

The War Emergency Radio Service

SINCE the suspension of all amateur operating as such, civilian amateur radio licensees have found many practical operating and constructional opportunities in the War Emergency Radio Service. The WERS is a temporary wartime communication service established to aid in the protection of civilian life and property in the event of enemy attack or natural disasters. It shall be the purpose of this chapter to demonstrate the workings of the three categories of WERS (Civilian Defense, State Guard and Civil Air Patrol), and to show how the equipment and personnel of the stay-at-home radio amateur can best be utilized in this service.

In the original rules governing this service, issued in June, 1942, operation was authorized to two kinds of organizations, civilian defense and state guard. The civilian defense organization is under the supervision of the U. S. Office of Civilian Defense, Protection Branch, and is executed by the U. S. Citizens Defense Corps, an organization of enrolled civilian volunteers established within OCD. Civilian radio amateurs have played a greater part in CD-WERS (civilian defense WERS) than in either of the other two categories.

Practically every state now has its own state guard organization, a semi-military group established within the state to provide protection and a military reserve for duty within that state. SG-WERS (state guard WERS) is a service operated by the state for communications relating directly to the activities of the state guard or other equivalent officially recognized organizations.

In January, 1943, the FCC included a third category within this service, that of the Civil Air Patrol, a rapidly expanding organization of civilian volunteer pilots and air personnel, established originally within the Office of Civilian Defense but later absorbed into the U. S. Army Air Forces.

In each category an official is appointed by the licensee (a local municipality in the case of civilian defense stations, a state in the case of state guard, and a "wing" in the case of the Civil Air Patrol) to supervise the network, after thorough investigation and certification by the licensee. This official is called a "radio aide" in CD-WERS, and a "communications officer" in SG- and CAP-WERS. One license authorization may be issued to cover the operation of all fixed, portable, mobile and

portable-mobile transmitters proposed to be used in a single coordinated system. Call letters are assigned with subnumbers, one number for each transmitter in the system; for example, WQRR-1 might be the control unit for a typical network, with WQRR-2 through WQRR-23 as subordinate units. Operation may be on any frequencies in the amateur 112-, 224- and 490-Mc. bands, using any normal type of emission, with a maximum input of 25 watts and certain stability specifications. WERS operation may take place only in those specific instances as defined hereafter, except for authorized practice blackouts and mobilizations and for weekly test periods. Station units may be operated only by the holders of WERS operator permits, available to any FCC operator licensee whose services are wanted by a WERS licensee, upon proper application with accompanying certification of the station licensee. The complete rules and regulations appear at the end of this chapter.

The radio amateur has played an important part in all three categories of this service, although perhaps more so in CD-WERS than in the other two. There is no priority rating available for equipment to be used in this service, and much of the equipment was supplied by amateurs who had it on hand or who were able to build it from parts out of their junk boxes. Amateurs themselves serve as administrators, technicians and often as operators, as well as in training additional personnel to qualify for operating assignments. Since the service has expanded greatly in scope and magnitude since its origin amateurs now represent an increasingly smaller part of the participating personnel, but an increasingly more important part by reason of their technical ability and operating experience.

Ⓐ Civilian Defense Stations

WERS was organized primarily at the request of the Office of Civilian Defense, which wished to fit WERS units into its nationwide plans for protection against enemy attack. With the disruption or overloading of normal telephone and telegraph circuits, a CD-WERS unit provides emergency radio channels between the Citizens' Defense Corps control centers, air-raid warden posts, police, hospitals and other strategic points. They also are available for use during other emergencies endangering life, important property and public

safety in connection with civilian defense or national security and, like all other WERS stations, at the request of any agency of the United States Government during emergencies endangering the safety of life or property. Aside from those periods during which CD-WERS stations are activated for essential operation in connection with their duties, certain hours of the week have been set aside for testing and practice drilling purposes so that the personnel involved, consisting entirely of civilian volunteers who may or may not have had previous experience in radio communication, can be trained to execute their assigned duties promptly and efficiently.

Plan of organization — Under FCC regulations, a civilian defense station license is issued to any local government, such as a town, city, borough or county, but the radio aide has actual control of all units under the jurisdiction of the license. This radio aide is appointed by the licensee, who must certify, on a prescribed form, that he is of proved loyalty and known integrity. The licensee then leaves most of the responsibility for the local CD-WERS in his hands; thus it is essential that the position of radio aide be given to the best possible man available for the job.

For control, communication and air-raid warning purposes, the OCD plan of organization is based fundamentally on what is known as an *air-raid warning district*. Such a district usually contains several hundred square miles — say, for example, an area 20 or 25 miles square — and its boundaries were originally chosen in terms of telephone toll-line organization. Somewhere near the center is a *district warning center*, usually in the largest city of the area. At this center, air-raid warning and other signals are received from regional information centers, which derive their instructions from the Army defense commander. The d.w.c. has the duty of relaying certain of these signals and information to other communities in its warning area, known as *subcontrol centers*. Through its communication facilities, the warning district's defense-corps staff arranges for allocation of apparatus for fire-fighting, road clearance, etc., in the event of a heavy air raid concentrated only in parts of the area. Communication with the warning-district center is important, since CD-WERS then can take over district air-raid warning signals and other traffic if the need develops, and is assured of prompt notification should the WERS be ordered off the air by the defense commander.

The control and communications section of OCD desires the establishment of networks based on these warning districts where possible. It wishes the station license for the entire district to be held by the city in which the d.w.c. is located, with subnumbers assigned in blocks to other cities in the area. In the fictitious example shown in Fig. 1601, Centralia is the d.w.c. city of its area; it holds the license for the entire warning district, blocks of sub-

numbers being distributed to its communities according to their communications requirements as shown. Some of the advantages of this arrangement are:

a) The important lines of civilian telephone communication for air-raid protection are paralleled by the radio network.

b) Available frequency channels can be apportioned to adjacent communities in such a manner as to keep interference at a minimum.

c) The station units have radio channels direct into the district warning center, and may thereby be notified immediately of any shut-down order.

d) Facilities, personnel and portable-licensed equipment can be exchanged among the various communities under the license at will without special FCC authorization.

This requires a communications set-up differing but slightly from individual community plans. Organization of a group of communities under the district plan requires the utmost cooperation among the communities involved, but, once such cooperation is pledged or found to be existent, plans can go forward smoothly. Here are the preliminary steps to be taken in such organization:

a) Each interested community in the district appoints its local radio aide.

b) Local radio aides and communications officials of all local defense councils get together and appoint a district radio aide. In most districts, it has been found that a district radio aide cannot do a good job if he is also a local radio aide. The district radio aide *nominally* is designated the radio aide of the licensee, which in this case is the d.w.c. city. As seen above, however, actually he is selected by agreement among the communities concerned.

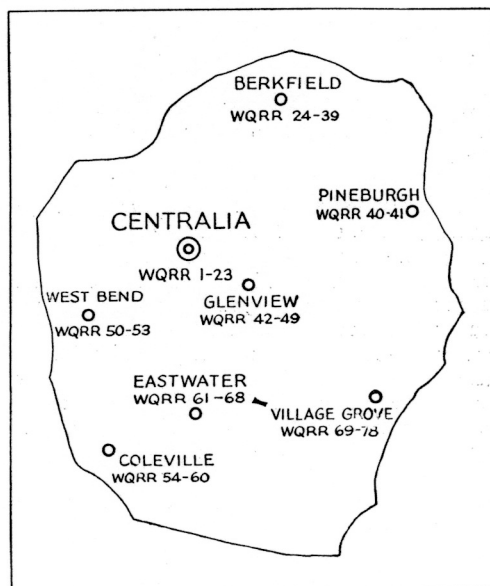


Fig. 1601 — Fictitious air-raid warning district map, showing allocation of subnumbers based on the size and communication requirements of individual communities.

c) Local radio aides then proceed to organize their own communities under the district plan, at the same time preparing the license data to be included in the license application. These data are forwarded to the district radio aide upon completion.

d) The district radio aide collects all license data from the local radio aides, executes the application, signs all operator permit applications and forwards the completed application to Washington.

It can readily be seen that licensing by districts is *not* practicable among communities which are at odds with one another. Unfortunately there are any number of reasons why district licensing might not be possible, such as: (a) the d.w.c. city may show no inclination to apply, or is in a very early stage of organization; (b) the d.w.c. city does not wish to have suburbs or adjacent communities included in its license application; (c) local defense officials insist upon an independent application, despite revelation of the advantages of the district system; (d) efforts on the part of outlying communities to help organize the d.w.c. city may have proved fruitless.

If, for one or more of the above or other reasons, it becomes necessary for communities of a district to apply independently, it is quite fitting and proper that they should do so rather than await a stalemated warning-district application. Individual communities thus applying should aim their organization at eventual consolidation with other communities of the district under the warning center. When the d.w.c. city becomes licensed, and is agreeable to a district license, the following steps then may be taken to effect a warning-area license:

- a) Appointment of a district radio aide.
- b) Preparation and submission of application for the entire district.
- c) Surrender for cancellation of the independent licenses.
- d) Request by independent licensees for special authorization to continue operation under the old license until the district license is issued.

e) Re-issuance of operator permits to be signed by the district radio aide and good for operation anywhere in the district.

Since this process will require quite a bit of altruism on the part of local communities, and since it will probably mean temporary disruption and rehabilitation of the local organization, it is quite likely that many independent licensees will be unwilling to be a party to any such scheme, preferring to maintain their independent status. It is unthinkable, however, that independent licensees should want to crawl inside their shells and have nothing to do with any adjoining licensees. If an independently licensed community finds itself unwilling to consolidate itself into the district license, the next best thing to do is to arrange for regular contact by radio with the district warning center by having one of the inde-

pendent licensee's station units represent its community in an intercommunicating network consisting of the control units of each community in the district, whether or not it be under the district license. The control unit of this "district net" should be located in the d.w.c. city, since the district warning center will be the only point in the district to receive shut-down or other orders from the Army Information Center as well as the point at which requests for aid will be received from and dispatched to adjoining communities.

Frequency allocations—It is one of the duties of the radio aide to coordinate the use of available frequencies by various communities so as to keep interference at a minimum. In setting up channels for employment by WERS stations, two factors must be considered: the frequency-stability requirements of FCC regulations, and the practical effect of possible interference between stations.

There are many schemes for frequency allocation in use among the hundreds of CD-WERS licensees in existence, and the one decided upon by any particular organization should be arrived at in consideration of the specific problems confronting that organization. Without doubt many of these problems will be peculiar to that organization, and therefore it is not possible for FCC, OCD or ARRL to set down a prescribed allocation scheme. The regulations give only the stability requirements and the band limits on which to base our plan.

OCD has proposed an allocation scheme which it has called its "Tri-Part Plan." This recommendation divides the 112–116-Mc. band into four segments, three of which are for use of CD-WERS while the other segment is to be used by SG- or CAP-WERS. Each segment is divided into a number of frequency channels 200 kc. apart, and each such band segment has a specific use. Nominally, they are the local-district (LD) band (112–112.8 Mc.) for the use of local control units in communicating with the district control unit, the local-fixed (LF) band (112.8–114 Mc.) for channels between local control units and fixed units of the local organization, the local-mobile (LM) band (114–115.2 Mc.) for contact with local control units and service headquarters by mobile units, and the Civil Air Patrol band (115.2–116 Mc.) for the use of the Civil Air Patrol and State Guard in areas where these categories of the services are in operation.¹

A simpler and probably more practicable method of frequency allocation, modifications of which are in actual use in many districts, is the following: The radio aide, in conference with radio aides of nearby districts, chooses a suitable spot on the "high stability" (112–114 Mc.) section of the band for the warning-district net, and assigns at least one additional

¹ For more details of the Tri-Part Plan, see *QST*, Feb. 1943, p. 19.

frequency to each community within the district for dispatch purposes or other use of its own choice. In the "low stability" section (114-116 Mc.) he should assign two frequencies to each community (including the d.w.c. city), one for a local net and the second for subnets of the local nets, constantly keeping in mind the geographical location of each community and the possibilities of mutual interference. Assuming that each community of our fictitious warning district intends to make full use of each each kind of service, the allocation for the first half of the band might be shown as follows:

Frequency	Use
112.1 Mc.	Guard Band
112.3	Warning District Network
112.5	Guard Band
112.7	Berkfield and Eastwater dispatch
112.9	Coleville and Pineburgh dispatch
113.1	Centralia dispatch
113.3	Glenview dispatch
113.5	West Bend dispatch
113.7	Village Grove dispatch
113.9	Guard Band

The second half of the band might be apportioned like this:

Frequency	Sector Warden Nets	Lower Nets
114.2	Centralia	Coleville
114.6	Village Grove, Berkfield	Glenview, Eastwater
115.0	Coleville	West Bend, Pineburgh
115.4	Glenview, Eastwater	Centralia
115.8	West Bend, Pineburgh	Village Grove, Berkfield

Actually the smaller communities may not have use for more than one channel, in which case more channels will be available for larger communities with a more complicated network scheme. An appreciable amount of duplicate and triplicate use of a single channel is quite practicable in lower nets of most warning districts. The type of receiver which will be in general use (the superregenerator) has the characteristic of featuring the loudest signal existent in its input circuit, completely annihilating any signal of appreciably less strength.

Note that 400-kc. channel separation is provided in the "low-stability" part of the band. This is to allow plenty of breathing room for each channel and provide for inevitable inaccuracy in frequency spotting by stations in the net. In the "high-stability" section of the band the channels need be only 200 kc. apart, since units capable of operating in this segment are expected to be more accurately calibrated and capable of better frequency stability.

The above plan makes no provision for State Guard or Civil Air Patrol operation in the area, but this should not imply that the possibility of their existence can be ignored. In the event that other categories of WERS are active, it is simply the duty of the radio aide to plan his frequency allocations accordingly, which will make the problem more complex because of resultant shortage of channels.

Because the "standard" vacuum tubes available at present do not perform efficiently

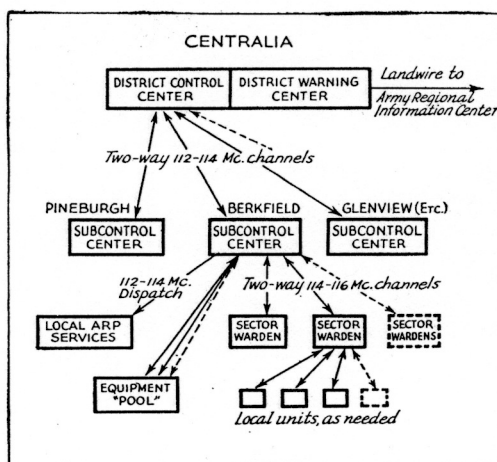


Fig. 1602 — A possible set-up of communication channels in an air-raid warning district, under one license. In this fictitious district, the city of Centralia houses the district warning center and the city itself is known as a main control center. The block "Local ARP Services" designates the fire, police, demolition-squad and other protection services to which a dispatching channel is desired. The block "Equipment Pool" designates a number of portable-mobile units available at a central point for immediate dispatch to an area suffering from unusual enemy bomb hits. For space reasons, only the Berkfield subcontrol center is shown subdivided here.

at 224 Mc., that amateur band has not been included in the basic allocations above. For organizations whose amateurs already have suitable tubes and equipment for a successful 224-Mc. communications system, additional channels are available which will simplify the problem.

Operating personnel — Everyone who operates a WERS station unit must possess a WERS operator permit. *There are no exceptions to this rule.* To be eligible for such a permit, an individual must possess a radio license of any class issued by FCC. Thus a licensed amateur is already eligible, as is any commercial radio operator; he may secure an operator's permit simply by filing a completed FCC Form 457 with his radio aide, who forwards it to FCC.

With thousands of amateurs in military and government communication service, it has been found that very few communities have sufficient licensed operator personnel to carry out a satisfactory plan of CD-WERS communication. In most communities it has been found necessary to set up brief but intensive training courses for desirable personnel aimed either at securing an amateur license or a restricted radiotelephone permit, probably with emphasis on the latter because of the comparative ease in qualifying for it.

A course for the 'phone permit might be set up for a total of six hours, in two-hour periods. A preliminary period could well be spent on presenting a general background of radio and the need for regulation and licensing; then a period of brief general exposition of the high spots of commercial rules and regulations, followed by individual discussion of typical ques-



Fig. 1603 — A typical WERS district control center station — WODF-5, Akron, Ohio. Duplicate operating positions enable dual-channel contacts with the central control station and field groups simultaneously. Auxiliary transceivers are kept in reserve to supplement regular equipment in the event of failure and for use as field units.

tions and answers; and lastly, several hours spent in simulated operation, practicing voice technique, phonetic word lists, signing the station off, repeating dummy message reports — all to make operators as well as licensees.

FCC commercial operator regulations provide to "employees of a division of local or state government" the convenience of "resident" examinations for the restricted 'phone permit. FCC has extended this privilege to personnel selected to operate WERS stations. In practice the municipality should communicate with the district inspector, submitting to him completed application forms with all other necessary attachments (fingerprint forms, proof of citizenship, photographs) for each applicant, along with the name of the person designated to supervise the examination (who might well be the radio aide) and the date and place it will be given. In the case of WERS stations, resident examinations will not be authorized prior to the issuance of the station license. Please note that this convenience applies to the restricted 'phone permit only — not to amateur licensing.

Operating procedure — One of the greatest faults with many CD-WERS organizations is that either they have failed to evolve any operating procedure or the procedure they have adopted is inadequate or unbecoming a government communications service. Realizing that the procedure used necessarily would vary according to the particular situation involved FCC did not limit WERS operation to any set form, except for a requirement that the procedure to be used be described as one of the supplementary statements in the application. From this it is not to be concluded that WERS units may say what they please on the air or conduct their operation in any way they see fit. "Ragchewing," attempting to establish DX records, and experimenting on the air except for the sole purpose of establishing re-

liable communication between two or more licensed points, especially are to be discouraged. Operators should be trained to make their transmissions brief and to the point. Participating amateurs, in particular, should be watched for this discrepancy, since WERS is not an amateur service and should not be conducted like one.

It is difficult to foresee what actual communications need there will be during an air raid and therefore one can only plan as best he knows how, altering the specifications as it is found they can be improved. Thus all that can be discussed here are general principles.

Identification must be complete at the beginning and ending of each complete exchange of communication. The net control unit might call the roll and be answered by the net units in the following manner:

WXXX1: WXXX1 calling WXXX2, answer roll call, go ahead.
WXXX2: WXXX1 from WXXX2, answering roll call, go ahead.
WXXX1: OK 2. WXXX1 calling WXXX3, answer roll call, go ahead.
(Etc., until roll call completed)

WXXX1: 2 from control, ready for your traffic, go ahead.
WXXX2: Control from 2, here traffic. . . .

With enemy planes approaching, however, announcement of call letters might reveal location of units. In some sections the Army requires that call letters, as well as any other information that might be of value to the enemy, be omitted during actual air raids. At such times the Army will issue a *limited transmission order*, which will come through the district control center and must be immediately obeyed by CD-WERS networks. Identification at that time should be by unit number only, omitting all assigned call letters. *At all other times the FCC requirement that complete identification be given must be observed.*

To expedite the handling of incident reports, CD-WERS systems should use the same report forms as are used by the wardens in reporting incidents. These report forms usually consist of items numbered one to eleven. In transmitting messages using these forms the operator can merely designate the item number to follow, without repeating any other printed information on the form. Some systems of operating procedure, although following the order of the regular report form, nevertheless omit the item number altogether.

Since the urgency of messages will vary it is well to arrange priority ratings for messages, such as "regular" (a routine warden report not requiring action), "rush" (a warden report necessitating action to be taken by one of the protective services), or "duplicate" (indicating

that no action had followed a previous report and the situation was becoming urgent).

Many licensees have devised systems for coding messages transmitted over CD-WERS networks, so that their meanings would not be apparent to the casual or enemy listener. Only information that might be useful to the enemy need be coded. The only effective way of putting such a code into practice is to agree on certain letters or numbers to represent certain words or phrases, and then to practise incessantly the technique of handling traffic using such a code. Code lists may consist of frequently used phrases, each containing its code number, which cover almost any conceivable need. To indicate locations, the city can be divided into zones, each street within that zone being numbered, so that a certain street could be indicated by saying "Zone 3-14," meaning the street numbered 14 in Zone 3, or "357 Zone 3-14" if it is desired to give the number of the house affected on that street. A simpler and perhaps more effective way of coding streets is to assign a number to each street in the city or district, starting, for example, with 0001 for Aaron Street and ending with 2500 for Zephyr Way; or, if desired, the numbers could correspond to the geographical location of the street instead of its alphabetical sequence; or there need be no relation between the street and the number assigned it. In any case each station unit should be equipped with a list of the number codes, arranged both numerically and alphabetically for ease of reference in coding and decoding.

Remember, however, that in handling traffic the important thing is to get the message through quickly. After efficient speed has been developed in handling messages, it is time enough to start considering coding devices. In no case should secrecy codes be developed at too great expense in speed.

In general, the following principles of operating procedure should be applied:

- a) Comply with FCC and Army regulations.
- b) Make transmissions short and to the point. Eliminate all words that can be eliminated without affecting the sense.

ARMY-NAVY PHONETIC WORD LIST

A — Affirm	J — Jig	R — Roger
B — Baker	K — King	S — Sail
C — Cast	L — Love	T — Tare
D — Dog	M — Mike	U — Unit
E — Easy	N — Negat	V — Victor
F — Fox	O — Option	W — William
G — George	P — Prep	X — X-ray
H — Hypo	Q — Queen	Y — Yoke
I — Inter		Z — Zed
0 — Zē-rō	3 — Thuh-ree'	7 — Sev'-ven
1 — Wun	4 — Fō-wer	8 — Ate
2 — Too	5 — Ft-yiv	9 — Ni-yun
	6 — Siks	

Example:

WQRR-49 — William Queen Roger Roger Fō-wer Ni'-yun

c) Adopt a procedure which will conform as closely as possible to that used by other branches of the ARP communications service.

d) Evolve your procedure around the slogan, "The enemy might be listening," and arrange it so that a listening enemy agent in no way may be aided by your transmissions.

e) Avoid unnecessary complications. The ideal operating procedure is one which will accomplish the objectives in view as simply, quickly and effectively as possible.

