tunis	FM4
	Algeria	FM8
G	United Kingdom:	
	Great Britain except Ireland	G
	Northern Ireland	GI
HAA-HAZ	Hungary	HA
HBA-HBZ	Switzerland	HB
HCA-HCZ	Ecuador	HC
HHA-HHZ	Haiti	HH
HIA-HIZ	Dominican Republic	HI
HJA-HKZ	Colombia	HJ
HRA-HRZ	Honduras	HR
HSA-HSZ	Siam	HS
I	Italy and colonies	I
J	Japan	J
K	United States of America:	
	Continental United States	W
	Philippine Ids.	KA
	Porto Rico and Virgin Ids.	K4
	Territory of Hawaii	K6
	Territory of Alaska	K7
LAA-LNZ	Norway	LA
LOA-LVZ	Argentine Republic	LU
LZA-LZZ	Bulgaria	LZ
M	Great Britain	G
N	United States of America	W
OAA-OCZ	Peru	OA
OFA-OHZ	Finland	OH
OKA-OKZ	Czechoslovakia	OK
ONA-OTZ	Belgium and colonies	ON
OUA-OZZ	Denmark	OZ
PAA-PIZ	The Netherlands	PA
PJA-PJZ	Curacao	PJ
PKA-POZ	Dutch East Indies	PK
PPA-PYZ	Brazil	PY
PZA-PZZ	Surinam	PZ
RAA-RQZ	U. S. S. R. ("Russia")	RA
RVA-RVZ	Persia	RV
RXA-RXZ	Republic of Panama	RX
RYA-RYZ	Lithuania	RY
SAA-SMZ	Sweden	SM
SPA-SRZ	Poland	SP
STA-SUZ	Egypt:	
	Sudan	ST
	Egypt proper	SU
SVA-SZZ	Greece	SV
TAA-TCZ	Turkey	TA
TFA-TFZ	Iceland	TF
TGA-TGZ	Guatemala	TG
TIA-TIZ	Costa Rica	TI
TSA-TSZ	Territory of the Saar Basin	TS
UHA-UHZ	Hedjaz	UH
UIA-UKZ	Dutch East Indies	PK
ULA-ULZ	Luxemburg	UL
UNA-UNZ	Yugoslavia	UN
UOA-UOZ	Austria	UO
UWA-VGZ	Canada	VE
VHA-VMZ	Australia	VK
VOA-VOZ	Newfoundland	VO
VPA-VSZ	British colonies and protectorates:	
	British Guiana	VP
	Fiji, Ellice Ids., Zanzibar	VPI
	Bahamas, Barbados, Jamaica	VP2
	Bermuda	VP9
	Fanning Id.	VQ1
	Northern Rhodesia	VQ2
	Tanganyika	VQ3
	Kenya Colony	VQ4
	Uganda	VQ5
	Malaya (including Straits Settlements)	VS1-2-3
	Hongkong	VS6
	Ceylon	VS7
VTA-VWZ	British India	VU
W	United States of America:	
	Continental United States	W
	(for others, see under K.)	
XAA-XFZ	Mexico	X
XGA-XUZ	China	AC
YAA-YAZ	Afghanistan	YA
YHA-YHZ	New Hebrides	YH
YIA-YIZ	Iraq	YI
YLA-YLZ	Latvia	YL
YMA-YMZ	Danzig	YM
YNA-YNZ	Nicaragua	YN
YSA-YSZ	Republic of El Salvador	YS
YVA-YVZ	Venezuela	YV
ZAA-ZAZ	Albania	ZA
ZBA-ZHZ	British colonies and protectorates	
	Transjordania	ZC1
	Palestine	ZC6
	Nigeria	ZD
	Southern Rhodesia	ZE1
ZKA-ZMZ	New Zealand:	
	Cook Ids.	ZK
	New Zealand proper	ZL
	British Samoa	ZM
ZPA-ZPZ	Paraguay	ZP
ZSA-ZUZ	Union of South Africa	ZS ZT ZU

STATIONS ALPHABETICALLY BY CALL LETTERS

—C—

CEC 10,670 kc., 28.12 m.
15,860 kc., 18.91 m.
19,690 kc., 15.24 m.
Santiago, Chile
CFA 6,840 kc., 43.8 m.
Drummondville, Quebec, Canada
CGA 4,780 kc., 62.7 m.
13,340 kc., 22.55 m.
13,750 kc., 21.82 m.
9,330 kc., 32.15 m.
18,170 kc., 16.5 m.
Quebec, Canada
CM6XJ 15,000 kc., 19.99 m.
Central Tuinucu, Cuba
CMCI 6,060 kc., 49.5 m.
Havana, Cuba
CN8MC 6,250 kc., 48 m.
Casablanca, Morocco
CNR 8,050 kc., 37.33 m.
9,300 kc., 32.26 m.
12,880 kc., 23.38 m.
Rabat, Morocco, Africa
CT1AA 6,990 kc., 42.9 m.
9,600 kc., 31.25 m.
Lisbon, Portugal
CT3AQ 11,181 kc., 26.33 m.
Funchal, Madeira

—D—

DAF 8,470 kc., 35.42 m.
12,400 kc., 24.19 m.
17,270 kc., 17.37 m.
Norden, Germany
DAN 11,340 kc., 26.44 m.
Nordeich, Germany
DFA 4,400 kc., 68.17 m.
19,240 kc., 15.58 m.
DFB 18,520 kc., 17.12 m.
DGK 6,680 kc., 44.91 m.
DGU 9,620 kc., 31.2 m.
DHC 11,435 kc., 26.22 m.
DHO 20,040 kc., 14.97 m.
DIH 19,950 kc., 15.03 m.
DIQ 10,290 kc., 29.15 m.
DIS 10,150 kc., 29.54 m.
Nauen, Germany
DJA 9,560 kc., 31.38 m.
Konigswusterhausen, Germany
DJB 15,200 kc., 19.73 m.
DJC 6,020 kc., 49.83 m.
DJD 11,760 kc., 25.51 m.
Zeesen, Germany
DOA 7,230 kc., 41.46 m.
7,390 kc., 37.8 m.
4,430 kc., 67.5 m.
3,620 kc., 82.9 m.
Doeberitz, Germany

—E—

EAJ25 6,000 kc., 50 m.
Barcelona, Spain
EAR110 6,980 kc., 43.0 m.
Madrid, Spain
EAQ 19,700 kc., 15.23 m.
10,000 kc., 30 m.
Alcalda 43—Madrid, Spain
EHY 10,100 kc., 29.7 m.
Madrid, Spain

—F—

F8KR 3,750 kc., 80 m.
F8KR 6,660 kc., 45 m.
Constantine, Algeria
F8MC 6,875 kc., 43.6 m.
Casablanca, Morocco
FIGA 6,000 kc., 49.97 m.
Tananarive, Madagascar
FL 6,120 kc., 49.02 m.
FLJ 9,230 kc., 32.5 m.
Paris, France
FQE 12,150 kc., 24.68 m.
FQO 12,150 kc., 24.68 m.
FRE 18,240 kc., 16.44 m.
FRE 19,400 kc., 15.45 m.
FRO 18,240 kc., 16.44 m.
St. Assise, France
FSR 20,680 kc., 14.5 m.
Paris, France
FTA 11,950 kc., 25.12 m.
FTD 19,830 kc., 15.12 m.
FTF 7,770 kc., 38.6 m.
FTK 15,690 kc., 19.12 m.
FTK 15,860 kc., 18.9 m.
St. Assise, France
FYA 11,705 kc., 25.6 m.
FYA 11,905 kc., 25.16 m.
FYA 15,240 kc., 19.68 m.
Pontoise (Paris) France
FZG 12,000 kc., 24.98 m.
FZR 16,200 kc., 18.5 m.
FZS 11,900 kc., 25.02 m.
FZS 18,310 kc., 16.38 m.
Saigon, Indo-China

—G—

GAA 20,380 kc., 14.72 m.
GAG 18,970 kc., 15.81 m.
GAS 18,410 kc., 16.38 m.
GAU 18,620 kc., 16.11 m.
GBB 13,580 kc., 22.09 m.
GBC 17,080 kc., 17.55 m.
GBC 12,780 kc., 23.46 m.
GBC 9,310 kc., 32.22 m.
GBC 8,680 kc., 34.56 m.
GBC 4,980 kc., 60.26 m.
Rugby, England
GBJ 18,620 kc., 16.1 m.
GBK 16,100 kc., 16.57 m.
9,250 kc., 32.4 m.
11,490 kc., 26.1 m.
Bodmin, England
GBP 10,770 kc., 28.04 m.
GBS 18,310 kc., 16.38 m
12,250 kc., 24.46 m.
12,150 kc., 24.68 m.
GBU 18,620 kc., 16.11 m.
22,300 kc., 13.45 m.
12,290 kc., 24.41 m.
9,950 kc., 30.15 m.
GBW 14,480 kc., 20.7 m.
9,790 kc., 30.64 m.
GPO, Rugby, Eng.
GBX 16,150 kc., 18.56 m.
10,390 kc., 28.86 m.
GCA 9,710 kc., 30.9 m.
GCB 9,280 kc., 32.33 m.
GCS 9,020 kc., 33.26 m.
GCU 9,950 kc., 30.15 m.
GCW 9,800 kc., 30.60 m.
GDS 6,900 kc., 43.45 m.
GDW 4,840 kc., 62.0 m.
Rugby, England
GSA 6,050 kc., 49.58 m.
GSB 9,510 kc., 31.55 m.
GSC 9,585 kc., 31.29 m.
GSD 11,750 kc., 25.53 m.
GSE 11,865 kc., 25.28 m.
GSF 15,140 kc., 19.81 m.
GSG 17,770 kc., 16.88 m.
GSH 21,470 kc., 13.97 m.
BBC, Daventry, Eng.
G6RX 4,320 kc., 69.44 m.
Rugby, England

—H—

HB9D 7,200 kc., 41.5 m.
Zurich, Switzerland
HBF 18,900 kc., 15.78 m.
HBJ 14,560 kc., 20.6 m.
Pragins, Switzerland
HBL 9,595 kc., 31.27 m.
HBP 7,800 kc., 38.47 m.
Geneva, Switzerland
HC1DR 6,382 kc., 47 m.
Quito, Ecuador
HC2JSB 8,000 kc., 37.5 m.
Guayaquil, Ecuador
HCJB 8,110 kc., 37.0 m.
5,714 kc., 52.5 m.
Quito, Ecuador, S. A.
HJ1ABB 5,800 kc., 51.75 m.
Barranquilla, Colombia
HJ2ABA 5,880 kc., 51.49 m.
Tunja, Colombia
HJ3ABD 7,400 kc., 40.55 m.
HJ3ABF 6,250 kc., 48.0 m.
Bogota, Colombia
HJ4ABB 7,150 kc., 41.6 m.
Manizales, Colombia
HJ4ABE 5,930 kc., 5.06 m.
Medellin, Colombia
HJ5ABD 6,380 kc., 47.0 m.
Cali, Colombia
HJB 7,470 kc., 40.16 m.
HJY 9,930 kc., 30.2 m.
18,460 kc., 16.25 m.
HKC 6,270 kc., 47.81 m.
Bogota, Colombia
HKF 7,612 kc., 39.14 m.
HKM 6,660 kc., 45 m.
Bogota, Colombia
HKO 5,900 kc., 50.8 m.
Medellin, Colombia
HKX 7,140 kc., 42.02 m.
Bogota, Colombia
HSP2 9,640 kc., 31.1 m.
HSP 17,750 kc., 16.92 m.
Bangkok, Siam
HVJ 5,970 kc., 50.26 m.
75,110 kc., 19.84 m.
15,120 kc., 19.83 m.
Vatican City, Rome, Italy

—I—

I2RO 11,810 kc., 25.4 m.
Rome, Italy
I3RO 3,750 kc., 80 m.
Rome, Italy
IAC 8,380 kc., 35.8 m.
6,650 kc., 45.1 m.
12,800 kc., 23.45 m.
Pisa, Italy
IBDK 11,470 kc., 26.15 m.
S. S. Elettra (Marconi's Yacht)
IRW 19,540 kc., 15.25 m.
Italy

J

JB 6,069 kc., 49.43 m.
Johannesburg, South Africa
J1AA 7,880 kc., 38.07 m.
13,090 kc., 22.93 m.
9,870 kc., 30.4 m.
15,490 kc., 19.36 m.
Tokio, Japan

—K—

K6XQ Experimental
S. S. Lake Miraflores
KAZ 9,970 kc., 30.09 m.
Manila, P. I.
KDK 7,520 kc., 39.89 m.
KEJ 9,020 kc., 33.27 m
Kauhuku, T. H.
KEL 6,860 kc., 43.7 m.
Bolinas, Cal.
KEQ 7,370 kc., 40.71 m.
Kauhuku, T. H.
KES 10,410 kc., 28.80 m.
KEZ 10,410 kc., 28.80 m
Bolinas, Cal.
KGHA 2,506 kc., 119.5 m.
Portable on snowplow, Wash.
KGHB 2,506 kc., 119.5 m.
Portable on snowplow, Wash.
KGHC 2,506 kc., 119.5 m.
Police car, Wash.
KGHD 2,506 kc., 119.5 m.
Seattle, Wash.
KGHE 2,506 kc., 119.5 m.
Snoqualmie Pass, Wash.
KGHO 1,534 kc., 191.1 m.
Des Moines, Iowa
KGJX 1,712 kc., 175.15 m.
Pasadena, Cal.
KGOZ 2,470 kc., 121.5 m.
Cedar Rapids, Iowa
KGPA 2,414 kc., 124.2 m.
Seattle, Wash.
KGPB 2430 kc., 123.4 m
Minneapolis, Minn.
KGPC 1,712 kc., 175.15 m.
St. Louis, Mo.
KGPD 2,470 kc., 121.5 m.
San Francisco, Cal.
KGPE 2,422 kc., 123.8 m.
Kansas City, Mo.
KGPG 2,422 kc., 123.8 m.
Vallejo, Cal.
KGPH 2,450 kc., 122.4 m.
Oklahoma City, Okla.
KGPI 2,470 kc., 121.5 m.
Omaha, Neb.
KGPJ 1,712 kc., 175.15 m.
Beaumont, Tex.
KGPK 2,470 kc., 121.5 m.
Sioux City, Ia.
KGPL 1,712 kc., 175.15 m.
Los Angeles, Cal.
KGPM 2,470 kc., 121.5 m.
San Jose, Cal.
KGPN 2,470 kc., 121.5 m.
Davenport, Iowa
KGPO 2,450 kc., 122.4 m.
Tulsa, Okla.
KGPP 2,442 kc., 122.8 m.
Portland, Ore.
KGPQ 2,450 kc., 122.4 m.
Honolulu, T. H.
KGPS 2,414 kc., 124.2 m.
Bakersfield, Cal.
KGPW 2,470 kc., 121.5 m.
Salt Lake City, Utah
KGPX 2,442 kc., 122.8 m.
Denver, Colo.
KGPY 1,574 kc., 189.5 m.
Shreveport, La.
KGPZ 2,450 kc., 122.4 m.
Wichita, Kans.
KGTP Various aero frequencies
KGZA 2,414 kc., 124.2 m.
Fresno, Cal.
KGZB 1,712 kc., 175.15 m.
Houston, Tex.
KGZC 2,422 kc., 123.8 m.
Topeka, Kan.
KGZD 2,430 kc., 123.4 m.
San Diego, Cal.
KGZE 2,506 kc., 120 m
San Antonio, Tex.
KGZF 2,450 kc., 122.4 m
Chanute, Kans.
KGZG 2,470 kc., 121.5 m.
Des Moines, Iowa
KGZH 2,442 kc., 122.8 m.
Klamath Falls, Ore.
KGZI 1,712 kc., 175.15 m
Wichita Falls, Tex.
KGZJ 2,430 kc., 123.4 m.
Phoenix, Ariz.
KGZL 1,712 kc., 175.15 m.
Shreveport, La.
KGZM 2,414 kc., 124.2 m.
El Paso, Tex.
KGZN 2,414 kc., 124.2 m.
Tacoma, Wash.
KGZO 2,414 kc., 124.2 m.
Santa Barbara, Cal.
KGZP 2,450 kc., 122.4 m.
Coffeyville, Kans.
KGZQ 1,712 kc., 175.15 m.
Waco, Tex.
KGZR 2,442 kc., 122.8 m.
Salem, Ore.
KGZT 2,470 kc., 121.5 m.
Santa Cruz, Cal.
KGZU 2,470 kc., 121.5 m.
Lincoln, Neb.
KGZV 2,414 kc., 124.2 m.
Aberdeen, Wash.
KGZW 2,458 kc., 122.8 m.
Lubbock, Tex.
KGZX 2,414 kc., 124.2 m
Albuquerque, N. M.
KGZY 1,712 kc., 175.15 m
San Bernardino, Cal.
KIO 11,670 kc., 25.68 m.
KKH 7,520 kc., 39.89 m.
KKP 16,040 kc., 18.71 m.
Kauhuku, T. H.
KKQ 11,945 kc., 25.1 m.
KKW 13,780 kc., 21.77 m.
KKZ 14,150 kc., 21.17 m.
KQJ 18,050 kc., 16.61 m.
Bolinas, Cal.
KSW 1,658 kc., 180.7 m.
Berkeley, Cal.
KVP 1,712 kc., 175.15 m.
Dallas, Tex.
KWN 21,060 kc., 14.24 m.
KWO 15,420 kc., 19.46 m.
KWU 15,350 kc., 19.54 m.
KWV 10,840 kc., 27.67 m.
KWX 7,610 kc., 39.42 m.
KWY 7,560 kc., 39.65 m.
KWZ 10,400 kc., 28.8 m.
Dixon, Cal.

—L—

LGN 9,600 kc., 31.23 m.
Bergen, Norway
LQA 9,600 kc., 31.25 m.
LSA 9,890 kc., 30.3 m.
LSA 14,530 kc., 20.65 m.
LSG 19,950 kc., 15.03 m.
LSG 19,906 kc., 15.07 m.
LSL 10,300 kc., 29.12 m.
LSL 21,160 kc., 14.17 m.
Buenos Aires
LSM 21,130 kc., 14.15 m.
Monte Grande, Argentina
(Buenos Aires)
LSN 14,530 kc., 20.65 m.
LSN 21,020 kc., 14.27 m.
LSN 20,680 kc., 14.5 m.
LSR 18,960 kc., 15.82 m.
LSX 10,350 kc., 28.98 m.
LSY 20,730 kc., 14.47 m.
LSY 10,410 kc., 28.8 m.
LSY 18,130 kc., 16.55 m.
Buenos Aires

—N—

NAA 16,060 kc., 18.68 m
NAA 12,045 kc., 24.89 m.
NAA 4,105 kc., 74.72 m.
Arlington, Va. (time signals)
NPO 8,872 kc., 33.81 m
Cavite, P. I. (time signals)
NSS 12,045 kc., 24.89 m
Annapolis, Md. (time signals)

—O—

OCI 18,680 kc., 16.06 m
OCJ 15,620 kc., 19.19 m
Lima, Peru
OKI 21,000 kc., 14.28 m
Podebrady, Czechoslovakia
OKIMPT 5,145 kc., 58.31 m.
OKIMPT 5,170 kc., 58 m.
Prague, Czechoslovakia
OPL 20,040 kc., 14.97 m
OPM 10,140 kc., 29.58 m.
Leopoldsville, Belgian Congo
ORG 19,210 kc., 15.62 m.
ORK 10,330 kc., 29.04 m.
Brussels, Belgium
OXY 15,300 kc., 19.6 m.
Lyngby, Denmark
OXY 6,075 kc., 49.4 m.
OXY 9,520 kc., 31.51 m.
Skamleback, Denmark
OZ7RL 3,560 kc., 84.24 m.
Copenhagen, Denmark

—P—

PCK 7,770 kc., 38.6 m.
18,400 kc., 16.3 m.
PCL 16,300 kc., 18.4 m.
PCV 17,830 kc., 16.82 m.
PDK 10,410 kc., 28.8 m.
PDU 7,830 kc., 38.3 m.
PDV 12,060 kc., 24.88 m.
Kootwijk, Holland
PHI 17,770 kc., 16.88 m.
11,730 kc., 25.57 m.
Huizen, Holland
PK2AG 3,156 kc., 95 m.
Samarang, Java
PK3AN 6,040 kc., 49.67 m.
Sourabaya, Java
PLE 18,200 kc., 15.94 m.
PLF 17,850 kc., 16.8 m.
PLG 15,950 kc., 18.8 m.
PLM 12,250 kc., 24.46 m.
PLR 10,630 kc., 28.2 m.
PLV 9,420 kc., 31.86 m.
PLW 8,120 kc., 36.92 m.
9,480 kc., 31.63 m.
PMB 20,620 kc., 14.54 m.
5,170 kc., 58 m.
PMC 18,370 kc., 16.33 m.
PMN 10,360 kc., 29.25 m.
PMY 5,170 kc., 58.0 m.
Bandoeng, Java
PPG 11,660 kc., 27.73 m.
PPU 19,270 kc., 15.57 m.
Rio de Janeiro
PRADO 6,620 kc., 45.31 m.
Riobamba, Ecuador
PRAG 8,450 kc., 35.5 m.
Porto Algero, Brazil
PSA 21,080 kc., 14.23 m.
PSH 10,220 kc., 29.35 m.
PSK 8,190 kc., 36.65 m.
Rio de Janeiro

—R—

RABAT 12,830 kc., 23.38 m.
8,035 kc., 37.33 m.
Morocco
RAU 15,100 kc., 19.85 m.
Tachkent, Turkestan
REN 6,610 kc., 45.38 m.
RIM 7,630 kc., 39.34 m.
RKI 7,500 kc., 39.97 m.
U. S. S. R.
RV15 4,273 kc., 70.2 m.
Khabarovsk, Siberia
RV59 6,000 kc., 50 m.
Radio Moscow, U.S.S.R.
RXF 14,500 kc., 20.69 m.
Panama City, Panama

—S—

SAJ 6,065 kc., 49.46 m.
Motola, Sweden
SRI 9,570 kc., 31.35 m.
Poznan, Poland
SUV 10,050 kc., 29.83 m.
Cairo, Egypt

—T—

TI4NRH 9,675 kc., 31 m.
Heredia, Costa Rica, C. A.
TIR 8,790 kc., 34.13 m.
14,500 kc., 20.69 m.
Cartago, Costa Rica
TGA 14,500 kc., 20.69 m.
TGW 6,660 kc., 45 m.
6,180 kc., 48.5 m.
TGX 5,940 kc., 50.5 m.
Guatemala City, C. A.