Application data — The person preparing a license application must make certain that it complies with the regulations, and he should be sure to prepare the application correctly *the first time* to avoid having it questioned by FCC — a time-wasting process, both for the applicant and for the Commission. On any doubtful issue it is wise to get the advice of someone who has "been through the mill." The comments to be made here, while necessarily of a general nature, are intended to cover points on which radio aides frequently go wrong.

The station-license application should be prepared on FCC Form 455 (available at any district FCC office). It may be executed only by municipal governments, such as cities, towns, counties, etc., and *not* by any subdivision of that government such as the police department, fire department or defense council. The application must be signed by the mayor, town manager or similar highest executive official of the government. For reasons of flexibility, many licensees have adopted the practice of listing all units as "portable" or "portable-mobile" except the fixed control units.

FCC will not issue a station license unless the application shows in detail the complete set-up of civilian defense communications. Extremely important is the map of operations, which should be included as a part of the supplementary data required in the regulations. A street map, available from the city clerk, should do the trick, with overmarking to show the communications plan. It should carry the locations of all station units, and if portable units are included their boundary lines of normal operation must be indicated. For warning-district organization, probably it will be more convenient to submit first a chart of the entire district, showing the channels between district and subcontrol centers, and second a series of smaller maps showing individual communities and details of unit locations.

The license application requires a number of attachments of supplementary statements and additional information, as follows:

- a) Additional lists of equipment too long for inclusion on page two of the application.
- b) A number of sheets identical to page three of the application, giving technical data on types of equipment not shown thereon.
- c) Form 455 (a), certification of radio aide.
- d) If the licensed community wishes to provide service to additional communities (as in the district plan of licensing), copies of inter-

municipal agreements made between the licensee and the various other communities to be covered, properly signed in each case by the mayor or similar official, must be included.

(e) Forms 457, one for each operator authorization requested. Make certain that these are properly executed and that two full-face recent photographs, not over $2\frac{1}{2} \times 2\frac{1}{2}$ inches and signed on the back by the individual applicant, are attached.

f) The general map of operations, as discussed above.

g) A statement concerning the scope of service to be rendered and type of messages handled. That is, whether a service for air-raid wardens alone, or for emergency equipment dispatch, or "incident officer" contact, or a combination of several.

h) Factual information on the exact area of operations to be included in the license.

i) A statement of the general operating procedure to be employed by all station units.

j) A list of all equipment procured, showing source (purchase, loan, gift, etc.) and distribution (usual area of operation of each unit).

k) A statement of methods to be used in supervising the operation of all station units, including data on monitoring, frequency-measurement methods, provision for frequent inspection by the radio aide, etc. If the latter has delegated controlling authority to deputies or assistants to act for him, this item should so state.

l) Methods used to ascertain the loyalty and integrity of operating personnel. This section should include a statement from the local chief of police giving the names of all operators for whom operating permits are requested and certifying to their character and loyalty to the United States. Also include data on plans for recruiting operators and whether they will serve on a paid or voluntary basis.

m) A positive statement of the applicant's ability to silence its units upon order of the regional defense commander. This entails establishing proof of close and continuous contact with the district control center and of arrangements for the immediate relaying of any such signals. The very nature of district organization permits an easy answer to this requirement, of course.

Carbon copies of all parts of the applications should be kept in the radio aide's files, so that he will be able to refer accurately to any part of the application which subsequently might be questioned by FCC.

Sample forms of agreements which may be adapted to the needs of the particular community are shown on this page. The first is the agreement executed between the amateur and the city when the former lends the city his equipment for the duration, and should be in duplicate. The second is the inter-municipal agreement for the license application under district organization, as adapted from the form used in the State of Massachusetts.

AGREEMENT

I, _____, residing at _____ in the city of _____;

being the unconditional owner of the radio equipment described in detail below, do hereby convey all my right, title and interest to such equipment to the City of Berkfield, Faryland, for use solely in the War Emergency Radio Service; PROVIDED THAT it shall be returned to me by the City at the end of the present war.

List of Equipment: _____

Dated this _____ day of _____

_____, 194____.

(Signed) _____

Witnessed by: _____

By its signed acceptance of this document the City of Berkfield acknowledges receipt of the equipment in good condition and pledges that at the end of the present war it will be returned to the above-named individual, his heirs or assigns, the City releasing all claims, right, title and interest thereto.

Accepted this _____ day of _____, 194____.

City of Berkfield, Faryland.

By _____

SEAL

WAR EMERGENCY RADIO SERVICE INTER-MUNICIPAL AGREEMENT

IT IS AGREED THAT the City of _____ hereinafter known as the licensee, will apply to the Federal Communications Commission for permission to construct and operate radio stations in the War Emergency Radio Service in the area known as _____,

AND THAT the City of _____, hereinafter known as the sub-licensee, lies within said area and wishes to participate in a single War Emergency Radio Service network serving that area;

IT IS HEREBY AGREED by both parties:

THAT all radio equipment installed by the sub-licensee for the above purpose shall be under the direction and control of the licensee;

AND THAT the Radio Aide agreed upon by the licensee shall administer the operation of and be responsible to the licensee for all equipment in said network;

AND THAT during the existence of this agreement, the sub-licensee will not request individual authority for a War Emergency Radio Service station license;

AND THAT this agreement may be terminated at will by either of the parties concerned but that notification shall be given to the Federal Communications Commission sixty days prior to the termination of this agreement by either of the parties.

IN WITNESS WHEREOF, we hereunto set our hands this _____ day of _____, 19____.

The City of _____ The City of _____

By _____ By _____

Title _____ Title _____

State of _____

County of _____

SUBSCRIBED and sworn to before me this _____ day of _____, 19____.

Notary Public _____

My commission expires _____

State Guard Stations

Reference to the regulations at the end of this chapter will indicate that much that has been said in the previous section concerning civilian defense stations applies also to state guard stations, but is presented from a civilian defense standpoint because specific information on state guard organization is lacking. This,

of course, is because a state guard is a semi-military organization, and therefore many of its functions are not public information.

In state guard work the "communications officer" performs the same function for the state guard licensee that the radio aide performs for the civilian defense licensee, and applications are executed on the same three forms with practically the same set of supplementary statements necessary. One of the chief differences is that the license is issued to the state guard of an entire state, and must be signed by the commanding officer for that state. The original license contains authorization only for those units of the state guard which are prepared to take part in SG-WERS communication. Additional units can be included in the license later only by modification of the station license. The fact that an individual is a member of a state guard organization which is licensed for SG-WERS *does not* automatically authorize him to operate station units of that licensee simply at the command of his commanding officer. He must possess the necessary eligibility for a WERS operator's permit and must apply for such a permit on FCC Form 457, which form must be signed by the communications officer of the licensee and not by the communications officer of a local state guard unit; however, other authority to supervise the operation of local units may be delegated to local communications officers by the state communications officer.

All SG-WERS license applications must be forwarded through the Army Service Command of the area in which the state is included. After approval, the application is forwarded to FCC and the license issued if the application is found to be in order.

Note that the scope of service of state guard stations differs slightly from that allowed civilian defense stations, and that tests are allowed at any time of the day or night provided that such tests do not exceed four hours per week. Amateurs desiring more details of this service should communicate with the communications officer at the headquarters of their local state guard unit.

◀ Civil Air Patrol Stations

Civil Air Patrol stations come under the same general rules and regulations as civilian defense and State Guard stations, and many of the specific rules for CAP-WERS stations are similar to those for CD- and SG-WERS.

CAP-WERS licenses are issued only to the duly appointed wing commanders of the Civil Air Patrol. A wing of the CAP usually covers an entire state, and under the wing commander is a wing communications officer similar to the radio aide in CD-WERS, who has the duties of preparing the license application and supervising the operation of all units of the wing. A wing is subdivided into "groups" and "squadrons," each of which has its commanding officer and its communications officer.

Some wings, in particular those of the smaller states, have omitted the group organization and have only squadron units under the wing.

CAP-WERS organization goes from squadron to group to wing. A squadron of the CAP which wishes to participate in CAP-WERS should have application data prepared by its communications officer. These data then are approved by the squadron commander and forwarded to group headquarters. The group communications officer collects all such data, has them approved by the group commander, and forwards them to wing headquarters. The wing communications officer then prepares the license application much as the radio aide prepares a CD-WERS application. This application, when completed, must be signed by the wing commander, who is the licensee, and forwarded to the national headquarters of CAP. There it is perused by the national communications officer, sent back to the wing for correction if necessary, and finally forwarded to FCC for issuance of the license.

Note that, as in both other WERS categories, individuals who operate CAP-WERS units are in no way relieved from the necessity of possessing a WERS operator's permit. There is no limit to the amount of testing which can be conducted by CAP-WERS licensees, except that it shall not exceed the minimum necessary to ensure the availability of reliable communications. Amateurs interested in this service should get in touch with their local CAP squadron communications officer, or with the national CAP communications officer at CAP national headquarters, Washington, D. C.

◀ Equipment

In the WERS regulations, power input to the transmitter r.f. output stage is limited to 25 watts or less, and the frequency bands available are each divided into two sections having differing frequency tolerances. The carrier frequency tolerance is set at 0.1 per cent in the lower half of the band and at 0.3 per cent in the upper half. With the possible exception of a few localities, where some 224-Mc. equipment may be available, all WERS communication is carried on in the 112-Mc. band because it is possible to operate with standard receiving tubes and ordinary circuit components at these frequencies. Only 112-Mc. equipment is discussed in this chapter, therefore.

In addition to the transmitters and receivers necessary for actual communication, provision must be made for frequency measurement. This is not necessary at every station, since it can be taken care of by the main station at each subcontrol center.

Measurements on representative types of amateur 112-Mc. equipment have shown that the stability requirement of 0.1 per cent can be readily met by any reasonably well-built oscillator-type transmitter, adjusted to frequency and thereafter left with its tuning controls untouched during an operating period. If the

transmitter can be crystal-controlled, so much the better, but crystal control is not at all a necessity. However, as an operating convenience crystal control is quite desirable, particularly at control stations, since two or more frequencies can be made available in the same transmitter simply by providing the necessary crystals and a switch. It should be possible to use any of the frequencies, provided the maximum frequency separation is not more than 2 Mc. or so, without touching the tuning controls. If a crystal-controlled transmitter is not available, it is desirable to provide separate transmitters for each frequency to be used, if the amount of apparatus on hand permits. With only one transmitter there exists the important practical difficulty of returning to exactly the same frequency each time a shift is made.

Each subcontrol center should have one receiver which can be used for continuous monitoring of the district warning center control station. This is a necessity as a means of securing immediate radio silence when so ordered by the Army. A second receiver should be available for communication within the local network. Although it is desirable, as a rule, to have separate transmitters and receivers rather than transceivers at the control station, the second receiver in the control station may be in a transceiver which is used, in the "transmit" position, as the transmitter for communication with the sector wardens.

One transmitter and one receiver (the two may be combined in a transceiver) should suffice for the sector wardens' stations (field stations). If a separate frequency channel is maintained for portable-mobile apparatus it will be necessary for the operators of the sector stations to monitor both this frequency and that on which they are to communicate with the subcontrol center. In many ways a transceiver, with its automatic tuning of both transmitter and receiver to the same frequency, will be simpler to operate in this type of service than separate transmitter and receiver units, unless two transmitters can be made available to take care of both frequencies. Where a transceiver is used, the two tuning spots should be plainly marked on the dial. In many networks both functions can be carried out on one frequency, thus simplifying operation.

Mobile apparatus, which is required to work only on one frequency, can be of almost any type, either a transceiver or separate transmitter and receiver units.

Transceivers, particularly the dry-battery-operated units, cannot be depended upon to maintain carrier stability within the 0.1 per cent necessary to meet the requirements for operation in the low-frequency half of the band. The more powerful transceivers, for operation on a.c. or from storage-battery supply, are fairly stable as transmitters, but if the receiver has to be tuned to two or more frequencies the unavoidable inaccuracies in re-

setting the dial preclude the possibility that the frequency can be reliably maintained within 0.1 per cent. It is better to confine the use of transceivers to the high-frequency half of the band; the average unit of this type is readily capable of meeting the requirement of 0.3 per cent.

It should hardly need saying that all equipment must be capable of operating from sources of power supply independent of the a.c. mains, and must in fact have such power supply

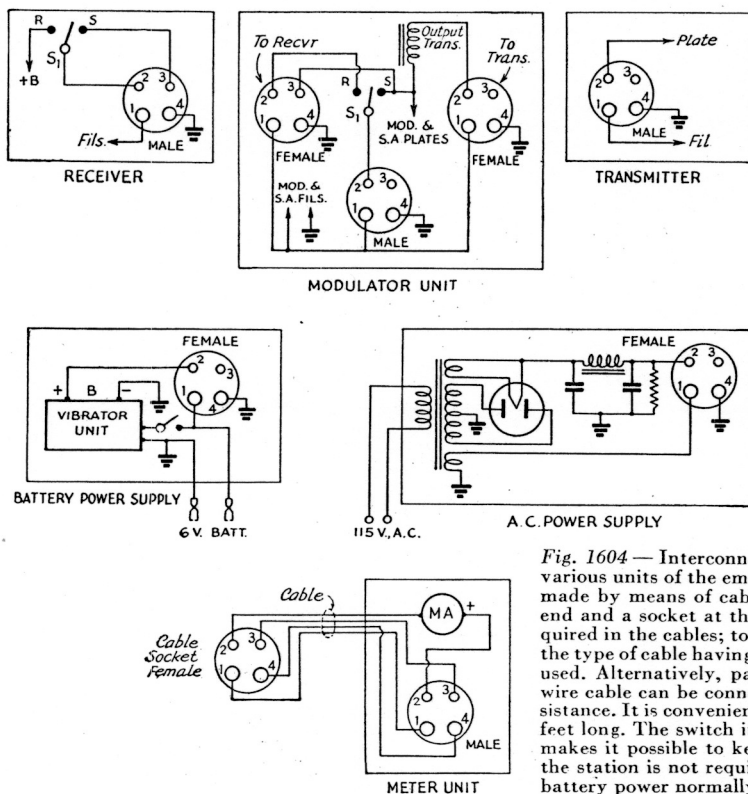


Fig. 1604 — Interconnection and switching system for various units of the emergency station. Connections are made by means of cables provided with a plug at one end and a socket at the other. Four conductors are required in the cables; to minimize filament voltage drop, the type of cable having two heavy conductors should be used. Alternatively, pairs of wires in an ordinary six-wire cable can be connected in parallel to lower the resistance. It is convenient to make the cables about three feet long. The switch in the battery power-supply unit makes it possible to keep the tube filaments hot when the station is not required to be on the air, saving the battery power normally consumed in the vibrator unit.

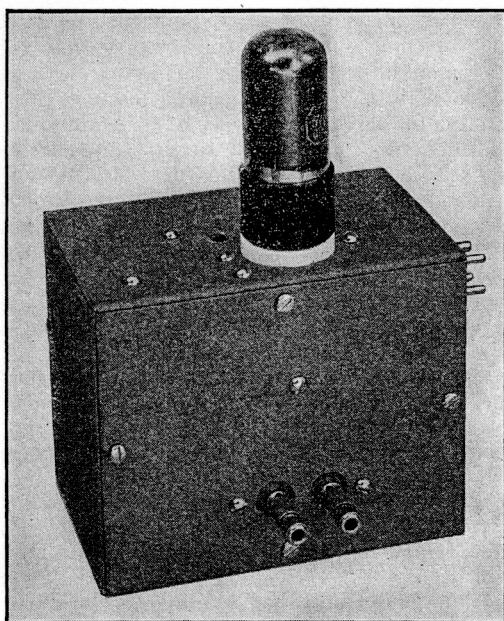


Fig. 1605 — A stable 112-Mc. transmitter. The oscillator is built in a small metal box, with only the tube, power plug and antenna posts on the outside. The small hole on the top beside the tube is for adjustment of the excitation condenser. The grommited hole on the left side is for screw-driver adjustment of the tank condenser.

available. It is not likely that a.c. power would remain on tap throughout an emergency. Nevertheless, the emergency power can be conserved for the time when it is needed if the stations are capable of operating from either a.c. or emergency power supplies. It is helpful therefore to equip the fixed stations with alternative power supplies. Various types of emergency power-supply systems are considered later in this chapter.

Since many radio components now are unobtainable, the apparatus designs in this chapter should, in the majority of cases, be considered as a source of circuit and constructional ideas rather than as items to be duplicated. Fortunately 112-Mc. equipment suitable for WERS work is quite simple, and it is readily possible to adapt an idea used in one piece of equipment to a different circuit layout. In view of the nature of the service, it is well to keep in mind a few general principles:

- 1) The apparatus must be simple to operate. Much of the actual operation must be done by those who have never built radio equipment or operated anything more complicated than a broadcast receiver. The number of controls should be reduced to the minimum necessary to perform the *operating* functions. There is no necessity, for instance, for using tuning dials on a transmitter intended to be operated on a fixed frequency. If such apparatus can be enclosed so that only the on-off and change-over controls are accessible, there is that much less chance that the equipment will be misadjusted accidentally or otherwise.

- 2) Keep in mind the possibility that replacement of some components may be necessary. If, for example, a choice of tubes exists, take the type which has the best chance of being available at short notice, even though it may not actually be the best type for the purpose. Stick to the more popular types of tubes used in broadcast receivers and follow the same policy with respect to other components, such as filter and by-pass condensers which may eventually require replacement.

- 3) Build the equipment, including the power supply, so that it can be moved to a new location without difficulty and can be set up for operation again with a minimum of delay. While this does not mean that "suitcase" construction is necessary, it does call for construction of a type which will stand the knocks and jars of transportation. It also means that it is a good idea to enclose the equipment so that wiring cannot be damaged or projecting components knocked loose.

- 4) Insofar as equipment permits use uniform control methods for all installations, so that an operator who fills in at a station to which he is not normally assigned can work effectively with a minimum of special instruction.

- 5) Standardize on a system of making connections, particularly between the power supply and the r.f. and audio parts of the assembly, so that interchangeable units can be substituted in case of failure. Remember that it may be necessary to assemble a station in a hurry at a point not previously equipped. Do not neglect such apparently minor considerations

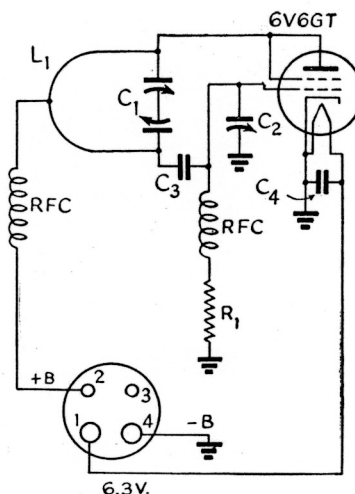


Fig. 1606 — Stable 112-Mc. transmitter circuit diagram.

C₁ — 100 μ fd. per section (Hammarlund MCD-100-S or Millen 24100).

C₂ — 3-30- μ fd. padder (National M-30, Millen 28030, Hammarlund MEX, etc.).

C₃ — 50- μ fd. midget mica.

C₄ — 250- μ fd. midget mica.

R₁ — 15,000 ohms, $\frac{1}{2}$ -watt.

L₁ — See Fig. 1608.

RFC — $1\frac{1}{4}$ -inch winding of No. 28 d.s.c. on $\frac{1}{4}$ -inch polystyrene rod, no spacing between turns.

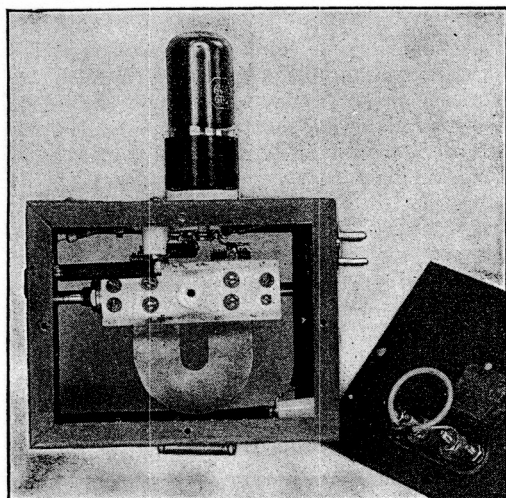


Fig. 1607 — Looking into the 112-Mc. transmitter from the antenna-terminal side. The grid choke is in the upper left corner, with its "hot" end supported by a small ceramic stand-off insulator. The plate choke is partly visible in the lower right corner; it is mounted endwise, also on a ceramic stand-off insulator. The one-turn antenna coil may be seen mounted on the antenna terminals on the side plate, shown here removed from the box.

as connections for microphones and headsets. With the possibility of using two or three different kinds of plugs and jacks, or even pin jacks, it would be well to standardize on one type at the outset, so that any microphone or headset will fit any transmitter or receiver.

A standardized connection scheme is suggested in Fig. 1604. Its application to an equipment assembly consisting of separate units — transmitter (oscillator), modulator, receiver, a.c. power supply, storage battery power supply — is indicated. Provision is made for a unit containing a 0-100 ma. d.c. milliammeter for testing and measuring purposes, so that a single instrument can be made to serve for a number of stations. In cases where the transmitter and modulator, for instance, are combined in one unit, the general scheme of connections readily can be carried out. Thus, if all power-supply units in the system are arranged to have the same output connections and the same output voltage ratings, within reasonable limits, any one of the units available can be used at any station in the network.

The system is based on the use of four-conductor cables, with four-prong sockets and plugs for quick and positive interconnection. Each cable has a plug at one end and a socket at the other. In the event that suitable cable-type connectors are not available, ordinary four-prong sockets and old tube bases readily can be adapted to the purpose. On the various units of the station, a socket (female) is used for *outgoing* power and a plug (male) for *incoming* power; thus there is no danger of shock nor any possibility of making wrong connections. Suggested cable plug and socket prong connections are indicated on the diagram.

When the equipment is built on the unit plan a cable runs from the power supply to the modulator, where the d.c. power is distributed to the transmitter and receiver. The modulator is provided with two outgoing sockets; the "B" + lead to the transmitter socket picks up the modulator audio output and carries it along with the d.c. to the transmitter when the cable is attached. On the receiver side, the fourth prong is used to provide duplicate send-receive switching at both modulator and receiver. The connections to the single-pole double-throw switches are shown in the appropriate units. With either switch in the "receive" position, the other may be used to switch the plate power back and forth. The cables simply carry through connections from plug prongs to corresponding socket prongs; all the cables are identical.