—U—

UIG 10,400 kc., 28.8 m.
Medan, Sumatra
UOR2 6,072 kc., 49.41 m.
Vienna, Austria

—V—

VE9AP 6,335 kc., 47.35 m.
Drummondville, Canada
VE9BJ 6,090 kc., 49.29 m.
St. John, N. B., Canada
VE9BY 4,795 kc., 62.56 m.
6,425 kc., 46.7 m.
8,650 kc., 34.68 m.
London, Ontario, Canada
VE9CA 6,030 kc., 49.75 m.
Calgary, Alta., Canada
VE9CF 6,050 kc., 49.59 m.
6,100 kc., 49.15 m.
Halifax, N. S., Canada
VE9CG 6,110 kc., 49.1 m.
Calgary, Alta., Canada
VE9CL 5,710 kc., 52.5 m.
6,147 kc., 48.8 m.
Winnipeg, Canada
VE9CS 6,069 kc., 49.43 m.
Vancouver, B. C., Canada
VE9CU 6,005 kc., 49.99 m.
Calgary, Alta., Canada
VE9DR 11,780 kc., 25.47 m.
6,005 kc., 49.96 m.
Drummondville, Quebec, Canada
VE9GW 6,095 kc., 49.17 m.
11,800 kc., 25.42 m.
Bowmanville, Ontario, Canada
VE9HK 6,120 kc., 48.98 m.
VE9HX 6,125 kc., 48.98 m.
Halifax, N. S., Canada
VE9JR 11,720 kc., 25.6 m.
Winnipeg, Canada
VK2ME 9,760 kc., 30.75 m.
10,520 kc., 28.51 m.
Sydney, Australia
VK3LR 9,510 kc., 31.55 m.
5,680 kc., 52.8 m.
Melbourne, Australia
VLJ 9,980 kc., 37.59 m.
VLK 9,760 kc., 30.75 m.
10,520 kc., 28.51 m.
Sydney, Australia
VPD 7,890 kc., 38.0 m.
Suva, Fiji Islands
VPN 4,510 kc., 66.5 m.
Nassau, Bahamas
VQ7LO 6,000 kc., 49.5 m.
Nairobi, Kenya, Africa
VRT 5,050 kc., 59.42 m.
10,070 kc., 29.8 m.
Hamilton, Bermuda
VSIAB 7,195 kc., 41.67 m.
Singapore, S. S.
VUC 6,110 kc., 49.1 m.
Calcutta, India
VWY 18,540 kc., 17.1 m.
Poona, India

—W—

W1XAB 4,700 kc., 63.79 m.
Portland, Me.
W1XAG Experimental
Police, Providence, R. I.
W1XAI Experimental
Tufts College, Medford, Mass.
W1XAK Experimental
Westinghouse, Chicopee Falls, Mass.
W1XAL 11,790 kc., 25.45 m.
W1XAL 6,040 kc., 49.67 m.
W1XAL 15,250 kc., 19.67 m.
W1XAL 21,460 kc., 13.98 m.
Boston, Mass.
W1XAN Experimental
Round Hills, Mass.
W1XAU 1,560 kc., 199.35 m.
W1XAV 1,600 kc., 187.5 m.
Boston, Mass.
W1XAW Experimental
Tufts College, Medford, Mass.
W1XAZ 9,570 kc., 31.35 m.
Westinghouse, Springfield, Mass.
W1XG 43,000 kc., 6.52 m.
Boston, Mass.
W1XJ Experimental
Harvard U., Cambridge, Mass.
W1XK Experimental
Westinghouse, Port. & Mob.
W1XL 6,040 kc., 49.67 m.
Boston, Mass.
W1XM Experimental
M.I.T.
Cambridge, Mass.
W1XP Experimental
W1XV Experimental
M.I.T.
S. Dartmouth, Mass.
W1XW 41,000 kc., 7.32 m.
W1XW 51,400 kc., 5.83 m.
W1XW 60,000 kc., 5.00 m.
W1XW 400,000 kc., ¾ m.
A. F. Sise, Milton, Mass.
W2XAA Experimental
Bell Labs., Port. & Mob.
W2XAB 2,750 kc., 109.1 m.
CBS, New York, N. Y.
W2XAC 8,690 kc., 34.5 m.
W2XAD 15,330 kc., 19.56 m.
W2XAF 9,530 kc., 31.48 m.
GE, Schenectady, N. Y.
W2XAK 43,000 kc., 6.52 m.
W2XAK 48,500 kc., 6.18 m.
W2XAK 60,000 kc., 5.00 m.
CBS, New York, N. Y.
W2XAO 17,850 kc., 16.8 m.
W2XAR Experimental
Long Island City, N. Y.
W2XAV Experimental
Bell Labs., Port. & Mob.
W2XAW Experimental
GE, Schenectady, N. Y.
W2XBB Experimental
RCA, New York, N. Y.
W2XBC 25,700 kc., 11.67 m.
RCA, New Brunswick, N. J.
W2XBG Experimental
Radio Marine, New York, N. Y.
W2XBI Experimental
RCA, Rocky Point, N. Y.
W2XBJ 14,700 kc., 20.27 m.
Rocky Point, N. Y.
W2XBL Experimental
RCA, Port. & Mob.
W2XBS 2,750 kc., 109.1 m.
NBC, Bellmore, L. I.
W2XBT 43,000 kc., 6.52 m.
W2XBT 48,500 kc., 6.18 m.
W2XBT 60,000 kc., 5.00 m.
NBC, Portable
W2XBW Experimental
Globe Wireless, Garden City, N. Y.
W2XBX Plane, Experimental
Bell Labs.
W2XC Experimental
Federal Tel. Co., Port. & Mobile.
W2XCJ Experimental
Police, Bayonne, N. J.
W2XCS Experimental
W2XCT Experimental
Police, Eastchester, N. Y.
W2XCU 12,850 kc., 23.35 m.
W2XCU 8,650 kc., 34.68 m.
Rocky Point, N. Y.
W2XDC Experimental
RCA, Portable & Mobile
W2XDJ 21,420 kc., 14. m.
ATT, Deal, N. J.
W2XDK Experimental
Polin, Inc., Port. & Mob.
W2XDO 17,110 kc., 17.52 m.
W2XDO 8,630 kc., 34.74 m.
ATT, Ocean Gate, N. J.
W2XDT Experimental
Press Wireless, Port. & Mob.
W2XDV Experimental
CBS, New York, N. Y.
W2XDY Experimental
W2XDZ Experimental
Central Hudson Gas & Electric Co.
Portable
W2XE 15,270 kc., 19.65 m.
W2XE 11,830 kc., 25.36 m.
W2XE 6,120 kc., 49.02 m.
CBS, Wayne, N. J.
W2XEA Experimental
W2XEB Experimental
W2XEC Experimental
W2XED Experimental
W2XEE Experimental
W2XEF Experimental
W2XEG Experimental
W2XEH Experimental
Police, Bayonne, N. J.
W2XEI Experimental
P. J. Golihofer, Port. & Mob.
W2XEJ Experimental
D. B. Whittemore, Yonkers, N. Y.
W2XEK Experimental
Knickerbocker Broad. Co., Port. & Mob.
W2XEL Experimental
Police, Eastchester, N. Y.
W2XER Experimental
D. B. Whittemore, Yonkers, N. Y.
W2XES 34,600 kc., 8.67 m.
Englewood, N. J.
W2XF 43,000 kc., 6.52 m.
W2XF 48,500 kc., 6.18 m.
W2XF 60,000 kc., 5.00 m
NBC, New York
W2XG Experimental
Bell Labs., Ocean Township, N. J.
W2XGG Experimental
Police, Bayonne, N. J.
W2XJ Experimental
Bell Labs., Ocean Township, N. J.
W2XK Experimental
NBC, New York, N. Y.
W2XL Experimental
Bell Labs., Port & Mobile
W2XM Experimental
W2XN Experimental
Bell Labs., Holmdel, N. J.
W2XO 12,850 kc., 23.35 m
GE, Schenectady, N. Y.
W2XP Experimental
RCA, Riverhead, N. Y.
W2XR 1,600 kc., 176.5 m.
W2XR 43,000 kc., 6.97 m.
W2XR 48,500 kc., 6.18 m.
W2XR 60,000 kc., 5.00 m.
W2XS Experimental
W2XT Experimental
RCA, Rocky Point, N. Y.
W2XU Experimental
Bell Labs., Portable
W2XV 30,100 kc., 9.97 m.
W2XV 31,100 kc., 9.65 m.
W2XV 31,600 kc., 9.49 m.
W2XV 33,100 kc., 9.06 m.
W2XV 34,600 kc., 8.67 m.
W2XV 35,600 kc., 8.43 m.
W2XV 37,100 kc., 8.09 m.
W2XV 37,600 kc., 7.98 m.
W2XV 38,600 kc., 7.77 m.
W2XV 40,100 kc., 7.48 m.
W2XV 40,600 kc., 7.38 m.
W2XV 41,000 kc., 7.31 m.
D. E. Replogle, Mobile in Auto.
Clifton, N. J.
W2XW Experimental
W2XY Experimental
Bell Labs., Portable
W3XAB Experimental
RCA, Camden, N. J.
W3XAD 43,000 kc., 6.97 m.
W3XAD 48,500 kc., 6.18 m.
W3XAD 60,000 kc., 5.00 m.
RCA, Camden, N. J.
W3XAJ Experimental
RCA, Camden, N. J.
W3XAK 2,100 kc., 136.4 m.
NBC, Portable
W3XAL 17,780 kc., 16.87 m.
W3XAL 6,100 kc., 49.15 m.
NBC, Bound Brook, N. J.
W3XAM Experimental
RCA, Port. & Mob.
W3XAN Experimental
Harrisburg, Pa.
W3XAR 34,600 kc., 8.67 m.
Haverford (Brookline), Pa.
W3XAU 9,580 kc., 31.32 m.
W3XAU 9,590 kc., 31.28 m.
W3XAU 6,060 kc., 49.5 m.
CBS, Philadelphia, Pa.
W3XAW Experimental
W3XAX Experimental
M. & H. Sporting Goods Co., Port.
W3XAY 30,200 kc., 9.93 m.
W3XAY 35,800 kc., 8.38 m.
W3XAY 41,800 kc., 7.17 m.
W3XAY 42,200 kc., 7.10 m.
W3XAY 47,800 kc., 6.27 m.
W3XAY 48,200 kc., 6.22 m.
W3XAY 53,800 kc., 5.57 m.
W3XAY 54,200 kc., 5.53 m.
W3XAY 60,200 kc., 4.98 m.
Atlantic Refining Co., Phila., Pa.
Experimental
W3XB Experimental
College Park, Md.
W3XE 9,580 kc., 31.32 m.
W3XE 43,000 kc., 6.52 m.
W3XE 48,500 kc., 6.00 m.
W3XE 60,000 kc., 3.75 m.
Philco, Philadelphia, Pa.
W3XE 8,650 kc., 34.68 m.
Baltimore, Md.

W3XL Experimental
NBC, Bound Brook, N. J.
W3XN Experimental
Bell Labs., Whippany, N. J.
W3XR Experimental
Bell Labs., Mendham Township, N. J.
W3XV Experimental
RCA, Arneys-Mount, N. J.
W3XW Experimental
Boonton, N. J.
W3XX 8,650 kc., 34.68 m.
W3XZ 4,795 kc., 62.56 m.
Washington, D. C.
W4XB 6,040 kc., 49.67 m.
Miami Beach, Fla.
W4XC Experimental
Portable
W4XD Experimental
Port. & Mob.
W4XG 8,650 kc., 34.68 m.
Miami, Fla.
W5XC Experimental
Shreveport, La.
W6XAC Experimental
Fred W. Christian, Jr., Portable
W6XAD Experimental
San Francisco, Calif.
W6XAH 2,000 kc., 150 m.
Bakersfield, Cal.
W6XAJ Experimental
W6XAK Experimental
Globe Wireless, Portable
W6XAO 43,000 kc., 6.97 m.
W6XAO 48,500 kc., 6.18 m.
W6XAO 60,000 kc., 5.00 m.
Los Angeles, Cal.
W6XAQ 51,400 kc., 5.83 m.
W6XAQ 60,000 kc., 5.00 m.
W6XAQ 400,000 kc., 0.75 m.
Police, Phoenix, Ariz.
W6XAR Experimental
W6XAS Experimental
Julius Brunton & Sons Co., Port. & Mob.
W6XBB Experimental
R. M. Heintz, Port. in Cal.
W6XC 41,000 kc., 7.32 m.
W6XC 51,400 kc., 5.83 m.
Remler Co., San Francisco, Cal.
W6XD 27,800 kc., 10.79 m.
MRT, Palo Alto, Cal.
W6XF Experimental
Heintz & Kaufman, Port. in Cal.
W6XJ Experimental
Heintz & Kaufman, Port. in Cal.
W6XP Experimental
Press Wireless, Portable and Mobile
W6XQ 24,000 kc., 12.48 m.
San Mateo, Cal.
W6XR Experimental
San Francisco, Calif.
W6XS 2,100 kc., 136.4 m.
Los Angeles, Calif.
W7XA Experimental
Globe Wireless, Ltd., Portable
W7XAW 2,342 kc., 128.09 m.
Seattle, Wash.
W7XC Experimental
Edmonds, Wash.
W7XK Experimental
Seattle, Wash.
W7XL Experimental
Northern Radio Co., Portable
W8XAC 34,600 kc., 8.67 m.
W8XAC 41,000 kc., 7.31 m.
W8XAC 51,400 kc., 5.83 m.
Police, Lincoln Park, Mich.
W8XAG 8,650 kc., 34.68 m.
Dayton, Ohio
W8XAL 6,060 kc., 49.5 m.
Crosley, Cincinnati, O.
W8XAN 43,000 kc., 6.97 m.
W8XAN 48,500 kc., 6.18 m.
W8XAN 60,000 kc., 5.00 m.
W8XAN 1,600 kc., 176.5 m.
Jackson, Mich.
W8XAS Experimental
W8XAT Experimental
V. G. Martin, Rochester, N. Y.
W8XAY Experimental
W8XAZ Experimental
Buffalo Broad. Corp., Buffalo, N. Y.
W8XD Portable
WBEN, Inc.
W8XF 43,000 kc., 6.97 m.
W8XF 48,500 kc., 6.18 m.
W8XF 60,000 kc., 5.00 m.
Pontiac, Mich.
W8XH Portable
WBEN, Inc.
W8XI Experimental
W8XK 21,540 kc., 13.93 m.
W8XK 17,780 kc., 16.87 m.
W8XK 15,210 kc., 19.72 m.
W8XK 11,870 kc., 25.26 m.
W8XK 9,570 kc., 31.35 m.
W8XK 6,140 kc., 48.86 m.
Westinghouse, E. Pittsburgh, Pa.
W8XL 17,300 kc., 17.34 m.
Dayton, O.
W8XL 43,000 kc., 6.97 m.
W8XL 48,500 kc., 6.18 m.
W8XL 60,000 kc., 5.00 m.
Cuyahoga Hts., Ohio
W8XN 1,600 kc., 176.5 m.
Jackson, Mich.
W8XP Portable
W8XS Experimental
Westinghouse, E. Pittsburgh, Pa.
W8XW Experimental
V. G. Martin, Rochester, N. Y.
W9XAA 6,080 kc., 49.31 m.
W9XAA 11,830 kc., 25.36 m.
W9XAA 17,780 kc., 16.87 m.
Chicago, Ill.
W9XAI Experimental
W9XAJ Experimental
Milwaukee, Wis. Portable
W9XAK 2,100 kc., 142.9 m.
Manhattan, Kans.
W9XAL 2,200 kc., 136.4 m.
Kansas City, Mo.
W9XAM 4,795 kc., 62.56 m.
Elgin, Ill.
W9XAO 11,840 kc., 25.34 m.
W9XAO 2,000 kc., 150 m.
W9XAP 2,100 kc., 142.9 m.
Chicago, Ill.
W9XAR Experimental
Portable & Mobile
W9XAT 43,000 kc., 6.97 m.
W9XAT 48,500 kc., 6.18 m.
W9XAT 60,000 kc., 5.00 m.
Dr. G. W. Young, Portable
W9XAV Experimental
Press Wireless, Port. & Mob.
W9XD 43,000 kc., 6.97 m.
W9XD 48,500 kc., 6.18 m.
W9XD 60,000 kc., 5.00 m.
Milwaukee, Wis.
W9XE 43,000 kc., 6.97 m.
W9XE 48,500 kc., 6.18 m.
W9XE 60,000 kc., 5.00 m.
Marion, Ind.
W9XF 17,780 kc., 16.87 m.
W9XF 11,880 kc., 25.24 m.
W9XF 6,100 kc., 49.18 m.
NBC, Chicago, Ill.
W9XG 2,750 kc., 109.1 m.
W. Lafayette, Ind.
W9XJ Experimental
State Univ., Grand Forks, N. D.
W9XK 2,000 kc., 150 m.
Iowa City, Iowa
W9XL 17,300 kc., 17.34 m.
W9XL 12,850 kc., 23.35 m.
W9XL 6,425 kc., 46.70 m.
Anoka, Minn.
W10XAA Plane, Experimental
Bell Labs.
W10XAC Experimental
Milwaukee, Wis., Port. & Mobile
W10XAF Experimental
Larry L. Smith, Portable
W10XAG Experimental
N. Y. Conservation Dept., Port. and Mobile
W10XAH Experimental
W10XAI Experimental
NBC, Portable and Mobile
W10XAJ Experimental
N. Y. Conservation Dept., Port. and Mobile
W10XAK Experimental
NBC, Portable and Mobile
W10XAL Experimental
CBS, Portable and Mobile
W10XAM Experimental
W10XAN Experimental
W10XAP Experimental
NBC, Portable and Mobile
W10XAQ Experimental
Westinghouse, Portable & Mobile
W10XAY Experimental
Polin, Inc., Portable and Mobile
W10XBA Plane, Experimental
W10XBB Plane, Experimental
W10XBC Plane, Experimental
Aeronautical Radio Inc.
W10XBE Experimental
N. Y. Conservation Dept., Port. and Mobile
W10XBF Experimental
W10XBG Experimental
W. G. H. Finch, Portable & Mob.
W10XBI Plane, Experimental
Roland Reed
W10XBK Experimental
W. G. H. Finch, Portable & Mob.
W10XE Experimental
RCA, Portable and Mobile
W10XI Plane, Experimental
Aircraft Radio Corp.
W10XJ Experimental
Bell Labs., Portable
W10XN Experimental
NBC, Portable and Mobile
W10XT Experimental
RCA, Portable and Mobile
W10XX 43,000 kc., 6.97 m.
W10XX 48,500 kc., 6.18 m.
W10XX 60,000 kc., 5.00 m.
RCA, Portable
W10XY Experimental
NBC, Portable and Mobile
W10XZ Experimental
CBS, Portable and Mobile
WAEQ Various aero frequencies
Elmira, N. Y.
WAJ 13,480 kc., 22.26 m.
Rocky Point, N. Y.
WBA 190 kc., 1,579 m.
Harrisburg, Pa.
WBR 190 kc., 1,579 m.
Butler, Pa.
WCK 2,414 kc., 124.2 m.
Belle Island, Mich.
WCN 5,070 kc., 59.08 m.
Lawrenceville, N. J.
WDX 190 kc., 1,579 m.
Wyoming, Pa.
WEA 10,610 kc., 28.28 m.
WEB 6,940 kc., 43.23 m.
WEC 8,930 kc., 33.59 m.
WEF 9,590 kc., 31.6 m.
WEL 8,950 kc., 33.52 m.
WEM 7,400 kc., 40.54 m.
WES 9,450 kc., 31.74 m.
WGN 5,260 kc., 57.03 m.
WIY 13,870 kc., 21.63 m.
Rocky Point, N. Y.
WJL 190 kc., 1,579 m
Greensburg, Pa.
WKA 21,060 kc., 14.25 m.
Lawrenceville, N. J.
WKDU 1,712 kc., 175.15 m.
Cincinnati, Ohio
WKF 19,220 kc., 15.61 m.
WKF 4,750 kc., 63.21 m.
Lawrenceville, N. J.
WKJ 9,590 kc., 31.6 m.
Rocky Point, N. Y.
WKK 21,410 kc., 14.01 m.
WKN 19,830 kc., 15.13 m.
Lawrenceville, N. J.
WKU 14,700 kc., 20.27 m.
WKW 19,020 kc., 15.77 m.
Rocky Point, N. Y.
WLA 18,350 kc., 16.35 m.
WLK 16,330 kc., 18.44 m.
WLO 21,400 kc., 14.01 m.
WLO 16,300 kc., 18.4 m.
WLO 10,540 kc., 28.44 m.
ATT, Lawrence, N. J.
WMA 13,390 kc., 22.4 m.
Lawrenceville, N. J.
WMB 190 kc., 1,579 m.
West Reading, Pa.
WMDZ 2,442 kc., 122.8 m.
Indianapolis, Ind.
WMF 14,470 kc., 20.73 m.
Lawrenceville, N. J.
WMI 19,850 kc., 15.1 m.
WMI 9,700 kc., 30.9 m.
ATT, Deal, N. J.
WMJ 2,422 kc., 123.8 m.
Buffalo, N. J.
WMN 14,590 kc., 20.56 m
Lawrenceville, N. J.
WMO 2,414 kc., 124.2 m.
Highland Park, Mich.
WMP 1,574 kc., 189.5 m.
Framingham, Mass.
WNA 9,170 kc., 32.72 m.
WNB 10,680 kc., 28.09 m.
Lawrenceville, N. J.
WNC 19,200 kc., 15.6 m.
WNC 14,480 kc., 20.7 m.
WNC 9,750 kc., 30.75 m.
WND 18,350 kc., 16.35 m.
WND 13,400 kc., 22.38 m.
WND 6,753 kc., 44.4 m.
ATT, Deal, N. J.
WOA 6,750 kc., 44.41 m.
WOB 5,850 kc., 51.26 m.
WOF 9,750 kc., 30.77 m.
WOK 10,550 kc., 28.44 m.
WON 9,870 kc., 30.40 m.
Lawrenceville, N. J.
WOO 17,110 kc., 17.52 m.
WOO 8,550 kc., 35.09 m.
WOO 6,515 kc., 46.05 m.
WOO 8,630 kc., 34.74 m.
WOO 4,750 kc., 63.13 m.
WOO 4,116 kc., 72.87 m.
WOO 3,124 kc., 96.03 m.
WOP 19,380 kc., 15.48 m.
Ocean Gate, N. J.
WOU 2,590 kc., 115.8 m.
Green Harbor, Mass.
WOX 2,540 kc., 118.06 m.
New York, N. Y.
WPDA 2,414 kc., 124.2 m.
Tulare, Cal.
WPDB 1,712 kc., 175.15 m.
WPDC 1,712 kc., 175.15 m.
WPDD 1,712 kc., 175.15 m.
Chicago, Ill.
WPDE 2,442 kc., 122.8 m.
Louisville, Ky.
WPDF 2,442 kc., 122.8 m.
Flint, Mich.
WPDG 2,458 kc., 122.8 m.
Youngstown, O.
WPDH 2,442 kc., 122.8 m.
Richmond, Ind.
WPDI 2,430 kc., 123.4 m.
Columbus, Ohio
WPDK 2,450 kc., 122.4 m.
Milwaukee, Wis.
WPDL 2,442 kc., 122.8 m.
Lansing, Mich.
WPDM 2,430 kc., 123.4 m.
Dayton, Ohio
WPDN 2,458 kc., 122. m.
Auburn, N. Y.
WPDO 2,458 kc., 122. m.
Akron, Ohio
WPDP 2,470 kc., 121.5 m.
Philadelphia, Pa.
WPDR 2,458 kc., 122. m.
Rochester, N. Y.
WPDS 2,430 kc., 123.4 m.
St. Paul, Minn.
WPDT 2,470 kc., 121.5 m.
Kokomo, Ind.
WPDU 1,712 kc., 175.15 m.
Pittsburgh, Pa.
WPDV 2,458 kc., 122. m.
Charlotte, N. C.
WPDW 2,422 kc., 123.8 m.
Washington, D. C.
WPDX 2,414 kc., 124.2 m.
Detroit, Mich.
WPDY 2,414 kc., 124.2 m.
Atlanta, Ga.
WPDZ 2,470 kc., 121.5 m.
Fort Wayne, Ind.
WPEA 2,458 kc., 122.8 m.
Syracuse, N. Y.
WPEB 2,442 kc., 122.8 m.
Grand Rapids, Mich.
WPEC 2,470 kc., 121.5 m.
Memphis, Tenn.
WPED 1,712 kc., 175.15 m.
Arlington, Mass.
WPEE 2,450 kc., 122.4 m.
WPEF 2,450 kc., 122.4 m.
WPEG 2,450 kc., 122.4 m.
New York, N. Y.
WPEH 1,712 kc., 175.15 m.
Somerville, Mass.
WPEI 1,712 kc., 175.15 m.
E. Providence, R. I.
WPEK 2,422 kc., 123.8 m.
New Orleans, La.
WPEL 1,574 kc., 189.5 m.
W. Bridgewater, Mass.
WPEM 2,470 kc., 121.5 m.
Woonsocket, R. I.
WPEP 1,712 kc., 175.15 m.
Arlington, Mass.
WPES 2,442 kc., 122.8 m.
Saginaw, Mich.
WPET 1,712 kc., 175.15 m.
Lexington, Mass.
WPEV 1,574 kc., 189.5 m.
Portable, Mass.
WPEW 1,574 kc., 189.5 m.
Northampton, Mass.
WPEZ
Miami, Fla.
WPFA 1,712 kc., 175.15 m.
Newton, Mass.
WPFC 2,442 kc., 122.8 m.
Muskegon, Mich.
WPFD 2,430 kc., 123.4 m.
Highland Park, Ill.
WPFE 2,442 kc., 122.8 m.
Reading, Pa.
WPFG 2,442 kc., 122.8 m.
Jacksonville, Fla.
WPFH 2,414 kc., 124.2 m.
Baltimore, Md.