A switch should be provided in the modulator unit for the purpose of cutting off the microphone battery when the transmitter is not in use.

The meter unit has a plug and a short cable with a socket connector at its end. This unit is useful, although not essential, in regular operation, and is needed for initial transmitter checking and adjustment. By its use metering facilities are made available quickly and simply, yet the meter itself is not tied up permanently in the equipment.

The same connection scheme can be used in a mobile installation, with the addition of suitable control and extension wiring to fit individual layouts. This will facilitate removal or installation of the equipment, or any part of it, when necessary. The basic wiring, antennas, etc., can be permanently installed in

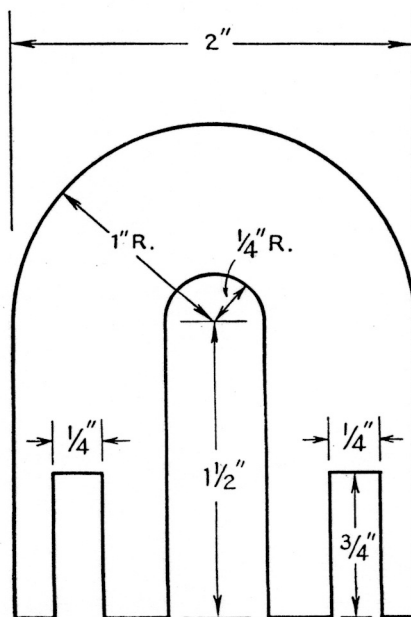


Fig. 1608 — Tank-inductance construction. This layout drawing is full-size and may be used as a template.

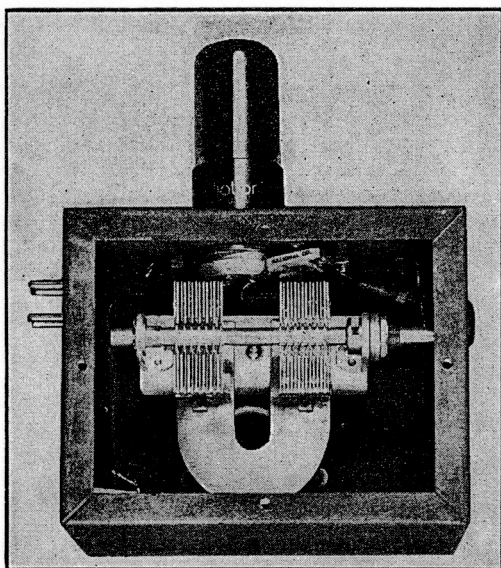


Fig. 1609 — Inside the oscillator unit. The tube socket is placed so that the plate prong is directly above the left-hand tank condenser stator terminal, making an extremely short plate connection. The grid condenser connects the grid prong and right-hand stator terminal.

the car, spare cables being provided for external use of the apparatus.

The unit plan illustrated by Fig. 1604 has a number of advantages. Should a particular unit develop trouble in operation, a spare can be substituted with negligible loss of time and the defective unit may be serviced without interrupting communication. Extra units can be built in anticipation of such a contingency with a probable saving in time, effort and components as compared to the alternative of providing a spare transmitter-modulator or complete transmitter-receiver, since with this system a few spare units should take care of the replacement requirements of a fair-sized network; it is unlikely that all parts of a station would fail simultaneously. One drawback is that it is somewhat more inconvenient to set up a multi-unit system than to place one integral station in operation, and a second is that it involves close coordination in design — possible when materials can be secured readily, but having its difficulties under present conditions. Nevertheless, the standardized connection idea can be applied with distinct benefits. The actual details can be based on the requirements of a particular network and the use of materials on hand.

Unit-Style Transmitter and Modulators

The 112-Mc. oscillator shown in Fig. 1605 is designed to minimize frequency modulation, and to that end is constructed around a high- C tank circuit of somewhat unconventional design. Reduction of frequency modulation is a step toward minimizing interference, since frequency modulation broadens the signal. The

circuit requires a minimum of parts, although the tank condenser, C_1 , may be difficult to obtain except from salvage stock.

The tank circuit consists of the balanced condenser, C_1 , and the U-shaped metal piece whose dimensions are given in Fig. 1608. This "coil" is designed to have as much surface area as possible, thereby reducing resistance and losses, and also to provide the lowest possible contact resistance where it connects to the condenser. The ends of the U-shaped inductance fit under the stator-plate assemblies, which in the types of condensers specified are provided with flat holding plates to which the individual condenser plates are soldered. The slots in the ends of the U allow the inductance to be slid in and out to adjust the L/C ratio over a small range. To assemble the tank circuit the condenser must be dismantled from the base, and washers about the same thickness as the metal of the tank coil must be inserted between the base and the rotor supports. This raises the rotor to correspond to the increased height of the stators. It is not difficult to replace the stators so that the plate spacing is uniform. If the inductance is made exactly as specified, the slotted ends should come within about 1/16th inch of the far side of the base to give the proper frequency range.

The inductance shown in the photographs was cut from a small piece of scrap sheet copper somewhat less than 1/16th inch thick. Aluminum also works well. The metal should have low resistance, although its thickness is of no importance except for mechanical stiffness.

The oscillator is assembled in a 3 × 4 × 5-inch metal box as shown in Figs. 1607 and 1609. The various views should make the construction obvious. Chief considerations are to keep the grid and plate leads short, to which end the tube socket is mounted directly above the plate section of the tank condenser, with

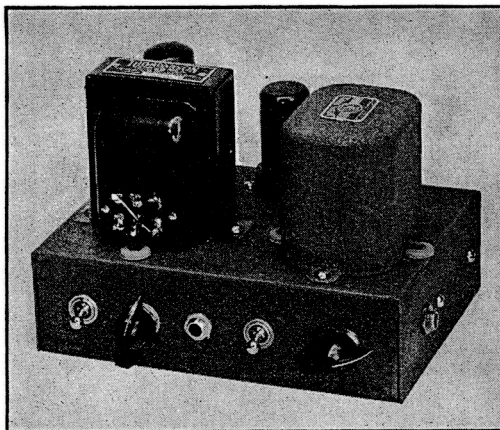


Fig. 1610 — The Class-B modulator unit. The output transformer is at the left, the driver transformer at the right. Controls along the front are send-receive switch, 'phone-c.w. switch, key jack, microphone battery switch, and gain control. The microphone jack is on the right-hand edge, around the corner from the gain control.

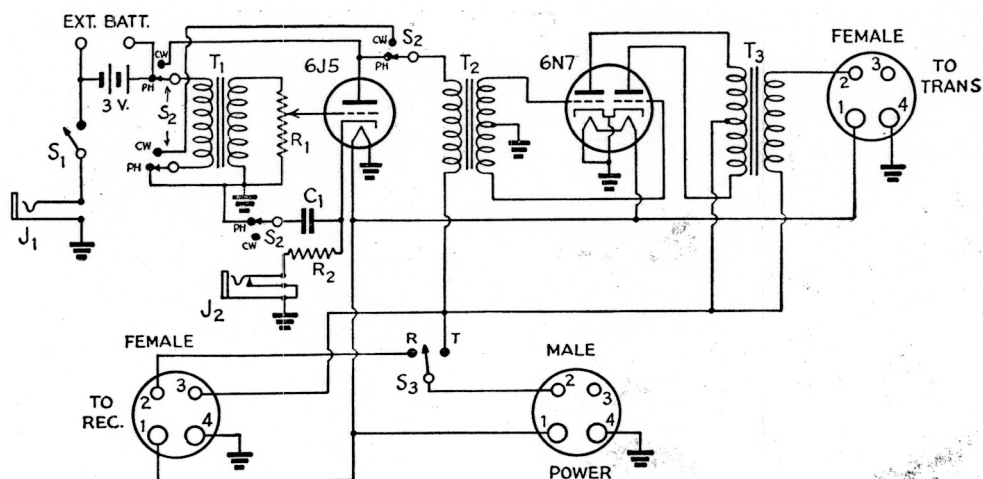


Fig. 1611 — Circuit diagram of the Class-B modulator unit used in connection with the 112-Mc. WERS transmitter.

C₁ — 10- μ fd. 50-volt electrolytic.
 R₁ — 0.5-megohm volume control.
 R₂ — 2000 ohms, 1-watt.
 T₁ — Single-button microphone-to-grid transformer (Stancor A-4706 or equivalent).

T₂ — Class-B driver transformer, (UTC S8 or equivalent).
 T₃ — Class-B output transformer, 6N7 to 5000-6000 ohms (Thordarson T-19M13 or equivalent).

J₁ — Open-circuit jack.
 J₂ — Closed-circuit jack.
 S₁ — S.p.s.t. toggle switch.
 S₂ — 4-p.d.t. rotary switch (Yaxley 3242J or equivalent).
 S₃ — S.p.d.t. toggle switch.

the latter just far enough below the plate prong to allow room for soldering a connection; and to keep the tank inductance as near the center of the box as possible so its flat sides will be well spaced from the steel side plates of the box. This spacing is accomplished by mounting the condenser on a 1-inch ceramic pillar fastened by a machine screw at the center hole in the base. The other end of the pillar is fastened to the side of the case. On the same side directly below is the r.f. output terminal assembly. The antenna pick-up coil is a 1-inch diameter single turn of No. 14 wire covered with spaghetti tubing. The antenna coupling is adjusted by

bending the supporting leads for the pick-up coil to bring the turn closer to or farther away from the tank inductance. The coupling is ordinarily rather close, physically, because of the peculiar shape of the field about a tank inductance of this construction.

The tank condenser is screwdriver-adjusted, a slot being sawed in the end of the shaft. The rotor shaft of the condenser cannot be grounded since the circuit is not actually balanced; grounding the rotor changes the excitation and reduces the output to negligible proportions. The capacity between the rotor and the case also should be kept as low as possible.

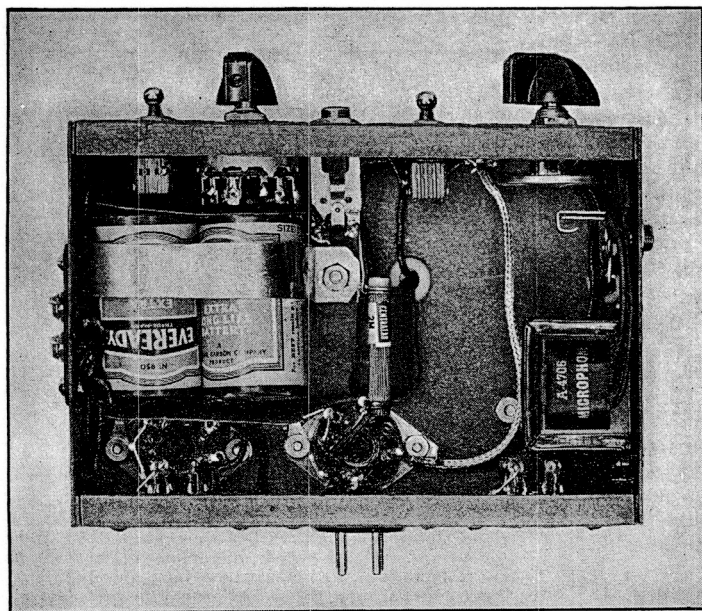


Fig. 1612 — Underneath the modulator chassis. The microphone transformer is mounted on the chassis edge alongside the microphone jack. The power plug and the two outgoing power sockets for the transmitter and receiver are mounted on the rear edge of the chassis (bottom edge in this view). A terminal strip for connecting an external microphone battery is located on the left-hand edge. The flashlight cell microphone battery is held in place by a metal strip; the cells are protected from accidental short-circuit by a piece of thin fiber or cardboard which is bent in the shape of a U to cover the terminals.

The plate voltage is fed to the tank circuit near the center of the U. The lead from the cathode to ground should be as short as possible and made of heavy wire, likewise the lead from the grounded filament pin. The same connection may be used for both, and also for the No. 1 pin. The excitation condenser, C_2 , should be mounted so as to keep it as far as possible from the plate section of the tank condenser.

Oscillator adjustment — The adjustments to be made are to determine whether the frequency range is correct and to set the output coupling and excitation for maximum stability and output. The tank inductance will be properly adjusted when it is set (by sliding the ends in and out under the stator-plate assemblies) so that with the condenser at maximum capacity the frequency is between 111 and 112 megacycles. The frequency may be measured by using Lecher wires. The output may be judged by connecting a dial light (150-ma. size or larger) to the output terminals, whereupon varying the coupling and adjusting C_2 will readily show the optimum settings. The stability is more difficult to check unless a 112-Mc. superheterodyne receiver is available. However, the maximum stability is obtained when the capacity of C_2 is set at the largest value which will give good output, and it is advisable to adjust C_2 by first increasing its capacity to the point where the output drops off and then decreasing it just to the point where the output comes back to normal. As the capacity is decreased still more the output should decrease somewhat.

With normal operation the plate current, with load, should be between 50 and 60 ma. The exact value will vary somewhat with individual tubes, and if it tends to be outside these limits it may be regulated by using a slightly different value of grid leak, larger values giving less plate current and vice versa. The current will drop a few ma. when the load is removed.

To adjust the coupling for working into a 600-ohm line, a 1-watt resistor of 500 or 600 ohms may be used as a load. To indicate current through the resistor a 60-ma. dial light may be connected in series with it. A 150-ma. lamp also may be used, but is a less convenient indicator since it glows only dimly. The coupling should be adjusted for maximum current.

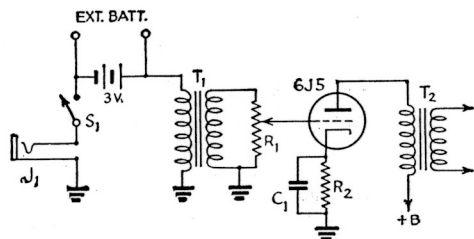


Fig. 1613 — Alternative microphone input circuit for eliminating the tone-modulation feature incorporated in the modulator circuits of Figs. 1611 and 1615. Circuit values correspond to those given in Figs. 1611 and 1615.

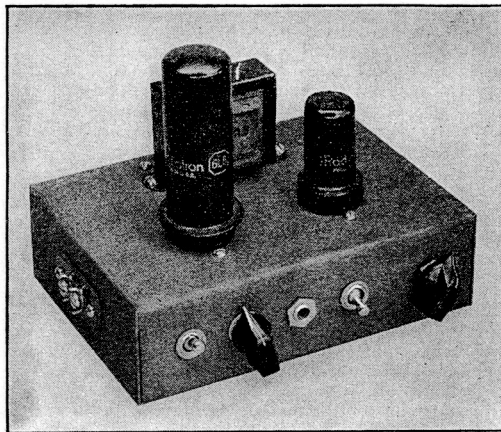


Fig. 1614 — A Class-A 6L6 choke-coupled modulator, using a minimum of transformers. The controls along the front are, left to right, the send-receive switch, 'phone-c.w. switch, key jack, microphone battery switch, and gain control. Terminals for external microphone battery are on the left edge. The microphone jack, not visible, is mounted on the right-hand edge of the chassis.

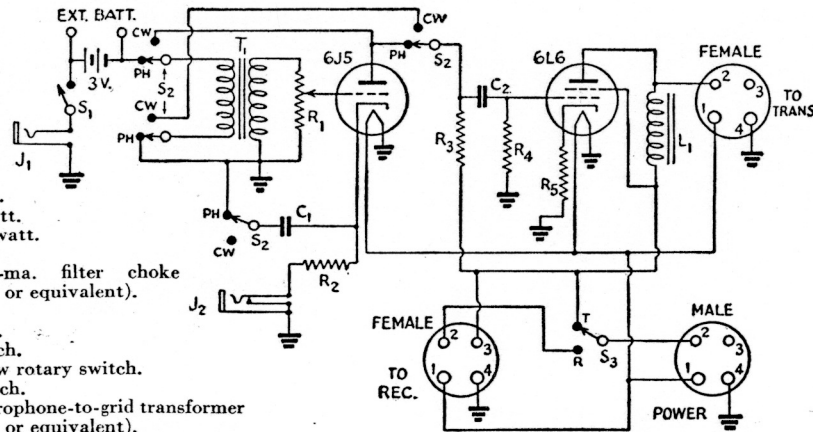
Class-B modulator — Except for the provision for modulated c.w. operation, which may be omitted by substituting the alternative input circuit of Fig. 1613, the modulator is a conventional Class-B arrangement, using a 6N7 driven by a 6J5. Class-B is used because of its higher plate efficiency and relatively low idling plate current. The oscillator load will be between 5000 and 6000 ohms, depending upon the plate current, and it will be sufficient to take the nearest value furnished by the output transformer, using a plate-to-plate load of 8000 ohms for the 6N7. There is ample gain with the single speech amplifier stage for ordinary single-button microphones operated from a 3-volt battery.

Power input and output connections conform to the standards previously described. To give tone modulation for code transmission, the speech amplifier tube is made to oscillate by connecting the primary of the microphone transformer as a tickler in series with the plate circuit. A four-pole double-throw switch is necessary to change from 'phone to c.w., two poles being used to transfer the primary of T_1 , a third to close the plate circuit for 'phone, and the fourth to disconnect the cathode condenser for tone modulation. This last is essential for good keying (the speech amplifier tube is keyed in the cathode circuit). The c.w. tone pitch depends upon the value of the cathode resistor and the volume control setting, but with several microphone transformers tested falls in the optimum region (500–1000 cycles) with a 2000-ohm cathode resistor.

A separate switch is provided to open the microphone battery circuit whenever desired. The battery would normally be left on while receiving when communication is being carried on, but during stand-by periods it would be desirable to switch off the microphone current

Fig. 1615—Circuit diagram of the alternative choke-coupled 6L6 Class-A modulator.

C₁—10- μ fd. 50-volt electrolytic.
 C₂—0.01- μ fd. paper.
 R₁—0.5-megohm volume control.
 R₂—1500 ohms, 1-watt.
 R₃—50,000 ohms, 1-watt.
 R₄—0.25 megohm, $\frac{1}{2}$ watt.
 R₅—500 ohms, 1-watt.
 L₁—10-15-henry 100-ma. filter choke (Stancor C-2303 or equivalent).
 J₁—Open-circuit jack.
 J₂—Closed-circuit jack.
 S₁—S.p.s.t. toggle switch.
 S₂—4-pole double-throw rotary switch.
 S₃—S.p.d.t. toggle switch.
 T₁—Single-button microphone-to-grid transformer (Stancor A-4706 or equivalent).



to prolong battery life. The same effect can be secured by pulling the microphone plug out of the jack, but the switch is more convenient. A battery of two flashlight cells connected in series is made a permanent part of the unit, since there is sufficient mounting room underneath the chassis, but additional terminals are provided for an external battery should the internal one wear out during an emergency. To use an external battery it is necessary to disconnect one of the leads to the self-contained battery unit.

The microphone jack is mounted on the side of the chassis, so the microphone plug and cord will be out of the way of the controls on the front. The key jack is on the front. Since the modulator unit is small (the chassis is $5 \times 7 \times 2$ inches) the send-receive switch is placed at the end, where it is easiest to handle.

The plate current taken by the modulator and speech amplifier tubes is in the vicinity of 35 ma. with no excitation. When the r.f. oscillator is added, the current drain is just

under 100 ma. With 100 per cent voice modulation, the maximum current is 110 to 115 ma.

Class-A modulator—While the Class-B type of modulator is to be preferred because of its higher audio-frequency power output for a given plate power input, Class-B transformers are practically unobtainable at the present time. Therefore, unless suitable transformers can be salvaged from old equipment, the probability is that a Class-A modulator will have to be used. Such a modulator, using a 6L6 with a preceding 6J5 as a speech amplifier, is shown in Fig. 1614. Provision for tone modulation also is incorporated in this unit, and again may be omitted by using the alternative speech amplifier connections of Fig. 1613.

Any filter choke capable of maintaining an inductance of 10 henrys or more with 100 ma. d.c. through its winding will serve as a coupling choke for the modulator. The higher the inductance the better the low-frequency response, but since "quality" is not a consideration so long as completely understandable speech is transmitted it is unnecessary to use higher inductance than is found in the ordinary 100-ma. choke.

To keep the total modulator plate current down to 40 or 45 ma. and thus avoid overloading the vibrator power supply (which delivers 100 ma. at 300 volts) when the modulator and r.f. oscillator are operated simultaneously, the cathode resistor is higher than is normal for a Class-A 6L6 at this plate voltage.

The plate-voltage switching and the input and output socket and plug arrangement are identical with the Class-B unit already described.

Controls and power-supply outlets are arranged similarly to the controls on the Class-B modulator. The chassis is the same size, $5 \times 7 \times 2$ inches. There are no especially critical points involved in wiring, and practically any parts layout will be satisfactory. The two-cell microphone battery is

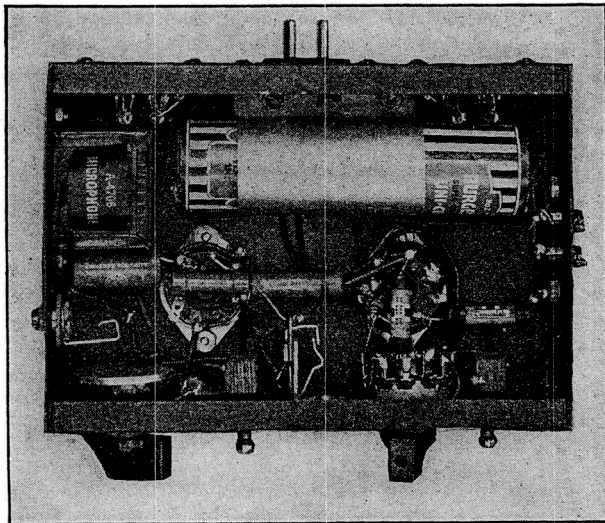


Fig. 1616—Underneath view of the 6J5-6L6 Class-A modulator unit. Parts are placed wherever found most convenient in wiring.

held in place by a bracket fitting around the battery, fastened to the chassis by the machine screws which mount the choke.