WPFI 2,414 kc., 124.2 m.
Columbus, Ga.
WPFJ 1,712 kc., 175.15 m.
Hammond, Ind.
WPFK 2,430 kc., 123.4 m.
Hackensack, N. J.
WPFL 2,470 kc., 121.5 m.
Gary, Ind.
WPFM 2,414 kc., 124.2 m.
Birmingham, Ala.
WPFN 1,712 kc., 175.15 m.
Fairhaven, Mass.
WPFO 2,470 kc., 121.5 m.
Knoxville, Tenn.
WPFP 2,414 kc., 124.2 m.
Clarksburg, W. Va.
WPFQ 2,470 kc., 121.5 m.
Swarthmore, Pa.
WPFR 2,470 kc., 121.5 m.
Johnson City, Tenn.
WPFT 2,442 kc., 122.8 m.
Lakeland, Fla.
WPFU 2,422 kc., 123.8 m.
Portland, Me.
WPFV 2,470 kc., 121.5 m.
Pawtucket, R. I.
WPFX 2,442 kc., 122.8 m.
Palm Beach, Fla.

WPFZ 2,442 kc., 122.8 m.
Miami Beach, Fla.
WPGA 2,442 kc., 122.8 m.
Bay City, Mich.
WPGB 2,414 kc., 124.2 m.
Port Huron, Mich.
WPGC 1,534 kc., 1.96 m.
So. Schenectady, N. Y.
WPGD 2,458 kc., 122.8 m.
Rockford, Ill.
WPGE 2,430 kc., 123.4 m.
Shreveport, La.
WPGF 1,712 kc., 175.15 m.
Providence, R. I.
WPGG 2,414 kc., 124.2 m.
Albany, N. Y.
WPGI 2,430 kc., 123.4 m.
Portsmouth, O.
WPGJ 2,414 kc., 124.2 m.
Utica, N. Y.
WPGK 2,470 kc., 121.5 m.
Cranston, R. I.
WPGL 2,442 kc., 122.8 m.
Binghampton, N. Y.
WPGS 2,414 kc., 124.2 m.
Mineola, N. Y.

WPPC 1712 kc., 175.15 m.
Providence R. I.
WRBH 2,458 kc., 122 m.
Cleveland, Ohio
WRDR 2,414 kc., 124.2 m.
Grosse Pt. Village, Mich.
WRDS 1,574 kc., 189.5 m.
E. Lansing, Mich.
WRDQ 2,470 kc., 121.5 m.
Toledo. Ohio.

—X—

X2GA 7,612 kc., 39.4 m.
Nuevo Laredo, Mexico
XAM 11,540 kc., 26.0 m.
Merida, Yucatan
XDA 5,857 kc., 51.22 m.
11,760 kc., 25.5 m.
14,620 kc., 20.5 m.
XDC 9,400 kc., 31.9 m.
XETE 9,600 kc., 31.25 m.
XEW 6,023 kc., 49.8 m.
XIF 6,167 kc., 48.65 m.
Mexico City, Mex.

—Y—

YNA 14,500 kc., 20.69 m
Managua, Nicaragua
YV1BC 6,110 kc., 49.1 m.
YV11BMO 6,130 kc., 48.95 m
YV1BC 6,120 kc., 49.02 m.
Caracas, Venezuela
YV2AM 14,110 kc., 21.26 m.
Maracaibo, Venezuela
YV3BC 6,130 kc., 48.9 m
9,510 kc., 31.56 m.
Caracas, Venezuela
YVQ 11,690 kc., 25.65 m.
13,500 kc., 22.48 m.
YVR 18,300 kc., 16.39 m.
Maracay, Venezuela

—Z—

ZGE 6,000 kc., 50 m.
Kuala, Lumpur, Malay States
ZL2ZX 6,060 kc., 49.5 m.
ZLT 7,390 kc., 40.6 m.
10,990 kc., 27.3 m.
ZLW 12,300 kc., 24.4 m.
18,340 kc., 16.35 m.
10,980 kc., 27.3 m.

Police Stations Alphabetically by Names of Cities

WHILE the regular alphabetical list of stations is the most convenient for general reference purposes, many readers have asked for a special list of the police radio stations alone, arranged alphabetically according to names of cities. This is very useful when a listener wants to hunt for a particular city and does not know either the call letters or the operating frequency in advance. The list below is the official list issued by the Federal Radio Commission, and is therefore accurate and dependable.

In addition to the frequency in kilocycles, the power of each station in watts is included. It is sometimes desirable to have this information as a means of comparing the range, signal strength, etc., of different stations. To find the wavelength in meters of any station, look in the regular list for the call letters, which are followed by both the frequency in kilocycles (kc.) and the wavelength in meters (m.).

LICENSED MUNICIPAL POLICE RADIO STATIONS

Location	Call Letters	Frequency (kc.)	Power (watts)
Akron, Ohio	WPDO	2458	100
Albuquerque, N. M.	KGZX	2414	50
Arlington, Mass.	WPED	1712	100
Atlanta, Ga.	WPDY	2414	150
Auburn, N. Y.	WPDN	2458	50
Bakersfield, Cal.	KGPS	2414	50
Baltimore, Md.	WPFH	2414	500
Bay City, Mich.	WPGA	2442	50
Beaumont, Tex.	KGPJ	1712	100
Hackensack, N. J.	WPFK	2430	200
Berkeley, Cal.	KSW	1658	400
Birmingham, Ala.	WPFM	2414	150
Buffalo, N. Y.	WMJ	2422	500
Cedar Rapids, Iowa	KGOZ	2470	50
Chanute, Kans.	KGZF	2450	5
Charlotte, N. C.	WPDV	2458	50
Chicago, Ill.	WPDB	1712	500
Chicago, Ill.	WPDC	1712	500
Chicago, Ill.	WPDD	1712	500
Cincinnati, O.	WKDU	1712	500
Clarksburg, W. Va.	WPFP	2414	30
Cleveland, O.	WRBH	2458	500
Coffeyville, Kans.	KGZP	2450	50
Columbus, Ga.	WPFI	2414	50
Columbus, O.	WPDI	2430	200
Dallas, Tex.	KVP	1712	150
Davenport, Iowa	KGPN	2470	50
Dayton, O.	WPDM	2430	400
Denver, Colo.	KGPX	2442	150
Des Moines, Ia.	KGZG	2470	100
Detroit, Mich.	WCK	2414	500
Detroit, Mich.	WPDX	2414	500
Washington, D. C.	WPDW	2422	400
E. Providence, R. I.	WPEI	1712	50
El Paso, Tex.	KGZM	2414	100
Flint, Mich.	WPDF	2442	100
Ft. Wayne, Ind.	WPDZ	2470	200
Fresno, Cal.	KGZA	2414	100
Grand Rapids, Mich	WPEB	2442	100
Grosse Point Village, Mich.	WRDR	2414	50
Highland Park, Mich.	WMO	2414	50
Honolulu, T. H.	KGPQ	2450	100
Indianapolis, Ind.	WMDZ	2442	400
Jacksonville, Fla.	WPFG	2442	100
Kansas City, Mo.	KGPE	2422	400
Klamath Falls, Oreg	KGZH	2442	25
Knoxville, Tenn.	WPFO	2470	400
Kokomo, Ind.	WPDT	2470	50
Lansing, Mich.	WPDL	2442	50
Lexington, Ky.	WPET	1712	500
Lincoln, Nebr.	KGZU	2470	50
Los Angeles, Cal.	KGPL	1712	500
Louisville, Ky.	WPDE	2442	200
Memphis, Tenn.	WPEC	2470	400
Milwaukee, Wis.	WPDK	2450	500
Minneapolis, Minn.	KGPB	2430	400
Muskegon, Mich.	WPFC	2442	50
Mineola, N. Y.	WPGS	2414	200
New Bedford, Mass. (Fairhaven)	WPFN	1712	100
New Orleans, La.	WPEK	2430	100
Newton, Mass.	WPFA	1712	50
New York, N. Y.	WPEE	2450	400
New York, N. Y.	WPEF	2450	400
New York, N. Y.	WPEG	2450	500
Oklahoma City, Okl	KGPH	2450	250
Omaha, Nebr.	KGPI	2470	400
Pasadena, Calif.	KGJX	1712	400
Pawtucket, R. I.	WPFV	2470	50
Philadelphia, Pa.	WPDP	2470	500
Phoenix, Ariz.	KGZJ	2430	100
Pittsburg, Pa.	WPDU	1712	400
Port Huron, Mich.	WPGB	2414	50
Portland, Me.	WPFU	2422	100
Portland, Oreg.	KGPP	2442	500
Reading, Pa.	WPFE	2442	100
Richmond, Ind.	WPDH	2442	50
Rochester, N. Y.	WPDR	2458	200
Rockford, Ill.	WPGD	2458	50
Saginaw, Mich.	WPES	2442	50
St. Louis, Mo.	KGPC	1712	500
St. Paul, Minn.	WPDS	2430	500
Salem, Oreg.	KGZR	2442	25
Salt Lake City, Utah	KGPW	2470	100
San Diego, Cal.	KGZD	2430	100
San Francisco, Cal.	KGPD	2470	400
San Jose, Cal.	KGPM	2470	50
Santa Barbara, Cal.	KGZO	2414	100
Santa Cruz, Cal.	KGZT	2470	50
Seattle, Wash.	KGPA	2414	250
Sioux City, Ia.	KGPK	2470	100
Somerville, Mass.	WPEH	1712	100
Swarthmore, Pa.	WPFQ	2470	50
Syracuse, N. Y.	WPEA	2458	400
Tacoma, Wash.	KGZN	2414	100
Toledo, Ohio	WRDQ	2470	200
Topeka, Kans.	KGZC	2422	50
Tulare, Cal.	WPDA	2414	150
Tulsa, Okla.	KGPO	2450	100
Vallejo, Cal.	KGPG	2422	7.5
Waco, Tex.	KGZQ	1712	50
Wichita, Kans.	KGPZ	2450	250
Wichita Falls, Tex.	KGZI	1712	50
Woonsocket, R. I.	WPEM	2470	50
Youngstown, O.	WPDG	2458	150

CONSTRUCTION PERMITS ISSUED FOR MUNICIPAL POLICE STATIONS

Location	Call Letters	Frequency (kc.)	Power (watts)
Aberdeen, Wash.	KGZV	2414	50
Albany, N. Y.	WPGG	2414	100
Binghamton, N. Y.	WPGL	2442	150
Cranston, R. I.	WPGK	2470	50
Hammond, Ind.	WPFJ	1712	100
Lakeland, Fla.	WPFT	2442	50
Lubbock, Tex.	KGZW	2458	50
Miami, Fla.	WPFZ	2442	100
Palm Beach, Fla.	WPFX	2442	50
Portsmouth, O.	WPGI	2430	50
Providence, R. I.	WPGF	1712	150
San Bernardino, Cal.	KGZY	1712	50
Shreveport, La.	WPGE	2430	50
Utica, N. Y.	WPGJ	2414	100

LICENSED STATE POLICE STATIONS

Location	Call Letters	Frequency (kc.)	Power (watts)
Iowa			
Des Moines	KGHO	1534	400
Massachusetts			
Northampton	WPEW	1574	Night–500, Day 1100
W. Bridgewater	WPEL	1574	Night–500, Day 1100
Framingham	WMP	1574	Night–500, Day 1100
Michigan			
E. Lansing	WRDS	1574	Night–1000, Day 5000
New York			
So. Schenectady	WPGC	1534	Night –500, Day 1000
Pennsylvania			
Butler	WBR	190	300
Greensburg	WJL	190	500
Harrisburg	WBA	190	300
W. Reading	WMB	190	300
Wyoming	WDX	190	300
Texas			
San Antonio	KGZE	2506	500

CONSTRUCTION PERMITS FOR STATE POLICE STATIONS

Location	Call Letters	Frequency (kc.)	Power (watts)
Washington			
Portable & Mobile Snowplow No. A232	KGHA	2506	10
Portable & Mobile Snowplow No. A227	KGHB	2506	10
Portable & Mobile State police car	KGHC	2506	10
Seattle	KGHD	2506	50
Snoqualmie Pass	KGHE	2506	50

Single Side Band Phone Signals

(*Continued from page 26*)

side-band transmission, as the success of this method of transmission is dependent on a complete knowledge of these underlying principles.

Modulation is the process of impressing voice vibrations upon a carrier of constant frequency and amplitude so that the carrier amplitude is made to vary between certain maximum and minimum limits, these limits being determined by the "depth of modulation." in Fig. 1 is shown a carrier having a constant amplitude, A. (This carrier for illustrative purposes might represent an antenna current of constant amplitude, A.)

The carrier wave of a station is a simple sine wave—a periodic variation of intensity in antenna current, for instance—the peak value of which is constant. It is this portion of the wave that contains about 2/3 of the energy of the transmitter and which I recommended removing together with one of the side-bands.

Now this current is said to be either modulated or not modulated, depending upon whether or not the amplitude is constant or varying. The current shown in Fig. 1, is an unmodulated current, since it has a constant amplitude, A. If, now, this constant current is made to vary between certain limits, or above and below the amplitude A at some other definite frequency, the current is said to be a *modulated* current, as the constant amplitude A is now varied above and below its original value by a new value B, as shown in Fig. 2.

An anlysis of the curve of Fig. 2 will show that, when modulated, the *amplitude* of the antenna current at the transmitter—and at the receiver, for that manner—varies above and below the value it has when not modulated—when it has no voice or music impressed on it. The amount of variation above and below the average value is represented by B.

Here is where the Masters of Logic enter the picture. By a juggling of trigonometry, the varying amplitude wave may be *considered* as being the same as three separate and distinct entities: (1) the carrier which we discussed before, (2) a current which has a frequency equal to the carrier *plus* a frequency equal to the variation in amplitude of the carrier, and (3) a current which has a frequency equal to that of the carrier *minus* a frequency equal to the variation of the amplitude. If the frequency of the carrier is w, and the frequency of variation of the carrier is w_0, then the three separate currents which may be considered as existing are w, $w+w_0$, and $w-w_0$.

The two bands of high frequencies $w+w_0$ and $w-w_0$, which extend on either side of the carrier frequency w_0, are called the *side bands*. The band having a higher frequency than that of the carrier is known as the upper side-band, and the one having the lower frequency is called the lower side-band. These two bands of high frequencies are generated in addition to the carrier frequency when the process of modulation takes place in the circuit. During the process of modulation, the voice frequencies combine with the carrier frequency in such a manner that the entire band of audio frequencies are raised in the frequency scale to new positions adjacent to the carrier frequency, as explained above. It is to be understood that the voice components consists of a large number of complex wave vibrations of different amplitudes and frequencies and for this purpose can be said to lie between the limits of 100 and 5000 cycles per second.

To illustrate the above paragraphs, assume a transmitter in which the oscillator is tuned to 100 kilocycles (100,000 cycles). Then w_0, the carrier frequency, will be equal to 100,000 cycles. If this carrier were modulated in some manner by a single frequency tone from another source, such as a 400-cycle note from an audio oscillator, then the three component frequencies produced in the plate circuit of the modulating circuit would consist of:

Component No. 1 equal to w_0 or 100,000 c.p.s.

Component No. 2 equal to $w + w_0$, or 100,000+400 or 100,400 c.p.s.

Component No. 3 equal to $w - w_0$, or 100,000—400 or 99,600 c.p.s.

Analyzing the Results

Analyzing these results further, it can be seen that only two terms contain the modulation frequencies. The other term represents only the carrier. Whether the carrier is modulated or not, this term remains the same. *The carrier frequency, therefore, contains in itself no intelligence.* It is merely the reservoir for the power necessary to transmit intelligence in the side bands. Also, it can be seen that either one of the two side bands (upper or lower) contains in itself all the intelligence of the original modulating signals. It is possible, therefore, to eliminate or suppress both the carrier and one side band and still transmit a wave (remaining side band) containing all the intelligence necessary for successful communication.

If, now, the carrier only were suppressed at the transmitter, and another (local) oscillator at the receiving station generated a carrier into the receiver of exactly the same amplitude and frequency as the suppressed transmitting carrier, then the incoming side bands would combine with the local carrier, and the received currents would now be exactly the same as if the original carrier had been transmitted. The *receiver* cannot discriminate between the local carrier and the original carrier, so that reception will take place in a normal manner. The local carrier combines, or beats, with the received side bands and produces frequencies equal to the difference betwen the local carrier and the voice components, producing, after detection, the original modulating signals.

It can also be seen that if only one side band were transmitted (either upper or lower), exactly the same received signal would be secured, which in itself contains all of the original intelligence, and at the same time occupies only *one-half of the frequency band.* This explains the advantage of using suppressed-carrier single side-band transmission in congested areas.

Oscillator Frequency

It might be mentioned at this point that the frequency of the local oscillator is not as critical in single side-band transmission as in methods where both side bands are transmitted. A difference of about 50 cycles can be tolerated between the original and local carrier frequencies in single side-band transmission without appreciable distortion of the received signals.

These past few paragraphs explained the principles outlining the necessity of a local oscillator at the receiving station to generate a carrier frequency having substantially the same amplitude and frequency of the carrier which was suppressed at the transmitting station.

The Uni-Shielded Short-Wave Three

(*Continued from page 17*)

low-power foreign stations, but there is nothing tricky about the tuning or the control of regeneration.

In constructing the receiver, the four sockets are mounted first. Then, the jack J1, plate choke L3, tuning condenser C6, and switch SW1 are mounted on the front panel. As mentioned above, the jack must be insulated from the panel by fiber washers. The twin binding posts, BP1, BP2, and the antenna tuning condenser C1 are mounted on the rear panel. Adjustment of C1 is made from the rear of the set.

The r.f. choke L2 is fastened beneath the chassis between the sockets provided for L1 and V2. The other small parts, which include carbon resistors and mica and cartridge condensers, are soldered in place while the set is being wired. In proceeding with the wiring, the grid circuits should be wired first, then the plates, next the filaments and finally the various bypass condensers. The positive filament terminals of the tube sockets may be grounded directly to the chassis—also the ground terminal BP2, the spring contact of jack J1, and the returns of the bypass condensers. The A plus lead of the cable is also grounded to the chassis, as well as one end of the volume control potentiometer R4. The diagram shows the wiring to the bottoms of the tube sockets.

After the wiring is completed and checked, the cable should be connected to the batteries in preparation for the initial test. Tubes, earphones, and one short-wave coil are plugged in and antenna and ground are connected. The coil covering the band up to 200 meters should be used for the first test. The regeneration control R4 is turned until the detector tube oscillates. Then a station whistle is tuned in. A slight adjustment of the antenna tuning condenser soon determines the condenser position for best reception, for the particular antenna being used. Turning back the regeneration control slightly to the point just before the set "spills over" clears up the whistle and brings in the desired station, loud and clear.

The Army Amateur Radio System

(*Continued from page 19*)

disaster. Since the Red Cross organization is broken down into three zones, namely, the Eastern, Midwest, and Pacific zones, each with its own headquarters, Army Amateur Radio stations are also assigned to these three headquarters. Each radio station operator establishes and maintains liaison with his Red Cross representative. He is fully informed as to the part he is to play in disaster, relief, and has prepared and on hand, ready to fill in on a moment's notice with the essential information, messages and reports to be transmitted as radiograms to the zone headquarters in case of a disaster.

When Disaster Strikes

When disaster strikes a section of our country the district nets in the affected area are "alerted," as well as the state and corps area and Army stations together with any others that are essential to establish the desired communication for the disaster. When the number of stations within the affected area is sufficient, they are assigned to specific tasks, such as Red Cross messages, press dispatches, personal messages of inquiry and assurance, etc.

To train and qualify a thousand amateur radio operators scattered throughout the country to work efficiently under such conditions requires that they be extremely well drilled in routine operation and thoroughly familiar with the normal methods to be followed and also have a personal "operating acquaintance" with the other operators with whom they must work. Weekly drills are conducted each Monday night. At this time each net functions and messages are exchanged between stations within the net and between nets. In addition to this, the Army station in Washington sends out a message addressed to all Army amateurs which each station is required to copy and acknowledge receipt of to its corps area signal officer. Also the corps area sends out a message for all stations within the corps area. These general messages usually contain information of general interest to all members or instructions to them.

The volume of traffic handled by some of the stations runs quite high. Particularly is this true of the corps area and Army stations, which are required to relay all of those going out from or in to their nets. The very nature of the work means that the station operators have a regular traffic load for their stations, thus providing an interest factor and at the same time affording them a wonderful opportunity to improve their ability as an operator.

Membership Requirements

Membership in the Army Amateur Radio System is open to any American citizen who holds a valid amateur station and operator's license and who further is the owner and operator of an amateur radio station (transmitting and receiving), who signifies a willingness to keep all assigned schedules in conformity with the purpose of the system, and who, further, is willing to abide by such rules and regulations as may be promulgated from time to time. Any radio amateur meeting the above qualifications who is desirous of becoming a member should make application to his corps area signal officer.

Clarifying Some Radio Terms

To avoid confusion in the minds of our readers, we wish to clarify certain words and terms used on practically every page of the magazine. The notorious looseness of radio terminology which has been prevalent for the past few years is giving way to increasing accuracy, so all users of radio apparatus should acquaint themselves with the correct forms.

Coils having the property of electrical *inductance* are specifically referred to as *inductors*. Devices having the property of *capacitance* are correctly called *capacitators*, although the older name *condensers* is likely to stick for quite a while. Devices having the property of *resistance* are logically *resistors*.

In most handbooks the *antenna* is defined as the entire radiating or intercepting system of wires, of which the *aerial* and *ground* are separate components. The tendency in the past has been to consider *antenna* and *aerial* as synonyms, although correctly the latter is actually only part of the former. Of course, where the ground plays no important part in the transmission or reception—as is the case with Hertzian antennas—the aerial wires by themselves constitute the antenna. This is a rather fine distinction which need not bother anybody.

Newcomers in the short-wave field are apt to refer to all short-wave transmitters as "broadcasting stations." This is definitely wrong. Stations like GSA, DJC, Radio Colonial, Radio Roma, Moscow, W8XK, W2XAF and W2XE are legitimate relay broadcasting stations, because they transmit actual programs on a more or less regular basis. However, police, amateur, airplane and airport, and trans-oceanic radio-telephone stations are not broadcasting stations but *communicating* stations, their messages being directed to specific receiving points. No amateur or airplane station ever "broadcasts"; it transmits.

Hum Difficulties

(*Continued from page* 29)

oscillator voltage being impressed directly on the grid of the second detector. A double-tuned i.f. transformer will remedy this defect by supplying the additional attenuation required.

Another source of hum which acts in much the same manner is that due to coupling from the oscillator because of insufficient filtering in the plate and screen leads from the oscillator.

Usually hum which is present only on tuning in a signal is called "modulation hum." If the incoming power line has not been filtered the signal may be fed into the rectifier tube, where it is modulated with the rectified hum voltage and then reradiated or carried to the antenna or input system of the receiver. A filter will correct this condition.