Superregenerative Receivers

By far the simplest type of receiver for very high-frequencies is the superregenerator, long a favorite in amateur work. It provides good sensitivity with a small number of tubes and very elementary circuits. Its disadvantages are lack of selectivity and the fact that, since the detector is an oscillator coupled to an antenna, it will radiate a signal which may cause interference to other receivers. To some extent the lack of selectivity is advantageous, since it increases the chances of hearing a call even though the transmitter and receiver may have drifted somewhat in frequency since the last contact was established. The radiation question is more serious. The avenue of approach in the reduction of radiation is to use every means possible, in the way of building as good an oscillator circuit as the circumstances will permit, to operate the detector at the lowest plate voltage that will give satisfactory operation. A means of providing regeneration control is therefore essential in any simple superregenerative receiver. Should existing equipment not have such a control, it is urged that one be installed.

The receivers to be described have been designed to use the commoner types of receiving tubes. An on-off switch for controlling the transmitter by the standardized connection system described earlier (Fig. 1604) is included in each unit. Both receivers are designed to operate from a 300-volt power supply, a dropping resistor being included for that purpose. They will also work well with lower-voltage supplies.

A simple superregenerative receiver is shown in Figs. 1617 to 1620. As shown in the wiring diagram, Fig. 1619, a 6J5 superregenerative detector is followed by resistance-coupled 6J5 and 6F6 audio stages. The circuit is fairly conventional except for the inductive tuning of the detector and possibly the use of resistance coupling throughout.

The receiver is built in a $3 \times 4 \times 5$ -inch metal box, with a 3×4 -inch face serving as the panel. The panel controls are the tuning knob and the regeneration control, and the headphone jack is also mounted on the panel. The power cable plug is mounted at the rear of the box, as are the speaker terminals. The on-off switch and the antenna terminals are mounted on the left-hand side of the box.

The detector trimmer condenser, C_1 , is fastened to the upper face of the box and can be adjusted from the top of the receiver. The quench-frequency r.f. choke, RFC_2 , is supported off the under side of the upper face of the box by a long screw, with a brass sleeve over the screw furnishing sufficient spacing from the box. The r.f. choke is essential because the resistance-coupled amplifiers show but slight attenuation of the quench frequency,

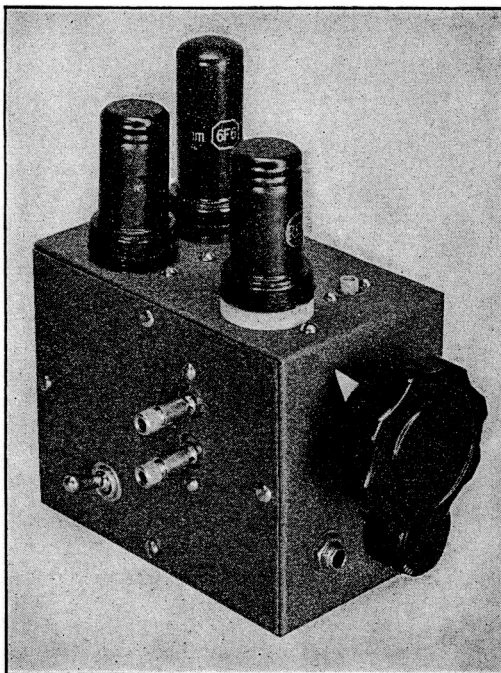


Fig. 1617 — The compact 112-Mc. receiver is built in a $3 \times 4 \times 5$ -inch metal box. Note the detector trimming condenser adjustment to the right of the 6J5 detector (front tube). The tuning control, headphone jack and regeneration control are on the front panel, the on-off switch and antenna binding posts on the side.

and the quench voltage will overload the output audio tube at rather low signal levels. When transformer coupling is used between the detector and first audio stage the transformer keeps most of the quench voltage out of the following stages and consequently the quench-frequency choke is not always necessary.

The wiring of the unit requires only brief mention. A soldering lug at each socket furnishes a convenient ground for the components of that stage. All condensers and resistors are mounted by fastening directly to the sockets and other terminals, with the exception of the coupling condenser, C_6 , one side of which must be run down to the headphone jack through an extra length of wire. The wires running to the toggle switch should be made of extra-length flexible wire so that the side of the box can be removed without unsoldering the wires to the switch. All wiring should be completed before L_1 and L_2 are put in place.

The detector coil is made by winding the wire around a $\frac{1}{2}$ -inch diameter drill or dowel as a former. The coil is then removed and the ends trimmed and bent until the coil can be soldered in place in proper alignment with the panel bushing used to support the tuning loop shaft. The plate lead of the tube socket is connected to the rotor of the trimmer condenser by means of a short length of wire, and the coil L_1 is connected to the center of this wire and to the stator connection of the condenser. A length of $\frac{1}{4}$ -inch shaft pushed through the shaft bearing

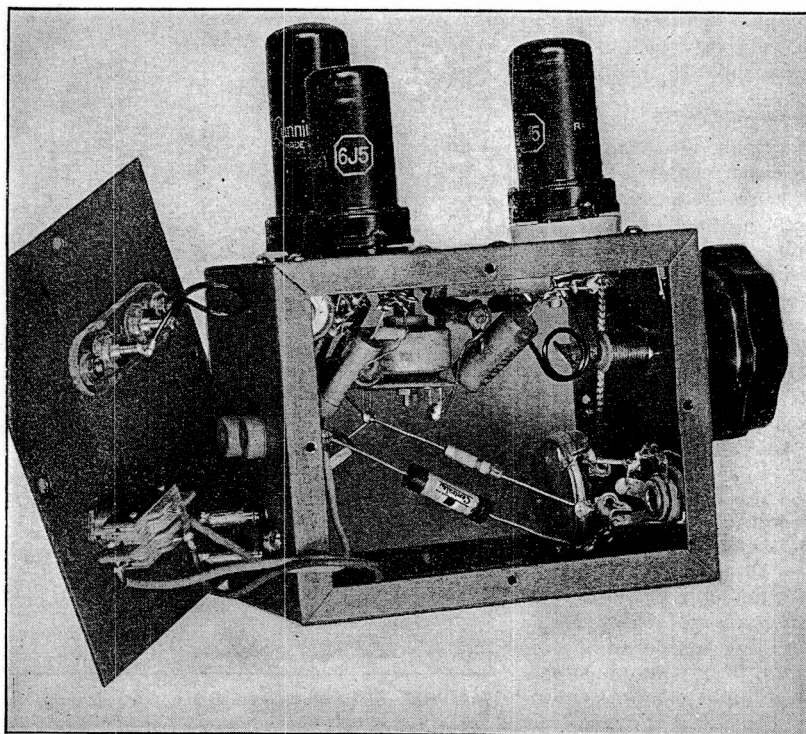


Fig. 1618 — Inside the small receiver, this left-hand view shows how the tuning-loop assembly and the send-receive switch are mounted on one of the side panels, together with the placement of some of the parts not visible in the other views. The power-supply plug and the loudspeaker binding posts may be seen at the rear of the chassis.

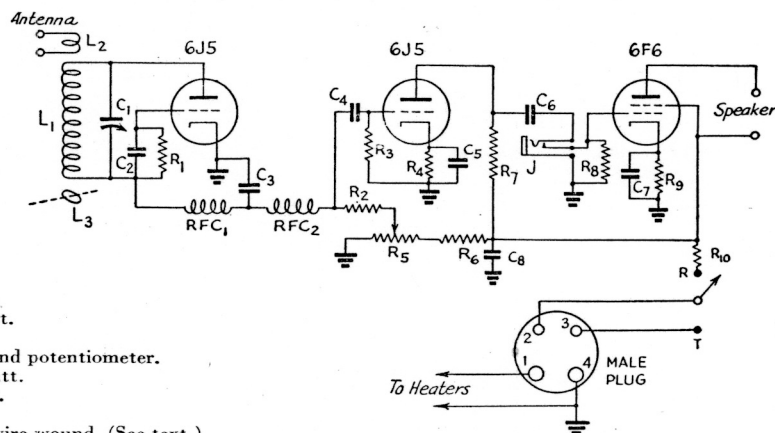
will serve as a guide in soldering the coil in place, and the axis of the coil should make an angle of 45 degrees with the shaft.

The inductive tuning loop is a small copper washer cemented to the end of a $\frac{1}{4}$ -inch shaft of insulating material (Lucite or bakelite). The end of the shaft is cut at an angle of 45 degrees to mount the washer at 45 degrees with respect to the axis of the shaft and, consequently, 180-degree rotation of the shaft turns the copper washer from a position coaxial with the coil to one at right angles to it. The copper washer, acting as a single shorted turn, decreases the effective inductance of the coil as it becomes

more closely coupled and consequently tunes the system. The copper washer is made by drilling a $\frac{1}{8}$ -inch hole in a small piece of sheet copper and then cutting around the hole to form a washer of $\frac{7}{16}$ -inch outside diameter. The washer is fastened to the angled face of the shaft by Duco cement. Because the copper washer is larger than the shaft, the shaft must be pushed through the panel bearing from the inside of the box, but this can be done easily by loosening the panel bearing while sliding the shaft through. A fiber washer should be placed on the shaft before it is pushed through the panel bearing, and later cemented

Fig. 1619 — Circuit diagram of the compact 112-Mc. superregen receiver.

- C₁ — 25- μ fd. air trimmer (Hammarlund APC-25).
- C₂ — 50- μ fd. midget mica.
- C₃, C₄, C₆ — 0.01- μ fd. 600-volt paper.
- C₅, C₇ — 10- μ fd. 25-volt electrolytic.
- C₈ — 8- μ fd. 450-volt electrolytic.
- R₁ — 5 megohms, $\frac{1}{2}$ watt.
- R₂ — 25,000 ohms, $\frac{1}{2}$ watt.
- R₃ — 0.25 megohms, $\frac{1}{2}$ watt.
- R₄ — 1500 ohms, $\frac{1}{2}$ watt.
- R₅ — 50,000-ohms wire-wound potentiometer.
- R₆, R₇ — 50,000 ohms, 1 watt.
- R₈ — 0.1 megohms, $\frac{1}{2}$ watt.
- R₉ — 500 ohms, 1 watt.
- R₁₀ — 2000 ohms, 10-watt wire-wound. (See text.)
- J — Closed-circuit jack.
- S₁ — S.p.d.t. toggle.
- L₁ — $1\frac{2}{3}$ turns No. 14 e., $\frac{1}{2}$ -inch inside diameter, spaced $\frac{2}{3}$ wire diameter.



- L₂ — $\frac{3}{4}$ turn No. 14 e., $\frac{1}{2}$ -inch inside diameter.
- L₃ — Tuning loop. See text.
- RFC₁ — V.h.f. choke (Ohmite Z-1).
- RFC₂ — 80-mh. r.f. choke (Meissner 19-2709).

to the shaft to serve as a collar to prevent the shaft's pulling through the bearing.

It is easier to check the performance of the receiver before the tuning loop is added, and with the large trimmer condenser used there should be no difficulty in finding the 112-Mc. band. The trimmer will be set at about two-thirds capacity if the coil is right. The detector should go into the hiss condition when the regeneration control is advanced not more than two-thirds of its travel. It is well to try different values of capacity at C_3 , using the one which allows the detector to be worked at the minimum setting of the regeneration control without by-passing too much of the audio.

When the receiver is working and the tuning loop installed, the tuning range of the loop can be adjusted by moving the shaft in the panel bearing so that the loop is nearer to or farther from the coil. Moving the loop closer will increase the tuning range. It will be found that the tuning rate is slow when the loop is at right angles to the coil and becomes faster as the loop and coil become more nearly coaxial. It is therefore advisable to set the band and bandspread so that the receiver tunes from about 111.5 to 119 Mc., since this will spread the band over the main portion of the dial. When the shaft position which gives proper bandspread has been found, the fiber washer can be fastened to the shaft with Duco cement. When this is dry, the dial or knob can be attached to the outside end of the shaft. Play of the shaft in the bearing can be cured

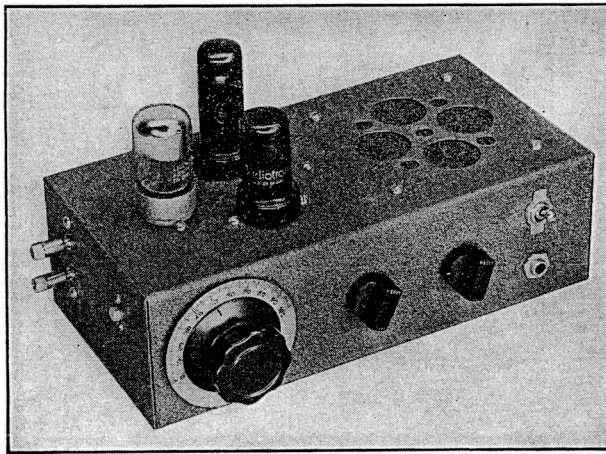


Fig. 1621 — A superregenerative receiver with built-in speaker, constructed on a standard chassis base. The detector trimming condenser is mounted on the side. The audio gain control is mounted next to the tuning control (extreme left). The regeneration control is between the volume control and the 'phone jack and on-off switch.

by slipping two metal washers and a half-slice of rubber grommet on the shaft before the dial is slipped on. The dial set screw should be tightened when the shaft is being pushed out from the inside, and the spring of the rubber grommet will then hold the collar (fiber washer) tightly against the inside of the panel bearing. A paper scale can be glued to the box and the megacycle and half-megacycle points marked on it, for ease in spotting stations and convenient resetting.

The antenna coupling should be adjusted with the antenna connected, and it should be made as tight as is consistent with some reserve in the regeneration control to take care of low voltages and other variables.

Superregenerative receiver with built-in speaker— The receiver shown in Figs. 1621 to 1623 is slightly more elaborate, differing from the receiver just described mainly in the inclusion of an audio volume control and a built-in loudspeaker. Minor differences include the use of a 7A4 detector (a slightly better but less common tube than the 6J5) and the use of capacitive tuning.

The receiver is built in a $10 \times 5 \times 3$ -inch chassis, with the tubes and speaker mounted on the 5×10 -inch face. One side is used for a panel and the opposite side is left clear in case one wishes to operate with the receiver resting on this side. The antenna terminals and the detector padding condenser are mounted on the left-hand side, and the four-prong power plug is mounted on the right-hand side. The only care necessary in laying out the chassis is to mount the tuning condenser and the padding condenser so that their respective terminals come close

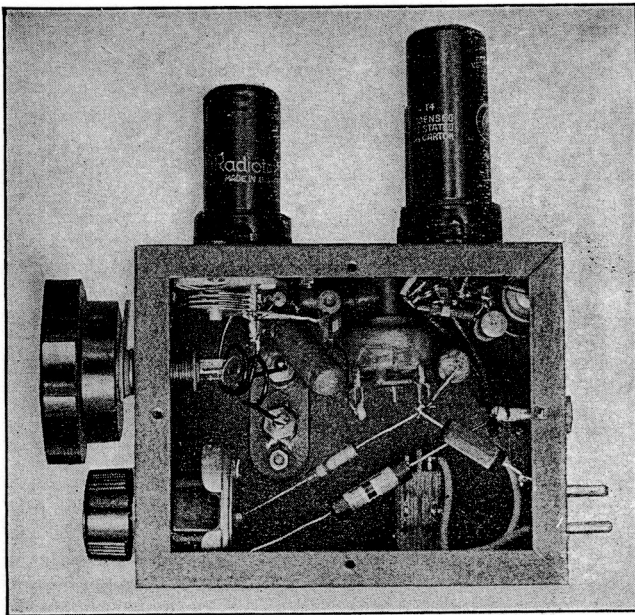


Fig. 1620 — A view from the right-hand side of the compact receiver.

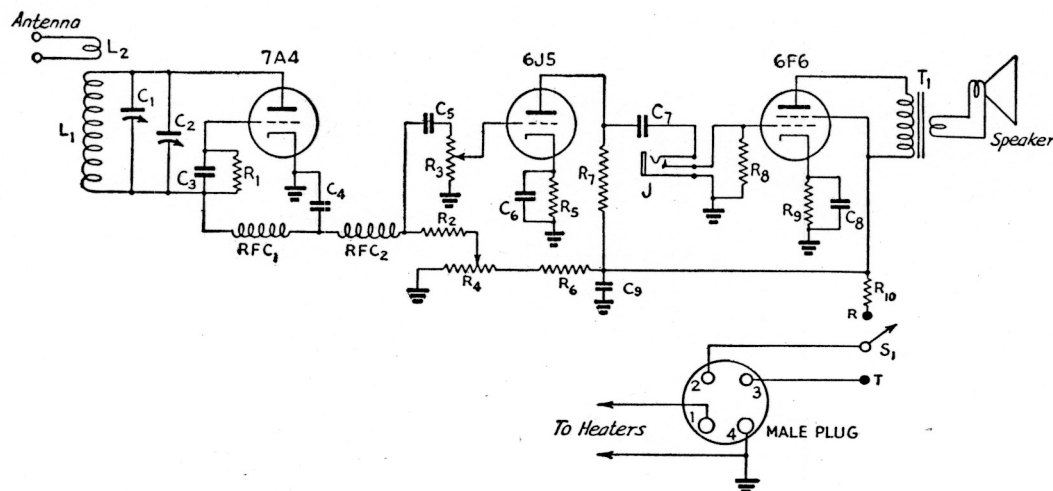


Fig. 1622—Wiring diagram of the 7A4 superregenerative receiver with built-in speaker shown in Fig. 1621.

- | | | |
|--|---|--|
| C ₁ —25- μ fd. air trimmer (Hammarlund APC-25). | R ₁ —5 megohms, $\frac{1}{2}$ watt. | RFC ₁ —V.h.f. choke (Ohmite Z-1). |
| C ₂ —5- μ fd. tuning condenser (National UM-15 with 2 stator and 2 rotor plates removed). | R ₂ —25,000 ohms, 1 watt. | RFC ₂ —80-mh. r.f. choke (Meissner 19-2709). |
| C ₃ —50- μ fd. midget mica. | R ₃ —0.5-megohm volume control. | S ₁ —S.p.d.t. toggle switch. |
| C ₄ —0.006- μ fd. mica. | R ₄ —50,000-ohm wire-wound pot. | T ₁ —Output matching transformer. |
| C ₅ , C ₇ —0.01- μ fd. 600-volt paper. | R ₅ —1500 ohms, $\frac{1}{2}$ watt. | Speaker—4-inch p.m. type. |
| C ₆ , C ₈ —10- μ fd. 25-volt electrolytic. | R ₆ , R ₇ —50,000 ohms, 1 watt. | L ₁ — $1\frac{3}{4}$ turns No. 14 e., $\frac{1}{2}$ -inch inside diameter, spaced diameter of wire. |
| C ₉ —8- μ fd. 450-volt electrolytic. | R ₈ —0.1 megohm, $\frac{1}{2}$ watt. | L ₂ — $\frac{1}{8}$ turns No. 14 e., $\frac{1}{2}$ -inch inside diameter. |
| | R ₉ —500 ohms, 1 watt. | |
| | R ₁₀ —2000 ohms, 10-watt wire-wound or higher. See text. | |
| | J—Closed-circuit jack. | |

together, to make the leads as short as possible. The tuning condenser, C₂, is supported back of the panel on long (1 $\frac{3}{4}$ -inch) 6-32 screws, and the padding condenser is mounted directly on the side of the chassis. A bakelite shaft extension is fastened to the tuning condenser shaft and brought out through a panel bearing. The quench r.f. choke, RFC₂, is supported between the two audio tube sockets on a $\frac{1}{2}$ -inch pillar.

Each socket has a soldering lug placed under one screw, and all of the grounds for that particular stage are made to the lug. Most of the resistors and condensers can be mounted directly on tube or variable resistor terminals.

The coil, L₁, can be trimmed slightly by squeezing the turns together or pulling them apart until the desired amount of bandspread is obtained. The antenna adjustment is made by moving the antenna coil, L₂, closer to L₁ until the regeneration control must be set at about $\frac{2}{3}$ full for "supering" to start. This adjustment is made with the antenna connected.

A superheterodyne receiver—The ordinary 112-Mc. superregenerative receiver is not very selective, and in localities where several networks are operating within a relatively narrow frequency band it may be necessary to go to a more selective type of receiver to

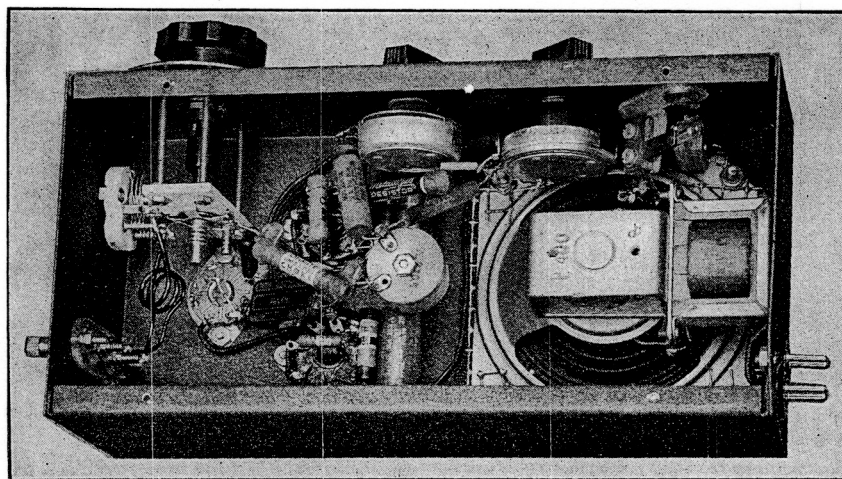


Fig. 1623—This underside view of the 7A4-detector superregenerative receiver shows the loudspeaker mounted at one end of the 5 $\times$ 10 $\times$ 3-inch chassis. The detector tuning condenser is mounted on long machine screws from the front "panel." The r.f. chokes may be seen in the clear at the left center. The male plug for the power-supply cable is to be seen mounted on one end at the corner near the loudspeaker.