When large signals are applied to the receiver the grid of the input tube may be driven positive during part of the cycle grid. The remedy for hum arising from this source is to insert sufficient attenuation between the input system and the input of the first tube.

The foregoing suggestions are the results of extensive investigations which have been made during the past season on many universal type radio receivers that have come to our attention. In general, improvements in set performance have been realized by making adjustments similar to those discussed in this article.
—*Hygrade Sylvania Corp.*

Byrd Notes

(*Continued from page* 15)

information therein contained for his own benefit or for the benefit of another not entitled thereto: Provided, That this section shall not apply to the receiving, divulging, publishing, or utilizing the contents of any radio communication broadcast or transmitted by amateurs or others for the use of the general public or relating to ships in distress."

Of course, there is nothing wrong in listening in on short-wave signals of any kind, as by their nature, no radio transmissions are particularly secret. However, listeners are cautioned against calling up their local newspapers and telling them what they hear over the air. The KJTY-U.S. transmissions are regarded as point-to-point communications, and, therefore, fall within the scope of Section 27. The Columbia Broadcasting System has been flooded with requests for verifications on KTJY and, of course, it is unable to supply these because the intercepted transmissions may have been tests, expedition business, or point-to-point transmissions of addressed material.

Curing Hand Capacity

HAND capacity effects sometimes appear unexpectedly in receivers using metal chassis and panels. This trouble can usually be traced to careless wiring insofar as the radio-frequency circuits are concerned. Instead of depending on the whole chassis and panel as the common "ground" lead, it is desirable to bring all r.f. leads that require grounding to a common screw on the chassis, preferably a few inches back of the panel. Indiscriminate "grounding" at the most convenient mechanical points, which was practiced in many early t.r.f. and superheterodyne short-wave receivers, is now known to be responsible for mysterious effects that manifested themselves as uncontrollable oscillation, tuning interlock between apparently decoupled circuits, and general receiver instability.

Probably the most annoying result of careless r.f. grounding of this kind is dial noise. The dial mechanism has been found to form an actual loop circuit paralleling a sensitive tuning circuit, and slight changes in the resistance of the dial, due to the friction-actuated members, therefore produce horrible grating sounds. Lubrication of the dial is just as likely to aggravate the trouble as to cure it.

With Bartlett in the Arctic

(*Continued from page* 9)

frequency and at this point, Mr. Moe had difficulty in contacting the New York stations, although every-one else was easily communicated with.

Mr. Moe stated that between July 21st and August 10th, when there was three hours of twilight and the nights began to get longer, 20-meter reception was excellent.

Although the temperature was, as might be expected, exceedingly low, Mr. Moe stated that it in no way effected reception. He made a special note of the effect of the Aurora Borealis. He noted that when this appeared, and his description of this weird act of nature was an interesting one,—"They were like blueish clouds of streaks, constantly shimmering," there was not a bit of noise. However, when the effect was medium, the signals died out completely. This is in contrast to many theories and reports made. Most of the listening on which all the above reports are based was done between the hours of 6 and 9:30 p. m.

An interesting point was brought to my attention by Mr. Moe regarding the water used for batteries. Ice was used. Mr. Moe explained that when water is frozen, salt disappears, consequently providing not only fresh battery water but excellent drinking water.

Tickler Polarity

Many experimenters, when connecting up a regenerative circuit, try connecting the tickler first one way and then another in an attempt to determine which is correct.

Remember, the end of the tickler coil which concides with the corresponding end of the secondary goes to the B+. That is, if the two coils are wound in the same direction, and if the beginning of the secondary is the grid, then the beginning of the tickler winding is the B+. If the two coils are wound in the opposite direction (hardly ever done), then the end of the tickler is B+.

A Tip on Selectivity

The selectivity of a number of stages of r.f. or i.f. amplification is the product of the number of stages and the selectivity of one of them, provided that the selectivity of each is the same. Selectivity curves are multiplied, not added, to obtain the total selectivity.

Lining I. F. Amplifiers

When lining up an i.f. amplifier, do not rely on maximum noise—as many do—as the peak. If you use a modulated oscillator, you will find that maximum oscillator response and maximum noise do not occur at the same place. The first gives the greatest signal, the latter the greatest noise.

Keep Arrestor Clean

Dust has a tendency to drift into some types of outdoor lightning arrestors; remember this when testing an aerial installation.

Southern Exams

Southern examinations for all classes of radio operator licenses will be held in the Civil Service Room, Federal Building, Winston-Salem, N. C., on Saturday, February 3rd, 1934. The examination will be held in two sessions beginning at 1 p.m. and 7 p.m. All applicants for amateur class A, commercial, and radiotelephone examinations must appear at 1 p.m. Edward Bennett, Room 17, Custom House, Norfolk, Va., is Inspector in charge..

Unique Tube Characteristics

(Continued from page 13)

the exhaust period. Therefore, this type of blue haze is in no way detrimental to the operation of these tubes.

Gas is a blue haze which is usually confined to the vicinity of the plate and filament structure. Its presence, when of large content, affects the operation of a receiver to the extent that erratic performance is noticeable. Gassy tubes should always be replaced with new tubes.

Testing for the above conditions can be best accomplished by actual operation in a receiver. It is not necessary to test for the blue glow evident in types 82 and 83, since this is characteristic of these two types of tubes.

When in doubt as to the blue content of other types of tubes, a sure test can be made by using a magnet next to the bulb. A gassy tube will not be affected in any way by the presence of the magnet, while the fluorescent glow, which has no effect on the performance of the tube, will shift about as the magnetic field is shifted.—*Hygrade Sylvania Corp.*

Learning The Code

Many short-wave listeners become interested in the numerous code stations they hear, and eventually they decide to learn the code, so that they may be able to "copy" the mysteriout dots and dashes. This is a commendable idea, for, as remarked previously in SHORT WAVE RADIO, a knowledge of the code greatly increases the enjoyment one can obtain from a short-wave receiver.

"The full Continental Code, which is universally used for all radio-telegraph transmission, appears in many radio textbooks. It is quite practicable for a person to study the code all by himself, as many stations send slowly enough to provide the beginner with plenty of practice.

The whole trick in learning the code is to think of the characters as "dits" and "dashs," *not* as dots and dashes. To memorize the character A, for instance, mumble to yourself, "Dit-dah, dit-dah, dit-dah" over and over until you involuntarily say dit-dah whenever you see the letter A, and your brain automatically registers A when the dit-dah sound appears in a radio transmission. Go through the whole alphabet this way, taking a few characters at a time and forming simple words with them.

It is a good idea to learn how to send as well as to receive. Simple, effective code practice sets can be bought very cheaply, and will provide a lot of fun. The manipulation of a telegraph key is known in radio parlance as "pounding brass," for the reason that all such keys are made of brass.

Fringe Howl and Dead Spots

By ALFRED A. GHIRARDI
Author of the "Radio Physics Course"

A GREAT many short-wave receivers are troubled with a condition known as fringe howl, or threshold oscillation. When the regeneration is increased just under the point where the tube acts as an oscillator, the receiver breaks into an audio howl. This condition is caused by radio-frequency disturbances which have found their way into the audio amplifier. It is not usually troublesome with one stage of amplification, but when two stages are used, the receiver becomes unmanageable.

Increasing the amount of regeneration will stop it, and taking the tube completely out of oscillation will stop it, but since the most sensitive point by far is just under oscillation, and since the noise is usually of an extremely annoying character, it is very desirable to remedy it if possible. One common, simple method of eliminating it is to shunt about a 100,000 ohm resistor (commonly of the grid-leak type) across the secondary of the first audio-frequency transformer. If a 100,000-ohm grid leak is sufficient to stop the howls, it will be found that it does not cause any appreciable loss in amplification, and the circuit seems to remain exactly as it was before the addition of the resistance, except that the "fringe howl" has stopped.

Dead Spots in Tuning

Many owners of short-wave receivers are troubled by the fact that at certain dial settings so-called dead spots, or narrow frequency bands, exist, over which either the receiver cannot be made to regenerate at all by means of the regeneration control, or an unusually large increase in its setting is necessary. These dead spots are caused in a variety of ways, and they may also be eliminated if their cause and nature is thoroughly understood.

A "dead spot" on the tuning scale of a receiver means simply that at the frequency corresponding to that dial setting, there exists a condition which causes the feedback to be reduced and the receiver does not oscillate properly. For the purpose of studying "dead spots," a regenerative receiver may be considered simply as an oscillator. Any oscillator can produce only limited power up to a certain point. Beyond this the output drops rapidly, and finally the oscillator ceases to operate.

Resonance Absorption

Any circuit tuned to resonance with an oscillator absorbs energy from it. If this absorption is too great for the power of the oscillator considered, the latter cannot operate properly. This is the reason for the "dead spots" on the dial of a short-wave receiver; there are tuned circuits which absorb power at those frequencies. One of the offending circuits is usually the antenna cirsuit of the receiver. The antenna, with its coupling coil, is tuned by its total antenna-ground capacity to a definite frequency, determined by the values of inductance and capacity in the antenna circuit. If these values are such that the "natural frequency" is the same as that to which the regenerative receiver is tuned, the antenna circuit absorbs energy from the oscillating detector circuit, and the oscillator will "plop" out of oscillation, simply because it can no longer supply the total power required to keep it oscillating plus that being absorbed from it by the tuned antenna circuit. Under this condition, no oscillations can be produced ordinarily, or else a large increase in the setting of the regeneration control is necessary.

The regeneration control, however, has a limited range, and cannot be increased very far before its entire range has been covered, so that the receiver will no longer oscillate.

Antenna at Fault

The antenna system causes dead spots also at the harmonics of its natural frequency; but these are less pronounced and not so disagreeable, because the regeneration control setting need be increased only slightly for these. Dead spots may also be caused by resonance in the r.f. choke used in the plate circuit of the detector itself or by apparatus near the receiver. It is possible to obtain dead spots from choke coils or tuned circuits near the receiver; it is not necessary for a circuit to be closed upon itself in order to produce a "tuned" circuit.

Assuming that all apparatus has been removed from the immediate vicinity of the receiver, let us consider various means for removing all dead spots from the dial. Since a dead spot is caused by resonance, it will, in general, be possible to eliminate such resonance by detuning the circuit causing the trouble. It is possible not to remove a dead spot entirely, but to shift it to some frequency which is not covered by the receiver dial. In the case of dead spots caused by the antenna circuit, a variable condenser of the 23 plate midget type (.0001 mf.) connected in series with the antenna circuit will usually permit of shifting the dead spot to another frequency each time. In sets employing plug-in coils, the dead spot may reappear when a different coil is plugged into the receiver; but if the series condenser in the antenna circuit is variable, the dead spot can again be shifted outside the new tuning range. In the case of an r.f. choke causing a dead spot, turns of wire may be added to or removed from the choke to shift its natural resonance frequency and the dead spot.

Why the Dome-Shaped Radio Tube?

WITH all radio tubes, including the older types used mainly as replacements, now dressed in dome-shaped envelopes, the question may well be asked, "Why the dome-shaped bulb?" The answer to that question is as follows:

One of the factors in adopting the dome-shaped bulb was the possibility of supporting the mount at the top through the use of a large mica disc fitting into the dome tightly enough to support the elements at this point. This improvement made the tubes less sensitive to change in characteristics when subjected to shocks such as occur in shipping tubes in the sockets of radio receivers. However, the problem of a satisfactory fit between the horizontal mica disc and the walls of the bulb was a difficult one because of variations in bulb diameter, which cannot be controlled with the degree of uniformity necessary to prevent development of rattles caused by the mica striking against the glass.

Several of the more important types of tubes are now being made with mica vertical end pieces mounted on the usual horizontal or top mica spacer, these vertical members being shaped to permit sufficient spring to compensate for variations in the dome diameter. This innovation has been particularly satisfactory in the case of power output tubes such as Type 42. It has also been applied to some of the R.F. tubes and will be adopted to other types as soon as practical details of construction are worked out. Tests on tubes incorporating the new construction show that they are particularly resistant to damage caused by severe blows or shocks, the small resilient mica pieces acting as buffers and protecting the tube elements. With this construction nothing short of breaking the bulb causes any damage to the tube.

★ ★ ★

Don't Drop Phones

Some radio experimenters do not seem to realize that earphones contain permanent magnets, and that permanent magnets will lose their magnetism if they are jarred violently. Therefore, be careful about dropping phones.

Choppy Signals

THE reception of voice or music signals on the short waves is sometimes accompanied by a peculiar chopping or wavering effect which resembles rapid fading but it is too consistent to be classified as fading. In most cases this will be found due to interference from a high-speed radio-telegraph or picture transmitting station on a closely neighboring wavelength.

Radio signals that sound very much like the noise produced by a wad of newspaper held against the blades of an electric fan are usually television or still picture images in electrical form. If the signals are heard about 100 meters, they may safely be classified as television; below 100 meters as picture transmission. Sooner or later the voice of an announcer will break into the television signals, but communication on the still picture channels is invariably done in the dots and dashes of the Continental Code.

Incidentally, there is no way the amateur can reproduce "still" radio pictures, as special, highly expensive apparatus, owned only by RCA, is required. Anyway, these pictures are not "broadcast," but are directed at particular stations, and therefore they fall in the same category as addressed radio messages.

SHORT WAVE EXCHANGE

Have you some apparatus to sell or swap, or some special service to offer to other short-wave fans? Take advantage of the low rates of this department to reach other "hams". Only 5 cents per word for amateurs, 8 cents per word for manufacturers or dealers. Name, initial and address each count as one word. Not less than 10 words accepted. Cash, money order or U. S. postage stamps must accompany all advertisements. Please write clearly.

49 METER RECEIVER: Shielded coils as specified in this issue. $6.00 per set of four. Complete receivers constructed. J. A Worcester, Jr., 159 South Street, Middletown, N. Y.

FOR SALE: Marlin Model 39 lever action calibre .22 repeating rifle, take down type. Beautiful walnut stock. Fired less than 100 times, in gun crank condition. With canvas case, complete, $14. R. Hertzberg, c/o SHORT WAVE RADIO, 1123 Broadway, New York, N. Y.

FOR SALE: 30-henry, 100 ma. AmerTran filter choke, type 854, $1.50 plus mailing. AmerTran deluxe second stage audio transformer, $1.50. National type VKCC full vision dial, never used. $1.50. Baldwin loud speaker unit only, no horn, new condition, ideal for small short-wave receiver, $1.00. Jewell 0-15 volt. A.C. voltmeter, small type, flush mounting, brand new, $1.50. Weston type 267 milliammeter, 0-100 mils. Completely encased, lies flat on table. Highly accurate needle indicator, with mirror reflector, a bargain at $3.50. A. A. Dolid, 5101—39th Avenue, Long Island City, N. Y.

CONDENSERS: Cardwell-Variable-types; 3 model 164 B, each $2.50; 2 model 503, each $3.25; 1 type 512 B with mycalex supports for 5 meter at $6.50; 2 type 123 B, each $2.25; 2 type 412 B, mycalex supports for 5 meter, each $2.50; 3 type 402 B, $1.15; 3 type 408 B, $1.40. R. H. Odwak, 250 E. 7th Street, Brooklyn, N. Y.

Want to Subscribe?

You will find a large, convenient coupon on page 48.

Class A, B, or C —Which?

PROBABLY more confusion exists in the minds of experimenters regarding the purpose of class A, B, and C amplifiers than about any other tube connection. What seems to be more appreciated is the results of the connections rather than the purpose of the connections themselves. For instance, every one knows—or at least realizes—that Class A amplifiers give undistorted output and excellent tone quality. Transmitting amateurs are familiar with classes B and C connections, since their work utilizes these modes of connection to a greater extent than that of the receiving amateur.

The strange part about the entire situation is that there is no definite line of demarcation between classes A and B amplifiers; in fact, during the last year and a half, an intermediary type has been adopted called class A prime, but let us begin at the beginning and see if we can clear up this situation without becoming too technical or too involved.

Class A Amplifiers

A tube is said to be operating as a class A amplifier when the form of the output current variations are identical with the form of the input signal. A study of this definition will show that so long as this similarity obtains, the tube is a class A amplifier.

Let us see under what conditions, then, similarity of plate current fluctuation and signal voltage can exist. If the grid voltage—plate current curves of tubes designed for class A operation are studied, it will be found that the curve is a straight line over a certain portion of the characteristic. Now, if the grid bias without signal is so adjusted that the operating point is at the midpoint of this straight portion, and furthermore, if the magnitude of the signal voltage is so adjusted that its extremities do not raise the bias beyond the straight portion of the characteristic, then class A amplification exists. In other words, because of the fact that the tube is continually operating on the straight portion of the characteristic, the increases and decreases of plate current coincide exactly with the signal.

This straight portion of the curve may exist in two distinct regions: first, with some positive bias on the grid, and second, with some negative bias on the grid. In the usual application, a negative bias is applied in order to minimize the distortion due to grid current. Although the amount of power obtainable with negative biases is smaller than that obtainable with positive biases, the maximum *undistorted* power output is greater. Since the efficiency of a power amplifier may be defined in terms of the power output per unit of signal voltage, and since the power output is a function of the plate current swing, it follows that the greater the plate current swing per signal volt applied, the more sensitive the tube as a power amplifier. In plain English, this means that the more nearly vertical the grid voltage-plate current characteristic, the more sensitive the power tube.

The important point to keep in mind here is that in the class A amplifiers in general use today, the grid never swings positive with the highest permissible signal. In fact, a good rule to remember is that the peak value of the signal shall never exceed the fixed grid bias.

Class A Prime Amplifiers

In the class A prime amplifier, the grid bias is so adjusted that a very heavy signal can be applied which results in considerable grid current being drawn. This grid current ordinarily would give rise to considerable distortion were it not for the fact that input and output transformers designed for class A prime amplifiers have very low resistances and very low leakage reactances. With these two items reduced to a minimum, the grid current may reach very high values before the distortion becomes appreciable.

In class A prime amplification the bias is made more positive than in an equivalent class A amplifier. The result, therefore, is that with a heavy signal, the grid swings positively over the straight portion of the characteristic on one half the cycle and on the negative portion of the characteristic on the other half of the cycle. Grid power flows, therefore, during that portion of the cycle during which the grid is positive.

The results claimed for this mode of operation are high power sensitivity and low distortion.

Class B Amplifiers

A class B amplifier is essentially a detector—it rectifies the signal exactly as does a detector tube designed for the purpose. In this connection, the grid bias is so adjusted that when the grid is positive the plate current increases and when the grid becomes negative on the other half of the cycle, the plate current remains unchanged from the value it normally has with no signal.

What seems to confuse most experimenters when considering class B amplifiers is the matter of grid bias. Some tubes require a very high bias for class B amplification while other tubes require no bias at all. This apparent fluctuation arises from the fact that those tubes (such as the type 46) specifically designed for class B work have their characteristics so shaped that rectification takes place with zero bias. On the other hand, some tubes require a high bias in order to bring the operating point near the lower bend in the curve in order to satisfy the requirements for class B operation.

It will be noted that with this type of amplification, the average plate current depends upon the magnitude of the signal, so the actual power consumption is a function of the signal strength.

Since the amount of distortion present in the output of class B amplifiers may be as high as 30 per cent, some means must be adopted to minimize it. Most of this distortion is in the form of even harmonics, present in the output of any detector tube. These even harmonics are present because the bottom parts of the signal have been eliminated in the process of rectification. Another tube connected so as to operate in phase opposition with the first will supply this missing half and theoretically, at least, considerably reduce the amount of distortion. It is for this reason that all class B amplifiers have a push-pull connection.

Class C Amplifiers

The third and last connection for amplifier tubes in general use is the class C amplifier. Although it has not as yet been adopted for general receiver output tubes, nevertheless, it has formed a very important part of transmitter circuits.

In this amplifier, an exceptionally heavy signal is applied to the grid of the tube. In fact, the signal must be so large that the plate current fluctuates between saturation and zero. Now, saturation is that maximum possible current which can be drawn from a tube regardless of plate or grid voltage. It is obvious, therefore, that this type of amplifier is replete with harmonics which must be removed.

L. M.

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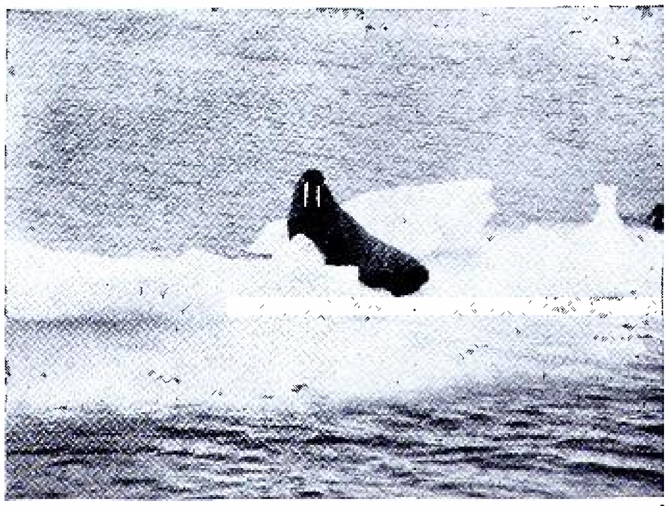

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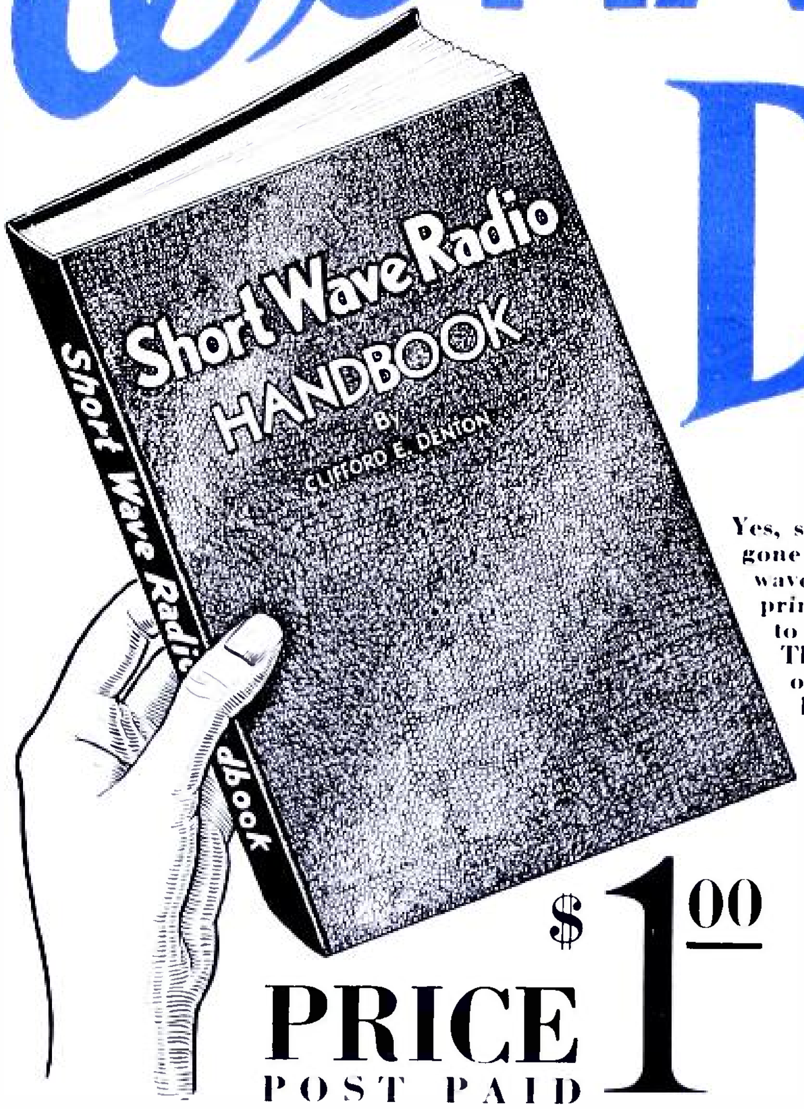

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