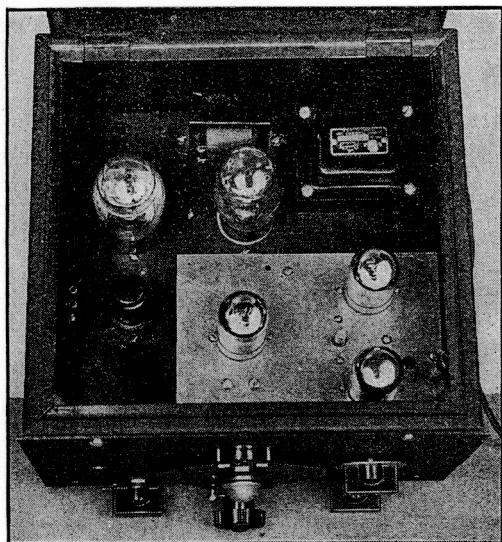


Fig. 1624 — A superregenerative superheterodyne receiver, designed for greater selectivity than can be obtained from the ordinary superregenerator. The audio section is along the left edge of the chassis and the self-contained power supply is at the upper right. The cabinet is approximately $9\frac{1}{2}$ inches square and 7 inches deep.

minimize interference. In addition, the radiation from a superregenerator can cause an annoying type of interference when station locations are fairly close together. Both these disadvantages can be overcome by using a superheterodyne. The well-known advantages of the superregenerator — simplicity, sensitivity and economy of tubes and components — can in large part be retained by using a superregenerative detector as the i.f. system of the superheterodyne. Since the intermediate frequency will be considerably lower than the signal frequency the selectivity will be increased in proportion, while the receiver as a whole is increased in complexity only by the addition of two tubes and relatively simple accompanying circuits.

A superheterodyne of this type is shown in Figs. 1624 to 1627. It uses commonly-available triodes in the r.f. and i.f. sections, and equivalent types such as the 6J5, 6C5, etc., can be substituted with little difference in performance. The i.f. in the receiver shown is approximately 26 Mc., a frequency low enough to give a worth-while increase in selectivity while still high enough to give good superregenerative operation.

A complete circuit diagram of the receiver is given in Fig. 1626. The audio section consists of a 6C5 and 6V6, and is conventional except for the fact that the headphone jack is shunted across the 6V6 grid circuit rather than being arranged to disconnect the audio signal from the speaker

tube when the 'phones are plugged in. This allows others to hear what is going on while the operator excludes outside noise by wearing headphones.

The mixer input circuit consists of the tuned circuit, L_2C_1 , coupled to the antenna or feeders by the one-turn coil, L_1 . Since the grid-cathode portion of the tube acts as a diode rectifier, it takes energy from the tuned circuit; consequently a rough impedance match between the circuit and tube is brought about by tapping down on the coil. Voltage from the oscillator is capacity-coupled to the mixer through C_8 .

The mixer plate circuit is tuned to the intermediate frequency, 26 Mc., by a $30\text{-}\mu\text{fd.}$ mica trimmer, C_3 , across the coil L_4 . To prevent short-circuiting the d.c. plate voltage a blocking condenser, C_4 , is incorporated in the tuned circuit. The plate coil, L_4 , is inductively coupled to the superregenerative detector coil, L_5 . For optimum sensitivity the mixer plate voltage should be in the vicinity of 20 to 25 volts. This voltage is obtained from a voltage divider, R_4R_5 .

The local oscillator should have a fairly high- C tank circuit to insure stability, and the grid-leak resistance should be low enough to prevent squegging. A value of 10,000 ohms is satisfactory with the oscillator operating at approximately 100 volts on the plate.

The superregenerative detector circuit is similar to those previously shown. For optimum results different values for the grid leak, R_2 , and the plate by-pass condenser, C_7 , should be tried.

The r.f. section of the outfit is the only part which requires particular care in construction; as shown in the photographs, this is assembled on a small subchassis and can be removed as a

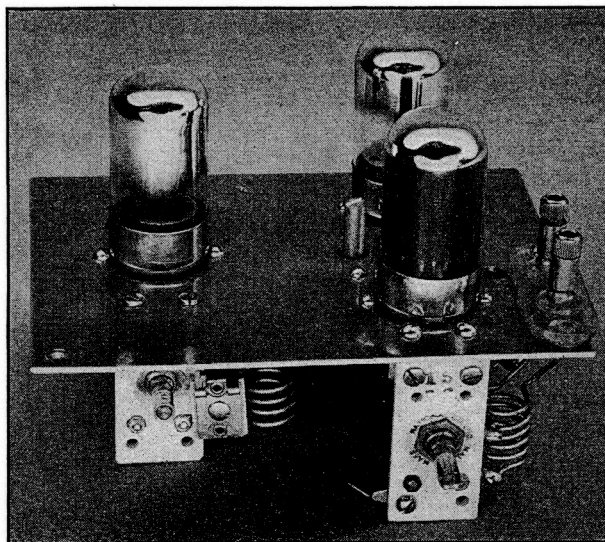


Fig. 1625 — The r.f. unit of the superregenerative superheterodyne, consisting of the mixer, high-frequency oscillator and superregenerative detector, is built on a small 4×6 -inch metal subchassis. The hole between the mixer tube and antenna binding post assembly is for screwdriver adjustment of the i.f. transformer primary.

unit from the receiver. The subchassis is a 4×6 -inch piece of aluminum and mounts to the main chassis by means of three brass-rod pillars a little over $2\frac{1}{4}$ inches long. Viewed from the top, the oscillator is to the left, the mixer is in the right foreground, and the i.f. tube is at the rear right. The oscillator is mounted somewhat back from the front to allow room for an insulated coupling and extension shaft, necessary because both ends of the tuning condenser are "hot." The mixer tuning condenser is mounted at the front of the subchassis so that its shaft can extend through the front panel. The tank coils in both the oscillator and mixer circuits are mounted directly on the condenser terminals.

The i.f. coils, L_4 and L_5 , are wound on a polystyrene form mounted between the mixer and detector as shown. The detector condenser, C_5 , is air-tuned and is mounted on the subchassis. Both sides must be insulated from ground. The primary tuning condenser, C_3 , is a mica trimmer mounted so that its adjusting screw is accessible through a hole in the subchassis. The movable plate should be connected to ground so that body capacity can be avoided in making adjustments. The plate choke, RFC_2 , is supported at one end by the tap on L_5 and at the other by C_7 , the grounded terminal of which is soldered to a lug fastened under one of the socket-mounting screws.

The sensitivity of the receiver depends a great deal on the amount of oscillator voltage injected into the mixer grid circuit. The sensitivity will be poor if the oscillator voltage is too small, but once enough is secured a further increase has relatively little effect. The "condenser" actually used is formed by fastening a machine screw in one of the mounting holes in the Isolantite frame of the tuning condenser, C_1 , so that it is fairly close to one stator mounting post of the condenser. The small capacity thus provided (C_8) is ample for coupling when the oscillator is operated with about 100 volts on the plate.

In making preliminary adjustments, the first operation is to get the superregenerative detector on frequency, which is best done by listening for its "hash" output on a regular communications receiver tuned to the approximate intermediate frequency of 26 Mc. The mixer and detector should be in their sockets but the oscillator should either be out or its plate voltage disconnected. Set the detector in operation, adjusting R_6 until superregeneration occurs, and tune C_5 to put the detector on frequency. Then tune C_3 to resonance, which will be indicated by absorption of energy from the detector circuit so that R_6 has to be advanced to maintain superregeneration. Since tuning one circuit affects the tuning of the other it will be necessary to go through this process several

Fig. 1626 — Circuit diagram of the superregenerative superheterodyne.

C_1 — 3-plate midget, approximately 5 μfd . (National UM-15 cutdown.)

C_2 — 50- μfd . mica.

C_3 — 3-30- μfd . mica trimmer.

C_4 — 500- μfd . mica.

C_5 — 35- μfd . variable (Millen 20035).

C_6 — 100- μfd . mica.

C_7 — 0.002- μfd . mica.

C_8 — See text.

C_9 — 15- μfd . variable.

For bandspread, use a 2-plate variable similar to C_1 in parallel with a 3-30- μfd . mica trimmer.

C_{10} — 100- μfd . mica.

C_{11} — 0.01- μfd . 400-volt paper.

C_{12} , C_{14} — 25- μfd . 25-volt electrolytic.

C_{13} — 0.1- μfd . 400-volt paper.

C_{15} , C_{16} , C_{17} — 8- μfd . 450-volt electrolytic.

R_1 — 2 megohms, $\frac{1}{2}$ -watt.

R_2 — 5 megohms, $\frac{1}{2}$ -watt.

R_3 — 10,000 ohms, $\frac{1}{2}$ -watt.

R_4 , R_5 — 50,000 ohms, 1-watt.

R_6 — 50,000-ohm volume control.

R_7 — 0.5-megohm volume control.

R_8 — 2000 ohms, 1-watt.

R_9 — 50,000 ohms, 1-watt.

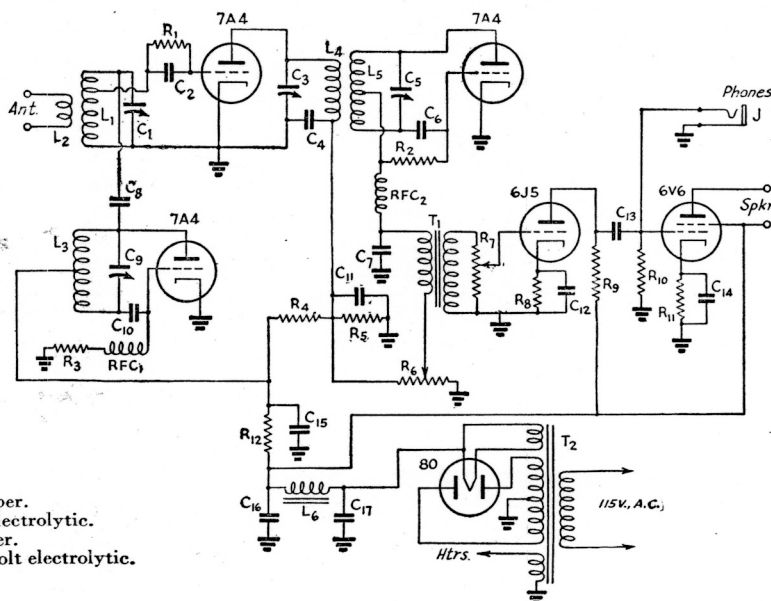
R_{10} — 0.5 megohm, $\frac{1}{2}$ -watt.

R_{11} — 750 ohms, 1-watt.

R_{12} — 15,000 ohms, 10-watt.

L_1 — 5 turns No. 14, $\frac{1}{2}$ -inch diameter, turns spaced slightly more than diameter of wire; grid tap $3\frac{1}{2}$ turns from ground end.

L_2 — 1 turn, same diameter as L_1 .



L_3 — 4 turns No. 12, $\frac{1}{2}$ -inch diameter, length $\frac{1}{2}$ inch.

L_4 — 12 turns No. 24 d.s.c. on $\frac{1}{2}$ -inch form, close-wound.

L_5 — Same as L_4 but tapped at center, spaced $\frac{1}{2}$ inch from L_4 .

L_6 — 10-henry 50-ma. filter choke.

J — Open-circuit jack.

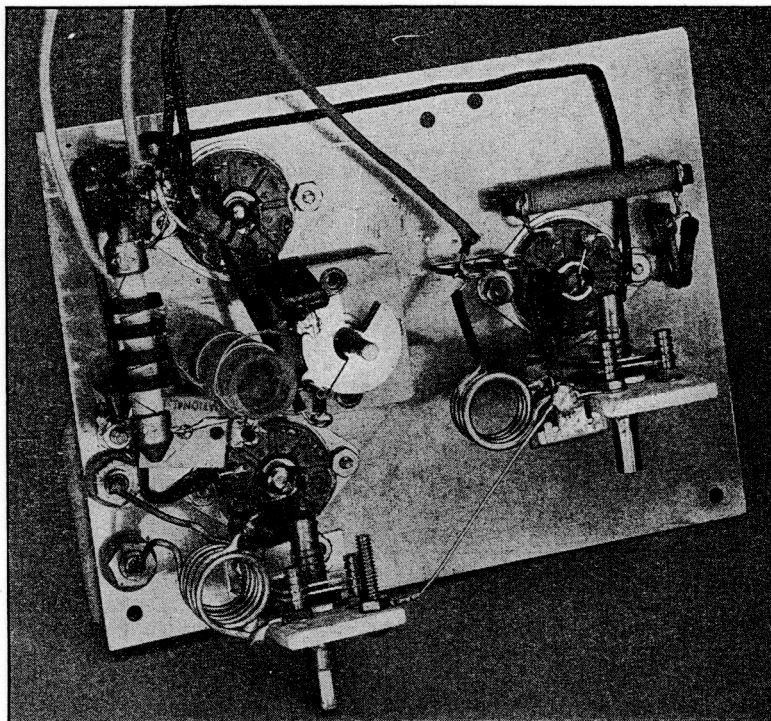
T_1 — Interstage audio transformer.

T_2 — Power transformer, 250 volts at 50-60 ma., with rectifier filament and 6.3-volt heater windings.

RFC_1 — $1\frac{1}{2}$ -inch winding of No. 30 s.c.c. on $\frac{1}{4}$ -inch diameter form.

RFC_2 — 2.5-mh. r.f. choke.

Fig. 1627—A bottom view of the superheterodyne r.f. unit. The mixer circuit is at the lower left, with the detector above and oscillator to the right. Note the machine screw (on the mixer tuning condenser) which forms one "plate" of the oscillator-mixer coupling condenser. The mica padders used in the oscillator and i.f. circuits are convenient and inexpensive, but air padders would be preferable for long-time stability.



times to maintain the desired frequency. If the primary circuit extracts too much energy, the superregenerative hiss will lose its smooth character and the sensitivity will be poor. This condition can be corrected either by loosening the coupling between the two coils or by detuning the primary sufficiently to obtain satisfactory operation.

To adjust the oscillator, set up a low-power 112-Mc. oscillator in the vicinity and then tune C_9 until a signal is heard. If the bandspread system with a mica padder is used, the movable plate on the padder should be fairly close to the fixed plate, but not squeezing the mica. The padding capacity required is of the order of $10 \mu\text{mfd.}$, depending upon the inductance of L_3 which will vary somewhat with the turn spacing. Some care must be used, because it is readily possible for harmonics of one or both of the oscillators to beat to produce a spurious i.f. signal. If several signals can be heard in adjusting the padder over its range, the strongest one should be chosen.

Once the signal is found, the mixer circuit should be adjusted to resonance. It is probable that the coil will have to be pruned or the turn spacing altered to bring the signal definitely on the tuning scale of C_1 . The coil size also depends upon the position of the grid tap. By a process of cut-and-try the coil size and tap position which give maximum signal strength can eventually be determined.

In practice the tuning of the receiver is effectively single control, since C_1 may be set at about the center of the band and the circuit will be broad enough to give good response at

both ends. The regeneration control is not affected by tuning of the r.f. circuits except when the primary condenser, C_3 , is set very close to the critical point with L_4 and L_5 overcoupled. Under these conditions any small change either in loading or capacity can throw the detector into or out of oscillation, and since the mixer is a triode such changes can be reflected from the r.f. circuits through the grid-plate capacity of the tube. Under optimum i.f. adjustments this does not occur.

A combination transmitter-receiver—It is frequently convenient to build the transmitting and receiving equipment in one assembly, arranged with a switch to shift both the antenna and plate supply from "receive" to "transmit" in a single operation. This type of construction is economical as well, since it becomes readily possible to use the same audio amplifier for both transmitter and receiver. A station of this type is shown in Figs. 1628, 1629 and 1631. The circuit is given in Fig. 1630.

In the receiver section, a 6J5GT is used as a self-quenching superregenerative oscillator. R_9 is the regeneration control. A 6V6, with its plate and screen tied together to form a triode, is used in the transmitter.

The audio section consists of a 6J5 speech-amplifier stage, resistance coupled to a Class-A 6L6 modulator. This section may be switched to act either as speech amplifier and modulator for the transmitter or as a resistance-coupled amplifier for the superregen detector in the receiver, when its output is coupled to a p.m. speaker. Separate audio gain controls are used for transmitting (R_3) and receiving (R_4).

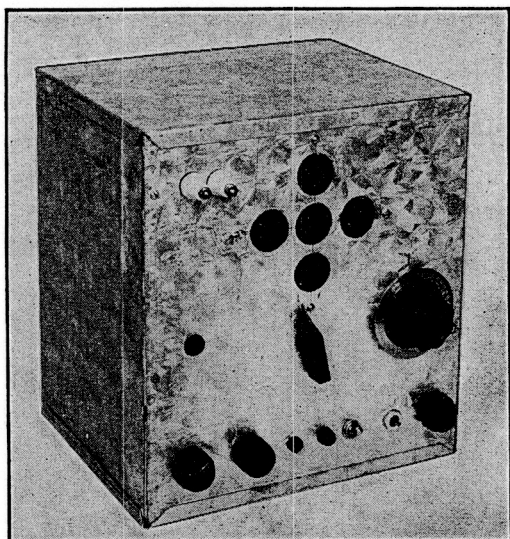


Fig. 1628 — The transmitter-receiver is built in a sheet-iron case. The large dial is the receiver tuning control. The transmit-receive switch is located in the center below the speaker opening. The adjusting hole for transmitter tuning may be seen at the left. Along the bottom, from left to right, are the microphone gain control, receiver audio gain control, headphone pin jacks (which may be used to replace the open-circuit jack, J_2 , in Fig. 1630 if desired), headphone-speaker switch, microphone jack, and regeneration control. Output terminals are in the upper left-hand corner. The five holes at the top are the speaker grille. The unit was constructed by W1DBM.

If a microphone transformer of the usual type is unobtainable, an ordinary bell-ringing transformer makes a very satisfactory substitute. For modulation purposes, the primary of the speaker output transformer is connected as an autotransformer with a 1-to-1 ratio. In this manner, the d.c. plate currents for the modulator and oscillator flow through separate sections of the primary winding and in such directions as to buck in core-magnetizing effects, thereby increasing the effective inductance of the primary winding:

The headphone signal is coupled from the primary of T_2 through C_{14} . Interchange between headphones and loudspeaker is by means of the double-pole double-throw toggle switch, S_2 . An 8-pole dual gang switch takes care of switching between receiving and transmitting. In the receiving position, the plate supply is connected to the detector, the audio

input is shifted to the detector output, speaker and headphones are connected to the output of the audio section, the mike battery and plate supply are disconnected from the transmitter, and the antenna is shifted to the receiver. In the transmitting position, the plate supply is disconnected from the detector, the audio input shifted to the output of the mike transformer, speaker and headphones disconnected from the audio output, mike battery and plate supply connected to the transmitter, and the antenna shifted to the transmitter.

A metal chassis, 10 inches long, 5 inches wide and 3 inches deep, forms the foundation for the unit. The receiver components are grouped at one end of the chassis, while those for the transmitter are similarly grouped at the other end. The 6J5GT detector tube is mounted horizontally by means of a metal bracket in which the ceramic socket is set. The receiver tuning condenser, C_1 , is mounted on a small stand-off insulator to space it from the chassis and to bring its terminals up close to the plate and grid prongs of the detector socket. The detector inductance, L_2 , is soldered directly across the terminals of C_1 , while the grid leak and condenser are connected between the rotor of C_1 and the grid terminal of the detector socket. A ceramic flexible coupling is used between the shaft of the condenser and the tuning dial. The dial-coupling extension shaft is passed through a rubber grommet set in the panel.

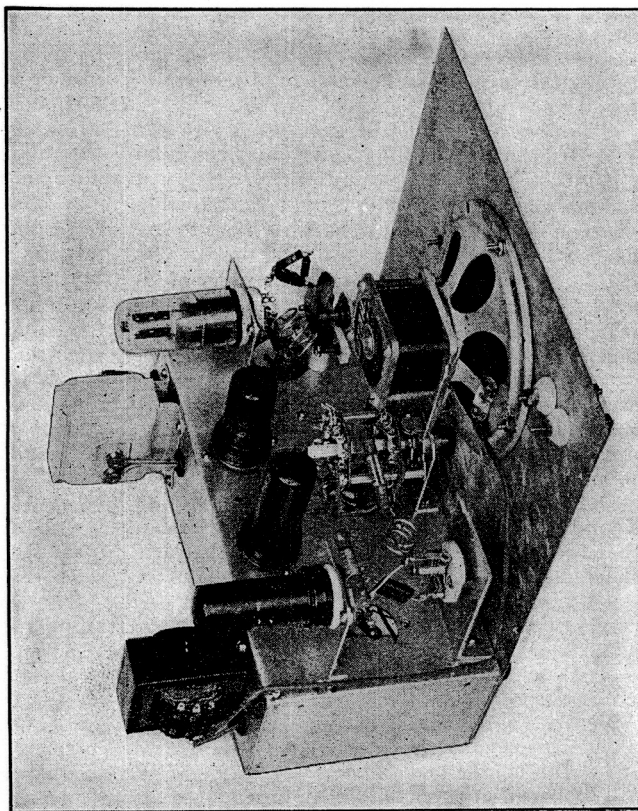


Fig. 1629 — Interior view of the transmitter-receiver. The transmitter section is in the left foreground, with the receiver section at the right-hand end of the chassis. This photograph was made before output terminals (at upper right on panel) were connected to the send-receive switch.

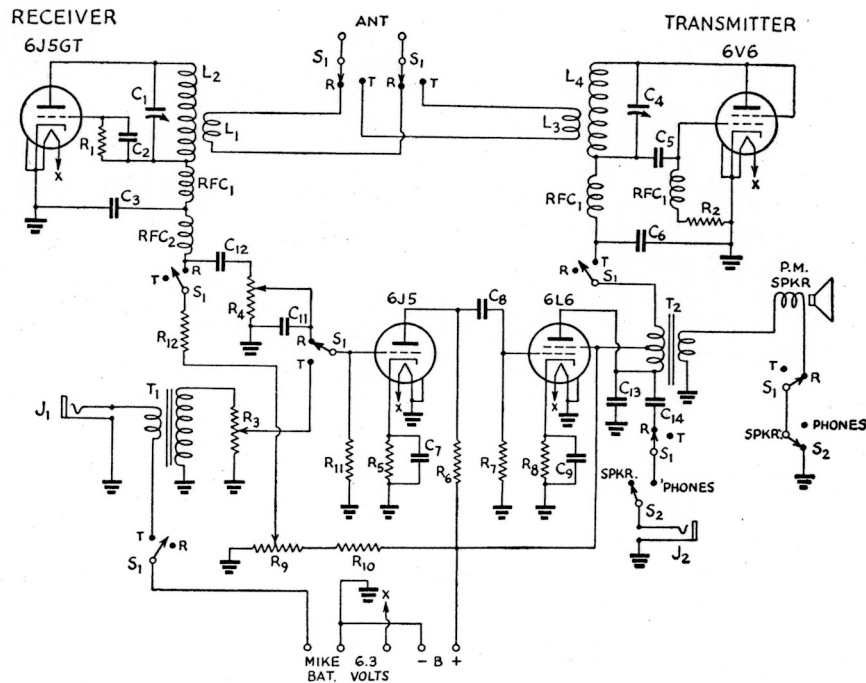


Fig. 1630 — Circuit diagram of the 112 Mc. combination transmitter-receiver for WERS.

- | | | |
|---|---|--|
| C ₁ — 2-plate midget variable (Hammarlund MCM type). | C ₁₄ — 0.01- μ fd. 600-volt paper. | J ₁ — Open-circuit microphone jack. |
| C ₂ — 50- μ fd. midget mica. | R ₁ — 5 megohms, $\frac{1}{2}$ -watt. | J ₂ — Open-circuit headphone jack. |
| C ₃ — 0.01- μ fd. 600-volt paper. | R ₂ — 15,000 ohms, $\frac{1}{2}$ -watt. | L ₁ — 1 turn No. 14, $\frac{1}{2}$ -inch diameter. |
| C ₄ — 5-plate midget air trimmer, approximately 20 μ fd. | R ₃ — $\frac{1}{2}$ -megohm potentiometer. | L ₂ — 4 turns No. 14, $\frac{1}{2}$ -inch diameter. |
| C ₅ — 50- μ fd. midget mica. | R ₄ — $\frac{1}{2}$ -megohm potentiometer. | L ₃ — 1 turn No. 14, $\frac{1}{2}$ -inch diameter. |
| C ₆ — 0.001- μ fd. midget mica. | R ₅ — 1500 ohms, $\frac{1}{2}$ -watt. | L ₄ — 3 turns No. 14, $\frac{1}{2}$ -inch diameter. |
| C ₇ — 10- μ fd. 25-volt electrolytic. | R ₆ — 50,000 ohms, 1-watt. | S ₁ — Sections of 8-pole, 2-gang rotary switch (Centralab). |
| C ₈ — 0.01- μ fd. 600-volt paper. | R ₇ — 100,000 ohms, $\frac{1}{2}$ -watt. | S ₂ — D.p.d.t. toggle switch. |
| C ₉ — 10- μ fd. 25-volt electrolytic. | R ₈ — 500 ohms, 1-watt. | T ₁ — Microphone transformer (bell-ringing transformer). |
| C ₁₀ — 0.01- μ fd. 600-volt paper. | R ₉ — 50,000-ohm potentiometer. | T ₂ — Universal output transformer. |
| C ₁₁ — 100- μ fd. mica. | R ₁₀ — 50,000 ohms, 1-watt. | |
| C ₁₂ — 0.01- μ fd. 600-volt paper. | R ₁₁ — $\frac{1}{4}$ -megohm, $\frac{1}{2}$ -watt. | |
| C ₁₃ — 0.001- μ fd. 600-volt paper. | R ₁₂ — 25,000 ohms, 1-watt. | |
| | RFC ₁ — V.h.f. choke (Ohmite Z-1). | |
| | RFC ₂ — 80-mh. r.f. choke. | |

At the other end of the chassis, the 6V6 is also mounted horizontally by setting the socket in a vertical metal bracket. A similar bracket serves to hold the transmitter tuning condenser, C₄. This condenser is adjusted by a screwdriver through a hole in the front panel. This type of control eliminates the possibility of throwing the transmitter frequency off by accidentally bumping a dial. Short-circuiting of the plate supply while adjusting the condenser is prevented by lining the adjusting hole with a rubber grommet. As in the receiver, the coil, L₄, is soldered directly across the condenser terminals.

At the center of the chassis are the submounted sockets for the two audio tubes and the change-over switch. The latter is mounted on a bracket fastened to the chassis. The microphone transformer, T₁, and the output transformer, T₂, both are mounted on the rear edge of the chassis.

The panel is made from ordinary galvanized sheet iron. There is room on the panel for a

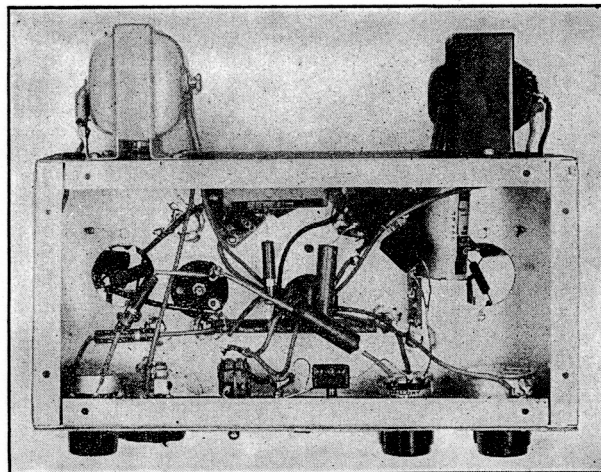


Fig. 1631 — Under-chassis view of the WERS transmitter-receiver.

five-inch permanent-magnet speaker. Large holes are cut in the speaker area as grille work and backed up with dust-proof cloth fastened under the rim of the speaker. A pair of feed-through insulators serve as output terminals.

The case for the unit also is made from galvanized sheet iron. The sides and back are made from a single piece bent into a U shape, with flanges at the front edges to which the panel may be fastened with machine screws. The top and bottom are identical, with edges bent to overlap the sides, back, and panel. If desired, the case may be dressed up by giving it a coat of "metal preparer," followed by a coat or two of enamel or Duco. Another possibility is to have it sprayed at a garage or automobile body works before the parts are mounted.

The unit is designed to operate from either an a.c. or battery-operated pack or from a combination pack delivering 300 volts at 100 ma. When loaded, the transmitter plate current should be 50 or 60 ma. This value may be adjusted within limits by altering the value of grid-leak resistance, higher resistance values resulting in lower plate current. The audio section should draw an average of about 50 ma. Normal r.f. power output is about 2 watts.

Transceivers

The transceiver shown in Figs. 1632 to 1635 is constructed from parts which in most cases can be readily salvaged from old equipment. It is built around the more numerous types of standard receiving tubes, several of which can be used interchangeably. For operation at 200 volts or less the 6J5GT is preferable as the oscillator, since it works more efficiently than some of the other types. An easily constructed vibrator-type power supply for 200-volt operation is described in a later section. Where a 300-volt supply is used, the 6V6GT is recommended.

The audio system consists of a triode first stage (6J5 or 6C5) followed by a 6V6 (or 6F6)

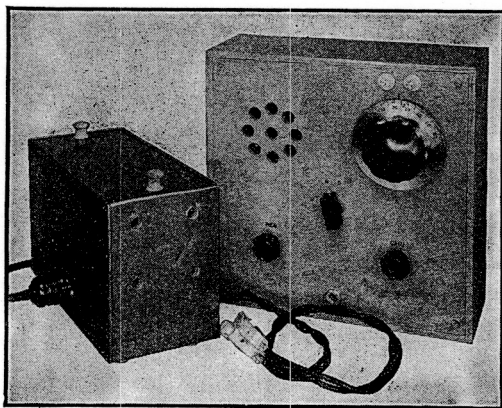


Fig. 1632 — This low-power transceiver and vibrator power supply can be built from receiver components which nearly every amateur can salvage from old equipment. The addition of an antenna, microphone, and storage battery makes it a complete emergency station.

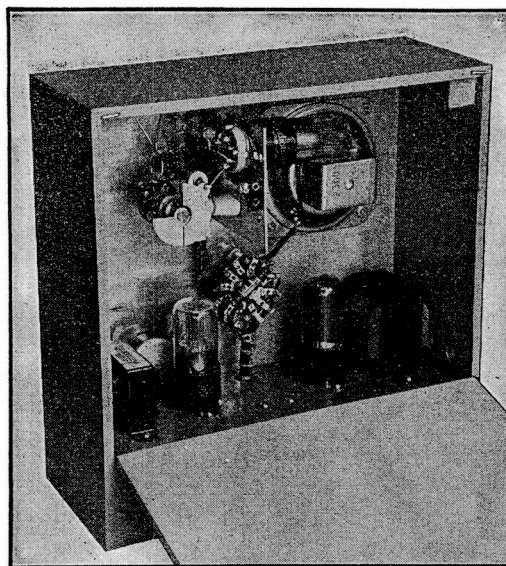


Fig. 1633 — A rear view of the transceiver installed in its case. The oscillator-detector is constructed as a unit on a projecting metal piece, with the audio unit below.

in any of the varieties of glass or metal. The pentode is used as a modulator in transmitting and to drive the loudspeaker in reception. There is no provision for headphone reception in this unit, but if it is wanted a jack can easily be connected in the 6J5 plate circuit. If this is done an additional switch section should be provided to cut out the headphone circuit when transmitting. As a matter of economy when operating from emergency power, the "B" drain could be cut to a very low value during reception periods if headphones only are used, since the change-over switch could be arranged to cut the "B" lead to the plate and screen of the pentode audio power tube. In the event that the speaker is not wanted or if a suitable unit is not available, this would be a worthwhile modification.

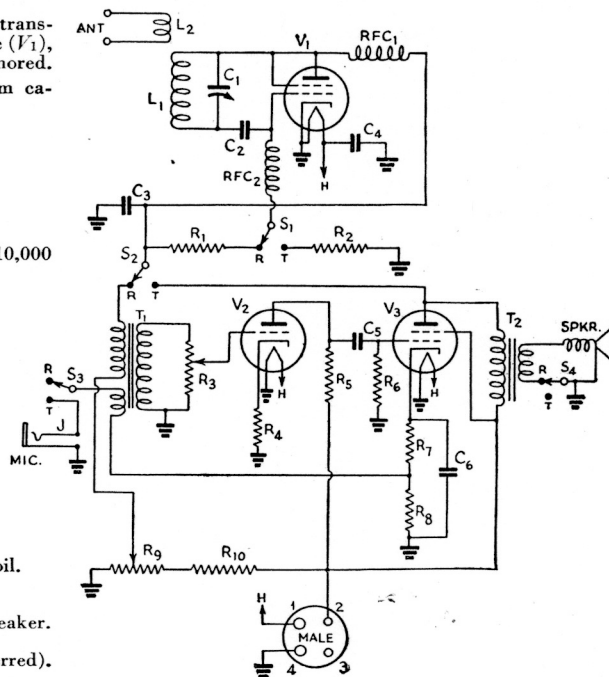
If a single switch wafer of the desired number of poles and circuits cannot be obtained, any 4-pole double-throw switch may be used. Usually some sort of wafer switch can be salvaged from old equipment; if it is necessary to use more than one gang, the only result is that the switch is more bulky.

Output transformers (T_2) usually can be taken from a discarded receiver, if not available new. The "transceiver transformer" used in this unit is an ordinary interstage audio (about 3:1 ratio) with a microphone primary added. There is usually enough space between the core and the windings to get in at least one layer of fairly fine wire, such as No. 30. It is necessary to take the core apart and possibly to remove some of the paper already around the windings. In the unit shown, the microphone primary is one layer of No. 30 s.c.c. (about 50 turns) wound over the existing windings. It was given a coat of shellac to hold it in

The box in which the transceiver is housed is made of $\frac{1}{4}$ -inch plywood, with inside dimensions $10 \times 10 \times 3\frac{1}{2}$ inches. At each corner the sides are glued to $\frac{3}{4} \times \frac{3}{4} \times 3\frac{1}{2}$ -inch pieces of wood. A strip of plywood $1\frac{1}{4}$ inches high runs along the back, and a piece $1\frac{1}{2}$ inches high is glued to it inside to form a support for the rear edge of the shelf when the assembly is placed in the cabinet. The re-

The plate and grid chokes are mounted from insulated lugs at the "cold" ends, the hot ends being placed as close as possible to the points in the circuit where they connect. The power

C₂—50- μ fd. mica.
C₃—0.005- μ fd. mica.
C₄—250- μ fd. mica.
C₅—0.1- μ fd. paper, 400 volts.
C₆—25 to 50 μ fd. electrolytic, 50 volts.
R₁—5 megohms, $\frac{1}{2}$ -watt.
R₂—5000 ohms, 1-watt (for 6J5, 6C5); 10,000 ohms, 1-watt (for 6V6, etc.).
R₃—0.5-megohm volume control.
R₄—1000 ohms, $\frac{1}{2}$ -watt.
R₅—0.1 megohm, 1-watt.
R₆—0.5 megohm, $\frac{1}{2}$ -watt.
R₇—250 ohms, 1-watt.
R₈—200 ohms, 1-watt.
R₉—50,000-ohm volume control.
R₁₀—50,000 ohms, 1-watt.
L₁—3 turns No. 12, $\frac{9}{16}$ -inch inside diameter, $\frac{1}{2}$ -inch long.
L₂—1 turn No. 12 or No. 14.
RFC₁, RFC₂—55 turns No. 30 d.c.c., close-wound, $\frac{1}{4}$ -inch diameter.
T₁—Transceiver transformer (see text).
T₂—Output transformer, pentode to voice coil.
S₁₋₄—4-pole double-throw switch.
J—Open-circuit jack.
Spkr—3-inch permanent-magnet dynamic speaker.
V₁—6J5, 6C5, 6V6, 6F6, etc.
V₂—6J5, 6C5. V₃—6V6, 6F6 (GT types preferred).



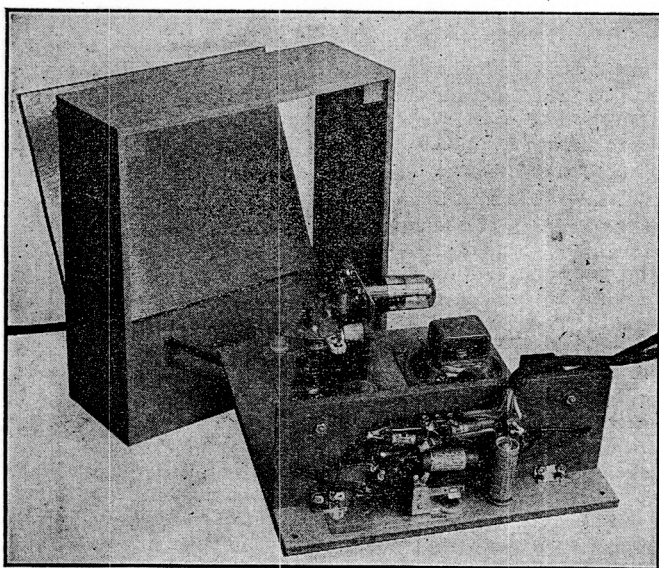


Fig. 1635 — Below-shelf wiring and construction of the 112-Mc. transmitter. The unit can be removed from the plywood cabinet for servicing.

leads from the r.f. section are cabled and brought down to the switch.

The speaker is mounted on the panel as shown. To protect the cone from damage, the grille holes are backed by a piece of window-screen material which is held in place by the bolts which fasten the speaker to the panel.

The metal strip running from top to bottom of the panel serves as a shield to prevent body capacity and also as a low-inductance ground connection between the oscillator and the audio section. It makes direct contact with the oscillator support, the rotor of R_3 , the metal frame of the switch, and the frame of the microphone jack. It is approximately $4 \times 9\frac{1}{2}$ inches, and was cut from an ordinary tin can.

In the rear view the transformer at the left is T_1 , the revamped audio transformer. The audio gain control, R_3 , is on the panel between R_1 and the 6J5 first audio. The modulator tube and speaker transformer are at the right, with the regeneration control, R_9 , behind them on the panel. All leads from the switch are cabled and pass through a hole in the shelf near the panel. The two grid leaks, R_1 and R_2 , are mounted directly on the switch contacts, but all other resistors are below the shelf. The below-shelf arrangement is of no particular consequence, since there are no r.f. circuits — except that the grid leads to both tubes should be kept short, so that hum pick-up will be minimized. The dropping resistor, R_{10} , for the regeneration control circuit is mounted on the lug strip at the rear; the other two resistors which connect together at this strip are the two sections of the modulator cathode resistor. Spare terminals on the tube sockets are used as tie points wherever necessary.

It is possible that in a particular layout the proper choke specifications will differ from

those given. The grid choke is the more critical. In both cases the number of turns should be adjusted so that the cold end can be touched with the finger without disturbing the operation of the oscillator. Effective superregeneration depends considerably on the grid choke and on the capacity of the plate by-pass condenser, C_3 . The circuit may not superregenerate at all with less than $0.002 \mu\text{fd.}$ at C_3 , while values higher than 0.005 tend to cut down the audio output because of the rather heavy by-pass effect across the primary of the audio transformer, T_1 . The value recommended is a good compromise. Two or more condensers may be connected in parallel or series if the exact capacity is not obtainable in one unit.

The coil inductance is adjusted by spreading or squeezing the turns until the proper frequency range is secured. It is best to adjust the coil inductance to bring 112 Mc. near the maximum-capacity end of the tuning range.

The size of the antenna coupling coil, which is mounted on the feed-through insulators on the panel, will depend upon the antenna system used. Usually a turn or two of wire is sufficient, the coupling being adjusted by bending the leads so that the position of the antenna coil is changed with respect to the tank coil.

The r.f. tube takes 20 or 25 ma. at 200 volts when transmitting, and has an r.f. output of a watt or so. Including the audio system, the total current drain in the transmit position is in the neighborhood of 60 ma. at 200 volts. In reception the plate current of the r.f. tube is negligible, and the total current at 200 volts is only about 35 ma.

Mobile equipment — The equipment previously described is readily adaptable to temporary mobile operation when provided with a storage-battery operated power supply and installed in a car having a suitable antenna (see pages 367–369 for discussion of antennas). In a permanent mobile installation, however, it is desirable to arrange the equipment so that it is instantly accessible for operation, yet does not interfere with the regular car controls nor occupy space normally available for passengers.

One method of accomplishing this is to make the transmitter and receiver separate units, installing the receiver on the car dashboard where its controls are within reach of the driver, and locating the transmitter and power supply in the luggage compartment. This is practicable because the transmitter ordinarily is operated on a fixed frequency and hence does not require frequent readjustment. A mobile station of this type is described in Chapter Fifteen (Figs. 1534–1537).

An alternative is to construct the transmitter and receiver as a unit and install it in some convenient spot, such as the glove compartment of the car. Such an installation is shown in Figs. 1636 to 1639. Normally the glove compartment will be too small to contain the necessary apparatus, but, if the fiber box is removed, the space behind the dash will, in most cases, be ample. In the set illustrated, the fiber box is replaced by a metal box of the same dimensions, backed by the chassis on which the transmitter and receiver are mounted. The box and chassis are made of No. 24 gauge sheet metal. If patterns are prepared beforehand, it will be possible to have the metal work done by a tinsmith at comparatively small cost. The actual dimensions naturally will be determined by the shape and size of the space available in the particular model of car in which the station is to be installed. The chassis shown in the photographs measures 12 inches wide and 10½ inches deep.

The circuit diagram of the mobile unit is given in Fig. 1638. Electrically, it is practically equivalent to the transmitter-receiver circuit of Fig. 1634. The transmit-receive switch is a Federal Radio anti-capacity type, with "out-board" antenna change-over contacts added. Below the change-over switch is the 1½-inch permanent-magnet dynamic speaker. To the left side of the speaker are the volume control and microphone jack. C_5 , C_6 , C_7 , C_{16} , RFC_3 , RFC_4 , R_2 , and the tank circuit, C_3L_4 , are clustered around the base of the 6V6 oscillator tube. Trial showed that C_7 is a worth-while addition; while the 6V6 will oscillate without it, the output is considerably less.

To the right side of the speaker are the regeneration control and filament switch, the pilot light and the detector circuit. C_1 , C_3 , RFC_1 , R_1 , and the tank circuit, C_2L_1 , are bunched about the base of the 6J5G. RFC_2 and C_4 are mounted on the underside of the chassis pan. RFC_2 is a low-frequency r.f. coil which, together with the associated condensers, forms a filter for the quench frequency.

The high-frequency chokes, RFC_1 , RFC_3 and RFC_4 , consist of 55 turns of No. 30 enameled wire wound on a drill shank, then sprung loose and fastened with Duco cement. The chokes

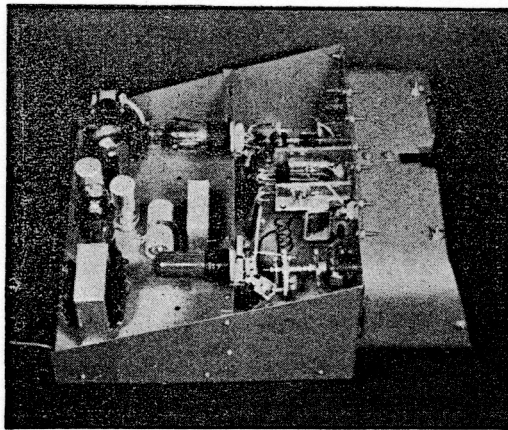


Fig. 1637 — Side view of the mobile unit, showing the chassis and mounting-hood arrangement. The metal chassis and hood are made of No. 24 gauge "black metal."

are very light in weight and are safely mounted by the wire with which they are wound.

Directly behind the tube-mounting partition and between the detector and oscillator tubes is the filter choke, L_5 . (This outfit obtained its plate power from the car broadcast receiver, which had a resistance-capacity filter. When this power was used for the transmitter-receiver, the filter resistor was shorted out, leaving only the condensers; hence the necessity for L_5 and C_{15} .)

Behind L_5 is the audio coupling condenser, C_{12} , which is too large to fit below deck. Left to right, across the back of the chassis, are the output transformer, the modulator tube, condensers C_9 , C_{13} , C_{14} and C_{15} , the first audio tube and the audio input transformer. The latter had enough room between the original windings and the core for the installation of approximately 50 turns of No. 30 enameled wire for microphone input. The new winding is covered with cellophane tape to keep it in place and to protect it from moisture.

Beneath the chassis are RFC_2 , C_4 , R_5 , R_6 , R_7 , R_8 , R_9 , C_{10} , C_{11} , R_{11} , and most of the audio and power wiring. Only two leads, each fused, leave the chassis. These are marked "A+" and "B+" in Fig. 1638. A third connection for negative returns is made through the frame of the car.

The numbered dials available were either too large to fit on the panel or too small for comfortable gripping. Pointer knobs were used, therefore, together with home-made scales. The scales were drawn in India ink on the backs of filing cards cut to size and fastened to the panel with rubber cement. The white plastic-knob pointers did not provide sufficient contrast with the white scale cards, and so the pointers later were roughed up with fine sandpaper and coated with black India ink.

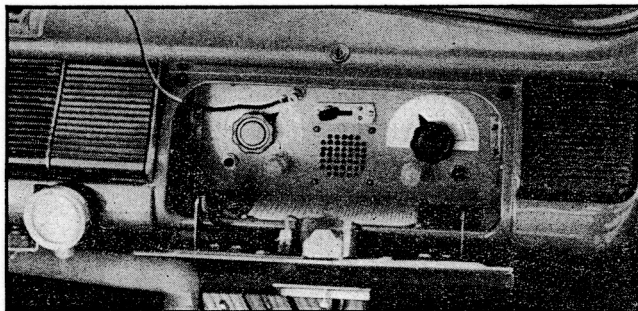
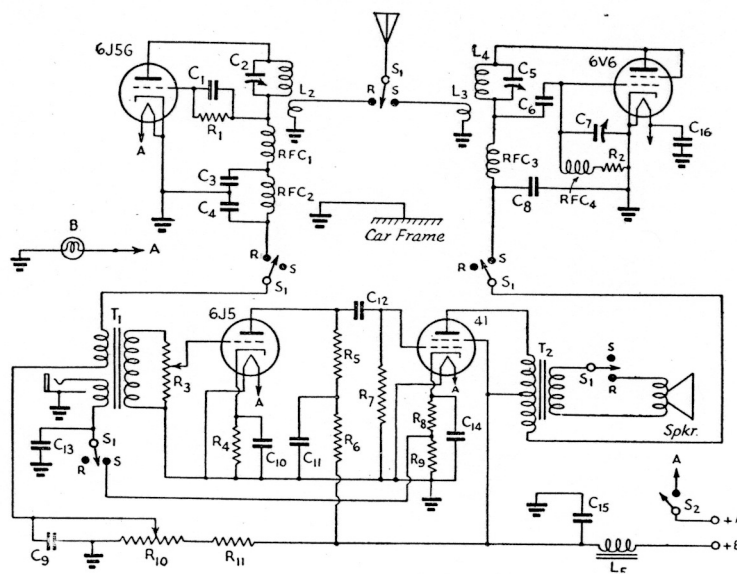


Fig. 1636 — A transmitter-receiver unit for mobile use, installed in the glove compartment of a car. This installation was made by W2DVG.

Fig. 1638 — Circuit of the mobile transmitter-receiver.

C₁ — 20- μ fd. mica.
 C₂, C₅ — 3-plate variable (Cardwell Trim-Air).
 C₃ — 0.006- μ fd. mica.
 C₄, C₆, C₈ — 0.001- μ fd. mica.
 C₇ — 3-30- μ fd. trimmer.
 C₉ — 20- μ fd. electrolytic.
 C₁₀, C₁₁ — 5- μ fd. electrolytic.
 C₁₂ — 0.5- μ fd. paper.
 C₁₃, C₁₄, C₁₅ — 20- μ fd. electrolytic.
 C₁₆ — 100- μ fd. mica.
 R₁ — 5 megohms, $\frac{1}{2}$ -watt.
 R₂ — 15,000 ohms, 1-watt.
 R₃ — 0.5-megohm pot.
 R₄ — 2250 ohms, 1-watt.
 R₅ — 0.1 megohm, $\frac{1}{2}$ -watt.
 R₆ — 20,000 ohms, 1-watt.
 R₇ — 0.5 megohm, $\frac{1}{2}$ -watt.
 R₈ — 500 ohms, 1-watt.
 R₉ — 200 ohms, 1-watt.
 R₁₀ — 50,000-ohm pot.
 R₁₁ — 50,000 ohms, 2-watt.
 L₁, L₄ — 3 turns No. 14, $\frac{1}{2}$ -inch diameter, turns spaced so tanks tune to WERS band.
 L₂, L₃ — 1 turn No. 14, $\frac{1}{2}$ -inch diameter.
 L₅ — Replacement-type filter choke.
 B — 6-volt pilot lamp.
 RFC₁, RFC₃, RFC₄ — 55 turns No. 30, self-supporting.
 RFC₂ — Low-frequency choke coil.



S₁ — Anti-capacity change-over switch (see text).
 S₂ — Filament switch (on R₁₀).
 Spkr — 1 $\frac{1}{2}$ -inch p.m. speaker (Cinaudagraph).
 T₁ — Transceiver transformer (WE213-D with microphone winding of 50 turns No. 30 e. See text).
 T₂ — Universal output transformer, push-pull type.

The volume- and regeneration-control knobs are made of $\frac{3}{4}$ -inch Lucite rod, drilled for shaft size and drilled and tapped for set screws. They project out from the panel an inch and one-half for easy handling.

The regular car-radio antenna is used for the transmitter-receiver. It is of the telescoping type, passing through the roof. The antenna is connected to the switch terminal by an 18-inch lead and the system extended to $\frac{3}{4}$ wavelength. A vernier adjustment for antenna tuning is obtained by sliding the antenna up or down inside the car. This does not change its physical length but alters the portion which closely parallels the windshield dividing strip.

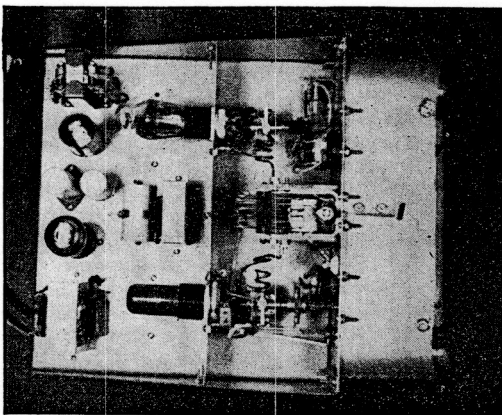


Fig. 1639 — Plan view of the mobile station, showing location of components. The oscillator and detector tubes are mounted horizontally from the partition, with associated tank-circuit components arranged close to the tube sockets. Audio equipment is at the rear. Most of the power wiring is concealed underneath the chassis.

Types of Power Supply

Under normal conditions there is available a fairly wide variety of equipment for generating plate power independently of the a.c. mains. Except possibly in isolated cases, these ready-made units cannot now be purchased from regular dealers. However, it may be possible to secure equipment of this type second-hand, and the information below is included for the benefit of those who may have occasion to need data on a particular type of power supply.

Dry batteries, both "A" and "B," are difficult to obtain. In the case of equipment built for dry-battery operation, such as certain models of commercial transceivers, it may be necessary, in portable operation to substitute a vibrator-type supply, even though this requires transporting a storage battery.

Dry batteries — Dry-cell batteries are ideal for receiver and low-power transmitter supplies because they provide steady, pure direct current. Their disadvantages are weight, high cost, and limited current capability. In addition, they will lose their power even when not in use if allowed to stand for periods of a year or more. This makes them uneconomical if not used more or less continuously.

Table I shows the life to be expected from representative types of batteries under various current drains, based on intermittent service simulating typical operation. The continuous-service life will be somewhat greater at very low current drains and from one-half to two-thirds the intermittent life at higher current drains.

The secret of long battery life at normal current drains lies in intermittent operation. The

duration of "on" periods should be reduced to a minimum. The more frequent the rests given a dry-cell battery, the longer it will last. As an example, one standard type will last 50 per cent longer if it is operated for periods of one minute, with five-minute rest intervals, in 24-hour intermittent operation than if it is operated continuously for four hours per day, although the actual energy consumption in the 24-hour period is the same in both cases.

Storage batteries — The most universally acceptable self-contained power source is the storage battery. It has high initial capacity and can be recharged, so that its effective life is practically indefinite. It can be used to provide filament or heater power directly, and plate power through associated devices such as vibrator-transformers, dynamotors and genemotors, and a.c. converters. For emergency work a storage battery is a particularly convenient power source, since such batteries are universally available. In a serious emergency it would be possible to obtain 6-volt storage batteries so long as there were automobiles to borrow them from, and for this reason the 6-volt storage battery makes an excellent unit around which to design the low-powered emergency station.

For maximum efficiency and usefulness the power drain on the storage battery should not exceed 15 or 20 amperes from the ordinary 100- or 120-ampere-hour 6-volt battery. Heavy connecting leads should be used to minimize the voltage drop; similarly, heavy-duty low-resistance switches are required.

Vibrator power supplies — The vibrator-type power supply consists of a special step-up transformer combined with a vibrating interrupter. When the unit is connected to a storage battery the circuit is made and reversed rapidly by the vibrator contacts, and the resulting square-wave d.c. pulses which flow in the primary of the transformer cause an alternating voltage to be developed in the secondary. This high-voltage a.c. in turn is rectified, either by a vacuum-tube rectifier or by an additional synchronized pair of vibrator contacts, and filtered, providing outputs as high as 400 volts at 200 ma. The high-voltage filter circuit usually is identical with that of an equivalent power source operating from the a.c. line. Noise suppression equipment, serving to minimize r.f. disturbances caused by the vibrator, is incorporated in manufactured units.

Although vibrator supplies are ordinarily used with 6-volt tubes, their use with 2-volt tubes is quite possible provided additional filament filtration is incorporated. This filter can consist of a small low-resistance iron-core choke, or the voice-coil winding of a speaker transformer. The field coil of a speaker designed to operate on 4 volts at the total filament current of the receiver may be used. The filaments are then connected in parallel, as usual, and placed in series with this winding across the 6-volt battery. In both 6- and 2-volt

receivers, "hash" can be reduced by heavily by-passing the battery at the vibrator supply terminals, using fixed condensers of 0.25 to 1 μ fd. capacity or more, and by including an r.f. choke in the battery lead near the condenser. Noise will be minimized if a single ground, consisting of a short, heavy copper strap, is used. Thorough shielding also will contribute to the noise reduction.

Table II lists standard commercial vibrator supplies suitable for use as emergency or portable power sources. Some of these units include a hum filter, while others do not. The design of a suitable filter is, for the most part, conventional, however. The vibrator supplies used with automobile receivers are satisfactory for receiver applications and for use with transmitters where the power requirements are small.

The efficiency of vibrator packs runs between about 60 to 75 per cent.

Dynamotors and genemotors — A dynamotor is a double-armature high-voltage generator, the additional winding serving as a driving motor. Dynamotors usually are operated from 6-, 12- or 32-volt storage batteries, and deliver output voltages from 300 to 1000 or more.

The genemotor is a refinement of the dynamotor, designed especially for automobile receiver, sound truck and similar applications. It has good regulation and efficiency, combined with economy of operation. Standard models of genemotors have ratings ranging from 135 volts at 30 ma. to 300 volts at 200 ma. or 500 volts at 200 ma., as can be seen from Table III. The normal efficiency averages around 50 per cent, increasing to better than 60 per cent in the higher-power units. The voltage regulation of a genemotor is comparable to that of well-designed a.c. supplies.

Successful operation of dynamotors and genemotors requires heavy, direct leads, mechanical isolation to reduce vibration, and thorough r.f. and ripple filtration. The shafts and bearings should be thoroughly "run in" before regular operation is attempted, and thereafter the tension of the bearings should be checked occasionally.

A.c.-d.c. converters — In some instances it is desirable to utilize existing equipment built for 115-volt a.c. operation. To operate such equipment with any of the power sources outlined above would require a considerable amount of rebuilding. This can be obviated by using a rotary converter capable of changing the d.c. from 6-, 12- or 32-volt batteries to 110-volt 60-cycle a.c. Such converter units are built with output ratings ranging from 40 to 300 watts.

The conversion efficiency of these units averages about 50 per cent. In appearance and operation they are similar to genemotors of equivalent rating. The over-all efficiency of the converter will be lower, however, because of losses in the a.c. rectifier-filter circuits and the necessity for converting heater as well as plate power.

TABLE I—BATTERY SERVICE HOURS

Estimated to 34-volt end-point per nominal 45-volt section.
Based on intermittent use of 3 to 4 hours daily.
(For batteries manufactured in U. S. A. only.)

Manufacturer's Type No.	Weight		Current Drain in Ma.											
	Lb.	Oz.	5	10	15	20	25	30	40	50	60	75	100	150
Eveready	14	—	2000	1100	690	510	400	320	200	170	130	100	50	30
386	13	5	1700	880	550	395	300	240	165	125	100	70	45	20
486	12	2	1400	800	530	380	260	185	130	85	60	40	30	14
586	8	13	900	450	290	210	130	100	60	45	25	20	11	5
585	3	3	320	140	81	54	37	27	—	—	—	—	—	—
762	2	—	320	140	81	54	37	27	—	—	—	—	—	—
482	1	2	160	70	30	20	10	7	—	—	—	—	—	—
738	—	10	50	20	11	7	5.2	—	—	—	—	—	—	—
733	—	8.6	70	20	11	7	5.2	—	—	—	—	—	—	—
455 ¹	—	—	—	—	—	—	—	—	—	—	—	—	—	—

¹ Same life figures apply to 467, 67½-volt, 10.5 oz.

Estimated to 1-volt end-point per 1.5-volt unit.
Based on intermittent use of 3 to 4 hours daily.
(For batteries manufactured in U. S. A. only.)

Manufacturer's Type No.	Weight		Voltage	Current Drain in Ma.											
	Lb.	Oz.		50	60	120	150	175	180	200	240	250	300	350	
Eveready	8	4	1.25				2000	1715	1500	1333	1250	1200	1000	854	
A-1300	6	12	1.5				1400	1200		1050		775	625		
740	2	14	1.5		1100	750				375	300	275	215	175	
741 ¹	2	1	1.5		750	325				245		180	135	110	
743	2	2	1.5		700	320			200		120		90		
7111	1	6	1.5		500	325			155	135	100	95	85	50	
742	15	8	2.5				2000	1715	1500	1333	1250	1200	1000	854	
A-2300	1		3.0		240	100			70		40		30		
723	1	3	4.5	200											
746	3		6.0	375											
718 ²															

¹ Same life figures apply to 745, wt. 3 lbs.

² Same life figures apply to 747, wt. 3 lbs.

TABLE II—GASOLINE-ENGINE-DRIVEN GENERATORS, AIR-COOLED

Manufacturer				Output		Weight	Starter
Eicor	Kato	Onan	Pioneer	Volts	Watts	Lbs.	
3AP6 ¹			BD-6 ¹	110 a.c. or 6 d.c.	300 200	100	Push-button
	JR-35 ²			110 a.c.	300	65	Push-button
	JRA-3 ²			110 a.c.	350	65	Rope crank
	19-A			110 a.c. or 6 d.c.	350 200	95	Push-button
		358 ^{1 3}		115 a.c.	350	91	Push-button
	JR-10 ²			110 a.c.	400	—	Rope crank
		5L ³		110 a.c.	500	165	Push-button
	23A			110 a.c. or 6 d.c.	500 200	105	Push-button
6AP1	14A		BA-6 ¹	110 a.c.	600	135	Push-button
		7L ³		115 a.c.	750	195	Push-button
10AP1		10L ^{3 4}	BA-10 ¹	110 a.c.	1000	170	Push-button
	26A			110 a.c.	1000	265	Manual
		OTC		110 a.c.	1500	135	Manual
			BA-15	110 a.c.	1500	365	Push-button

¹ Also available in remote-control models.

² Intermittent-duty model.

³ Also available in manual-started type.

⁴ 115-volt output; weight 200 lbs.

TABLE III—VIBRATOR SUPPLIES

Manufacturer's Type Number				Output		Rectifier	Output Filter
American Television and Radio Co.	Electronic Labs	Mallory	Radiart	Volts	Ma.		
VPM-F-7				90	10	Syn.	Yes
		VP-551 ¹		125-150- 175-200	100 max.	Syn.	No
			4201B ²	250	50	Syn.	Yes
		VP-540		250	60	Syn.	Yes
			4204F ³	100-150- 250	35-40- 60	Syn.	Yes
	605			150-200- 250-275	35-40- 50-65	Syn.	No
	604 ⁴	VP-552 ⁵		225-250- 275-300	50-65- 80-100	Syn.	No
			4201 ⁶	150-200- 250-275- 300	35-40- 50-70- 100	Syn.	No
	251 ⁷			300	100	Tube	Yes
		VP-555		300	200	Tube	Yes
VPM-6 ⁸	311 ⁹			250-275- 300-325	50-75- 100-125	Tube	Yes
		VP-557		400	150	Tube	Input cond.
			4202D	300- 400	200- 150	Tube	Yes
	606 ¹⁰			325-350- 375-400 and 110 a.c. 60 cycle	125-150- 175-200 20 watts	Tube	Input condenser

All inputs 6.3 volts d.c. unless otherwise noted.

¹ VP-553 same with tube rectifier.² In weatherproof case, 4201B2 same with tube rectifier.³ 180-cycle vibrator, lightweight, 4204 same without filter.⁴ 601 same with tube rectifier; 602 same except 12 v. d.c. input and tube rectifier; 603 same except 32 v. d.c. input and tube rectifier.⁵ VP-554 same with tube rectifier; VP-G556 same except 12 v. d.c. input; VP-F558 same except 32 v. d.c. input.⁶ 4200D same with tube rectifier; 4200DF same with tube rectifier and output filter.⁷ 551 same with 12 v. d.c. input.⁸ Also available without filter.⁹ 511 same except 12 v. d.c. input.¹⁰ Input 6 v. d.c. or 110 v. a.c., 607 same except 12 v. d.c. or 110 v. a.c. input; 608 same except 32 v. d.c. or 110 v. a.c. input; 609 same except 110 v. d.c. or 110 v. a.c. input.

TABLE IV—DYNAMOTORS

Manufacturer's Type No.			Input		Output		Weight
Carter	Eicor	Pioneer	Volts	Amps.	Volts	Ma.	Lbs.
135A			6	1.8	135	30	6½
180A			6	2.2	180	30	6½
240A			6	3.3	200	40	6½
210A			6	6.3	200	100	6½
220A			6	13	200	200	6½
250A	102 ¹	E1W272 ²	6	5	250	50	6½
251A		E1W339 ³	6	9	250	100	6½
277A			6	6	275	75	6½
301A	106 ⁴	E2W351 ⁵	6	9.7	300	100	6½
315A	158 ⁶	E2W243 ⁶	6	15	300	150	7½
320A		RAOW158 ⁷	6	19	300	200	9½
351A			6	10	350	100	6½
355A	108	E2W256 ⁸	6	15	350	150	7½
352A			6	22	350	200	9½
401A			6	13	400	100	7½
		E2W438	6	14.2	400	125	9¼
415A	109 ⁹		6	20	400	150	7½
420A			6	25	400	200	9½
425A		RA1W201 ⁹	6	30	400	225	9½
450A	110 ¹⁰		6	33	400	250	9½
		E3W413	6	15	500	100	11
515A	111 ¹¹		6	24	500	150	9½
520AR		RA1W189 ¹²	6	33	500	200	—

¹ Input current 4.6 amp.; wt. 4½ lbs.² Wt. 7½ lbs.³ Input current 7.5 amp.; wt. 7½ lbs.⁴ Wt. 5 lbs.⁵ Wt. 9¼ lbs.⁶ Input current 14 amp.; wt. 5¾ lbs.⁷ Wt. 16 lbs.; input current 18 amp.⁸ Input current 17 amp.⁹ Wt. 17½ lbs.; input current 25 amp.¹⁰ Input current 27.5 amp.; wt. 7½ lbs.¹¹ Input current 21.5 amp.; wt. 7½ lbs.¹² Input current 27 amp.; wt. 17½ lbs.

Construction of Power Supplies

With the possible exception of control stations, which in many instances will be installed at locations where emergency power already is provided for, WERS stations will have to be furnished with a type of power supply independent of the a.c. mains. The 6-volt automobile-type storage battery is by far the best choice for primary power, and while dynamos, genemotors, converters, and complete vibrator-type "B" supplies cannot now be purchased new, it is not difficult to remodel an old receiver-type power transformer for use in a vibrator supply. Furthermore, the power supply in a car radio receiver can be pressed into service if necessary. Aside from the vibrator and transformer (and rectifier tube, if one is used), most of the components can be found in old b.c. receivers or existing amateur equipment.

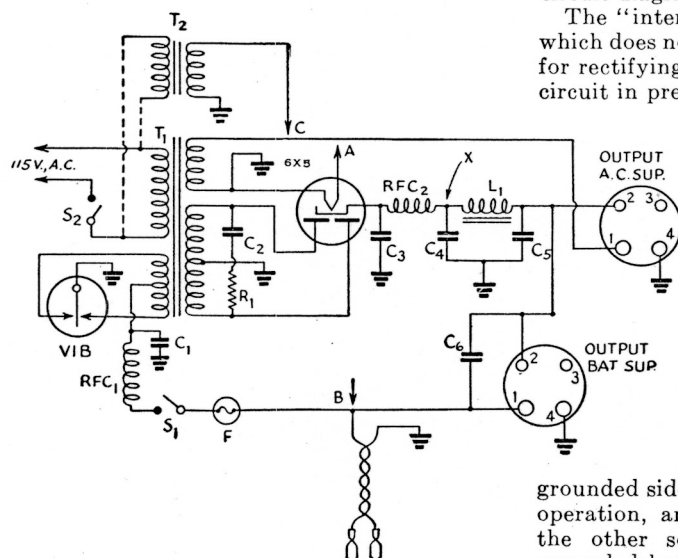


Fig. 1640 — Combination 115-volt and battery supply.

- C₁ — 0.5- μ fd. paper, 50-volt rating or higher.
 - C₂ — 0.005 to 0.01 μ fd., 1600 volts (see text).
 - C₃ — 0.01- μ fd. 600-volt paper.
 - C₄ — 8- μ fd. 450-volt electrolytic.
 - C₅ — 32- μ fd. 450-volt electrolytic.
 - C₆ — 100- μ fd. mica.
 - L₁ — 10-12 henry 100 ma. filter choke, not over 100 ohms (Stancor C-2303 or equivalent).
 - R₁ — 5000 ohms, $\frac{1}{2}$ - or 1-watt.
 - RFC₁ — 55 turns No. 12 on 1-inch form, close-wound.
 - RFC₂ — 2.5-mh. r.f. choke.
 - S₁ — S.p.s.t. toggle switch, heavy duty (10-12 amp.).
 - S₂ — S.p.s.t. toggle switch.
 - F — 15-ampere fuse.
 - VIB — Mallory 500P, 294, etc.
 - T₁ — Special vibrator transformer with 115-volt and 6-volt primaries, to give approximately 300 volts at 100 ma. d.c. (Stancor P-6166 or equivalent).
 - T₂ — 6.3-volt filament transformer, to be used when 6.3-volt filament winding on T₁ will not supply all heaters in both transmitter and receiver.
 - X — Insert a series resistor of suitable value to drop the output voltage to 300 at 100-ma. load, if necessary. If transformer gives over 300 volts d.c., a second filter choke may be used to give additional voltage drop as well as more smoothing.
- NOTE — All ground connections should be made to a single point on the chassis.

It must be emphasized again that no dependence should be placed on the continuance of power from the ordinary 115-volt lines during an emergency. An a.c. supply can be used for routine testing, of course, and also during an actual emergency so long as the line power lasts, but some independent source of power must be available.

Combination supplies — In a vibrator supply built from individual components it is necessary to filter out hash and to adjust the wave-form to minimize sparking at the vibrator contacts. When such a supply is built around a manufactured transformer it is advisable to use the type which has both 115-volt and 6-volt primaries, thereby making an a.c.-d.c. supply which uses the minimum of parts for both purposes. Such transformers have been made in various ratings. A suitable circuit diagram is given in Fig. 1640.

The "interrupter" type of vibrator, or one which does not also have synchronous contacts for rectifying the high voltage, is used in this circuit in preference to the synchronous type,

since the rectifier tube is needed for straight a.c. operation. The change between a.c. and battery supply is made by providing duplicate rectifier and output sockets, the heater voltage being supplied by the transformer in the one case and by the storage battery in the other. Switches could be used for the same purpose. "A" in the diagram indicates that the ungrounded heater lead on one 6X5 rectifier socket is connected to the ungrounded side of the filament winding for a.c. operation, and "B" that the same lead on the other socket is connected to the ungrounded battery lead. All other connections on the two sockets are paralleled. If the 6.3-volt filament winding is not rated for the total heater load, another 6.3-volt transformer may be used as shown.

Getting the right capacity for the buffer condenser, C₂, is of first importance. Under no circumstances can this condenser be omitted, since without it there will be excessive sparking at the vibrator contacts and the vibrator life will be short. Proper values usually are between 0.005 and 0.01 μ fd., the condenser being rated to withstand at least 1600 volts. The optimum value of capacity can be determined by trial, observing the vibrator sparking as the capacity is changed. For this purpose it is advantageous to use the type of vibrator which is mounted in a large tin can since this type is easily taken apart, the top and base being held together by a few spots of solder which can be easily softened. The more compact type having a narrow metal can crimped around a bakelite base can be pried apart, but this type is difficult to reassemble.

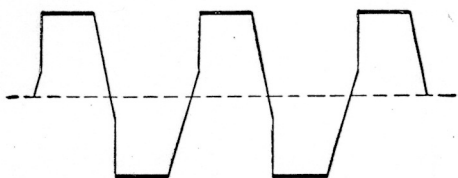


Fig. 1641 — Proper operation of the vibrator supply is indicated when an oscillogram such as is shown above is obtained with the vertical plates of the oscilloscope connected across the total primary winding. The dashed reference line in the center will not appear on the screen.

When the system is operating properly there should be practically no sparking at the vibrator contacts. There may be an intermittent spark of small amplitude, barely visible in daylight, but nothing resembling a continuous arc. A further check on the operation can be secured with an oscilloscope having a linear sweep circuit that can be synchronized with the vibrator. The vertical plates should be connected across the outside ends of the transformer primary winding to show the input voltage waveshape. Fig. 1641 shows an idealized trace of the optimum waveform when the buffer capacity is adjusted to give proper operation throughout the life of the vibrator. The horizontal lines in the trace represent the voltage during the time the vibrator contacts are closed, which should be approximately 90 per cent of the total time. When the contacts are open the trace should be partly tilted and partly vertical, the tilted part being 60 per cent of the total connecting trace. The oscilloscope will show readily the effect of the buffer capacity on the percentage of tilt. In actual patterns the horizontal sections are likely to droop somewhat because of the characteristics of the vertical amplifier in the 'scope and also because of the resistance drop in the battery leads as the current builds up through the primary inductance.

The 5000-ohm resistor in series with the buffer condenser in the diagram limits the secondary current in case the condenser fails.

R.f. filters for reducing hash are incorporated in both primary and secondary circuits. The secondary filter consists of a 0.01- μ fd. paper condenser directly across the rectifier output, with a 2.5-mh. r.f. choke in series ahead of the smoothing filter. In the primary circuit a low-inductance choke and high-capacity condenser are needed because of the low impedance of the circuit. A choke of the specifications given should be adequate, but if there is trouble with hash it may be beneficial to experiment with other sizes. The wire should be large — No. 12, preferably, and No. 14 as a minimum. Manufactured chokes such as the Mallory RF583 are more compact and give higher inductance for a given resistance because they are bank-wound, and may be substituted if obtainable. C_1 should be at least 0.5 μ fd.; even more capacity may help in bad cases of hash.

The power supply should be built on a metal chassis, with all unshielded parts underneath. A bottom plate to complete the shielding is advisable. The transformer case, vibrator case and metal shell of the tube all should be grounded to the chassis. If a glass tube is used it should be enclosed in a tube shield. The battery leads should be evenly twisted, since these leads are more likely to radiate hash than any other part of a reasonably well-shielded supply. A little care in this respect usually is more productive than experimenting with different values in the hash filters. Such experimenting should come *after* it has been found that radiation from the leads has been reduced to an absolute minimum. Shielding the leads is not particularly helpful.

The 100- μ fd. mica condenser, C_6 , connected from the positive output lead to the "hot" side of the "A" battery, may be helpful in reducing hash in certain power supplies. A trial is necessary to see whether or not it is required. It should be mounted right on the output socket.

Testing for methods of eliminating hash should be carried out with the supply operating a receiver. Since the interference usually is picked up on the receiver antenna leads by radiation from the supply itself and the battery leads, it is advisable to keep the supply and battery as far from the receiver as the connecting cables will permit. Three or four feet should be ample. The microphone cord likewise should be kept away from the supply and leads.

The smoothing filter for battery operation can be a single-section affair, but there will be some hum (readily distinguishable from hash because of its deeper pitch) unless the filter output capacity is fairly large — 16 to 32 μ fd.

Rewinding transformers — Those who cannot get either complete vibrator assemblies or special transformers, or who want to assemble a vibrator supply at the least possible expense, can find many of the necessary parts in old broadcast receivers. A power transformer

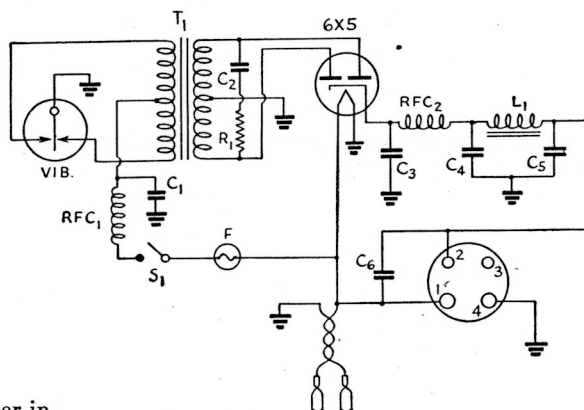


Fig. 1642 — Vibrator power-supply circuit diagram. Except for T_1 and T_2 , all components are identical with those of Fig. 1640. T_1 may be either a regular 6-volt input vibrator-type power transformer or a home-altered 115-volt receiver transformer as described in the text.

with a 100-milliamperere secondary is needed; the voltage rating should be 350 or so with any transformer of this type, but the exact value does not matter too much. The high-voltage secondary must be in good shape. Pick out a transformer with a case — one of the “fully shielded” type — but not one immersed in pitch. The receiver usually will have a filter choke or two as well as filter condensers which may be usable.

Before dismantling the transformer, measure the output voltages of the windings if these are not already known. This will require a multi-range a.c. voltmeter. If the builder does not have such an instrument, the measurements can be made by a radio repairman or at the local parts store.

Next take the transformer apart, being careful to avoid damaging the windings or bending the core pieces. The filament secondaries are nearly always on the outside of the coil assembly, so remove the outer layers of paper to expose the uppermost filament winding. Count the number of turns and divide this figure by the output voltage of the winding to find the number of turns per volt. Most small transformers have about three turns per volt. Make a note of the exact figure and then remove the remaining filament secondaries, leaving only the primary and high-voltage secondary.

When this has been done, slide one of the core pieces inside the coil and see how much space has been made available by removing the low-voltage secondaries. The battery primary to be put on will not have many turns, but the wire should be large to keep the losses low, so generally two layers will be required.

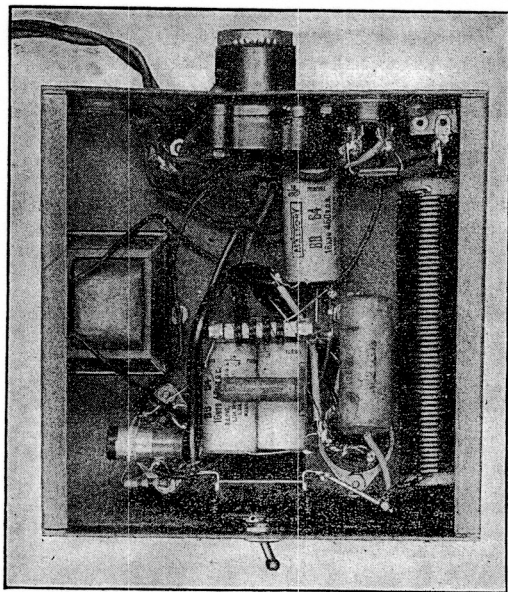


Fig. 1643 — Below-chassis view of a storage-battery power supply using a rewound transformer. The circuit is given in Fig. 1642. The various components can be easily recognized in this view. The transformer, vibrator and rectifier tube are mounted on top of the chassis.

The current to be carried will be in the vicinity of 8 amperes at full load, but since the primary is to be center-tapped each half of the winding carries current only half the time. Thus the heating effect is equivalent to 4 amperes. No. 12 wire is suitable, but is probably more conservative than is necessary; No. 14 will not get too warm and the losses should not be appreciably greater. It would not be advisable, however, to use smaller wire than No. 16, and that size only when a larger size will not fit the space. If the space still is too small, remove the 115-volt primary.

If the normal transformer output was about 300 volts at 100 milliamperes through an ordinary filter (this should be ascertained before taking the transformer apart, by hooking up a power supply and making a d.c. measurement) it is useful to save the old primary if possible, since such a transformer can be used for a combination a.c.-battery supply. However, it does not pay to save the old 115-volt primary at the expense of using too-small wire on the 6-volt primary; the efficiency and regulation will be better with larger wire sizes.

Whether the old primary is inside or outside the high-voltage secondary is a matter of chance. If the old primary is on the inside and it is necessary to remove it, the job can be done by pulling the outermost layer through the side of the assembly, after which the rest can easily be unwound. One half of the new primary should be wound directly on the insulating sleeve into which the core fits, then the high-voltage secondary slipped over it, and finally the second half of the new primary wound on top. Both halves should be wound in the same direction so that the end of the first half can be connected to the beginning of the second to give a center tap with the proper polarities. If separate leads are brought out from each half (this is usually the most convenient method) it is easy to check the polarities after the transformer is reassembled. Connect two leads together for trial, then apply 115 volts across the high-voltage winding. If the voltage across the outer ends of the new winding is twice the voltage across each half, the polarity is correct. A filament voltmeter should be used for this check, since the voltage is low.

To obtain 300 volts at the rated current of 100 ma. from the supply, using a 6X5 rectifier and a filter having a choke with a resistance of about 100 ohms, the secondary/primary turns ratio should be 70:1, assuming an even 6 volts from the storage battery. Multiply the original a.c. output voltage of the high-voltage secondary by the number of turns per volt to find the total number of turns, then divide the product by 70 to find the proper number of turns for the primary. For example, if the output voltage was known or measured to be 750 volts a.c. (375 each side of center-tap) and the transformer had three turns per volt, the total number of secondary turns is 750×3 ,

or 2250. Dividing 2250 by 70 gives 32 (dropping the fraction) as the total primary turns, or 16 each side of the center-tap.

The new windings should be sufficiently well insulated so that there is no possibility of a short-circuit to the core or secondary, but otherwise no special precautions are necessary since the voltage is low. Reassemble the transformer, interleaving the laminations. It is advisable to use no more than two laminations on a side before interleaving from the other side, but it

is not necessary to interleave them singly. With careful packing it should be possible to get back all of the core pieces.

Once the transformer is rebuilt, the remainder of the supply is constructed and adjusted as previously described. If the job has been done properly the efficiency should be about normal for vibrator supplies. Individual transformers have been found to vary somewhat, in that for an output of 100 ma. at 300 volts the battery current ranges from 7.5 to 9 amperes with the different units. This does not include the current taken by the rectifier heater. Because of this current and the power loss in the plate-cathode circuit of the rectifier tube, the over-all efficiency of the tube rectifier type of supply is not quite as high as with the synchronous vibrator. With no load on the supply the battery current should be about 1.5 amperes.

Low-voltage supply—A vibrator supply for operation at lower voltage (in the vicinity of 200 volts d.c.) is shown in Figs. 1644 to 1646.

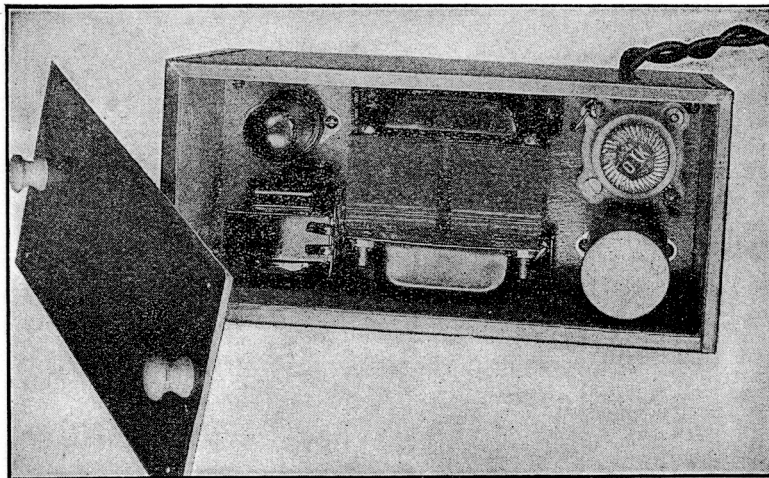


Fig. 1644 — A view inside the vibrator-type power-supply unit shown assembled in Fig. 1632. The rectifier tube is at the upper left with the filter choke just below. The primary fuse socket and vibrator are at the right. A synchronous-type vibrator may be substituted for the interrupter-type if it is desired to eliminate the rectifier tube.

This is especially suitable for use with the transceiver previously described when a 6J5 oscillator tube is used, or for commercial dry-battery transceivers modified to permit connecting an external power supply.

The transformer is a universal replacement-type unit having a d.c. output, when operated from 115 volts a.c., of about 70 ma. at 250 to 300 volts, and provided with 6.3-, 5- and 2.5-volt filament windings. The circuit is much the same as in the case of the homemade units just described. As shown in the circuit diagram, Fig. 1645, the filament windings on the transformer are used in the battery circuit; the 6.3-volt winding provides one side of the battery primary, and the other side consists of the 5-volt winding in series with half the 2.5-volt winding. This method gives lower output voltage than can be obtained with a properly proportioned primary, but avoids the inconvenience of rewinding the transformer. The output voltage is about 200 with a load of 60 ma.

Before the battery primary is permanently connected, the proper polarities of the filament windings must be determined. Apply line

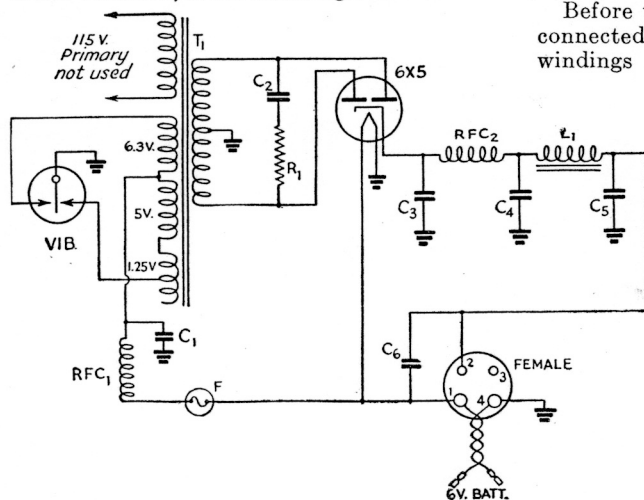


Fig. 1645 — Circuit diagram of the low-voltage vibrator-type power-supply unit.

- C₁ — 0.5- μ fd. paper, 200 volts.
C₂ — 0.008- μ fd. paper, 1600 volts.
C₃ — 0.01- μ fd. paper, 600 volts.
C₄ — 8- μ fd. electrolytic, 300 volts.
C₅ — 16- to 32- μ fd. electrolytic, 300 volts.
C₆ — 100- μ fd. mica.
R₁ — 5000 ohms, 1 watt.
L₁ — 10-henry 60-ma filter choke.
RFC₁ — 52 turns of No. 12, close-wound
on 1-inch diameter form.
RFC₂ — 2.5-mh. r.f. choke.
T₁ — Power transformer, 300 volts each
side of e.t., 60 to 70 ma.; with
6.3-, 5- and 2.5-volt windings.
115-volt primary is unused.
F — 10-ampere fuse.
VIB — Vibrator (Mallory 294, etc.).

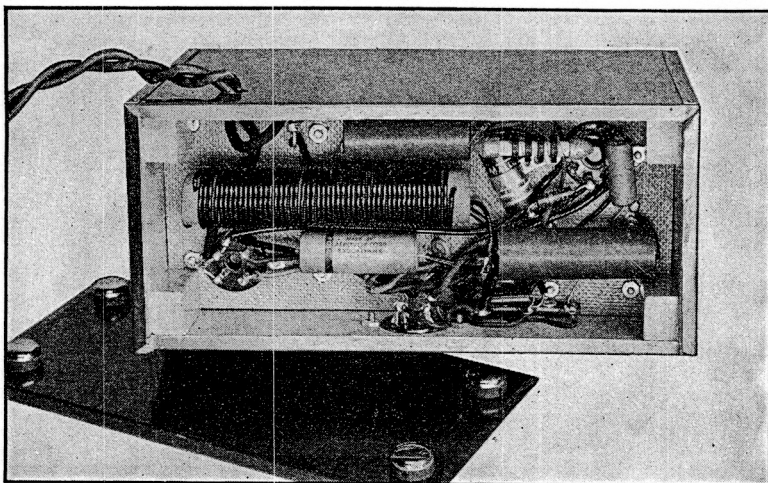


Fig. 1646 — Hash and smoothing filter components are mounted in the bottom of the low-voltage vibrator power supply. The 4-prong outlet socket is mounted on the side.

voltage to the regular 115-volt primary and connect the 6.3- and 5-volt windings in series. Measure the total voltage across the two. If it is something over 11 volts the polarity is correct, but if the voltage is very low the connections to one of the windings should be reversed. Then add half the 2.5-volt winding to the 5-volt winding and measure the voltage across these two in series. It will be between 6 and 7 volts when the polarities are correct. The connection between the 6.3- and 5-volt windings becomes the center-tap of the battery primary, as shown in the diagram.

All the components in the supply with the exception of the 4-prong outlet socket are mounted on a piece of quarter-inch tempered Masonite measuring $3\frac{3}{4} \times 9$ inches. This fits into a plywood box having inside dimensions ($3\frac{3}{4} \times 9 \times 5\frac{1}{2}$ inches) just large enough to contain the equipment. The Masonite shelf rests on $\frac{3}{4}$ -inch square blocks, $1\frac{1}{4}$ inches long, glued to the corners of the box at the bottom. The top and bottom of the box are removable. To provide shielding and thus reduce hash troubles, the box is covered with thin iron salvaged from 5-quart oil cans. Where the edges bend around the box to make a joint, the lacquer is rubbed off with steel wool so the pieces make electrical contact, and the metal is tacked to the plywood with escutcheon pins.

To make sure that the shielding will be complete, the top and bottom of the box slide into place from the side, with the metal covering extending out so that it fits tightly under a lip bent over from the metal on the sides. These lips also are cleaned of lacquer to permit good electrical contact. The general construction should be quite apparent from the photographs. The bottom is provided with rubber feet, and the top has a small knob at each end so that it can be pushed out. This is essential, since the fit is good and there is no way to get either the top or bottom off, once on, without having some sort of handle to grip.

Antenna Systems

In many cases, particularly at control stations, it will be necessary to use non-directive antennas because of the necessity for working field stations at random points of the compass. At field stations which normally work with only a single control station, however, it may be advantageous to use a simple form of directive array. The power gain will be worth while in bettering the signals in both directions, and in addition will minimize

interference to and from other networks. The simpler forms of antennas described in Chapters Ten and Seventeen are quite suitable for WERS work.

More important, perhaps, than the antenna itself is its location. Every effort should be made to get the antenna well above its surroundings and to provide, whenever possible, a clear path between the control station and the network stations with which it must communicate. Having a line of sight between antennas will ensure successful communication even though the power is very low and the antenna itself is nothing more than a simple half-wave wire. Where there are intervening obstructions, it will be helpful to use as much height as possible.

Vertical polarization is to be preferred to horizontal, since vertical polarization is better suited to mobile operation. A simple vertical antenna has practically no horizontal directivity, therefore it will work equally well in all directions except for effects attributable to its surroundings and to the terrain over which the signal must travel. The signal strength will be poor if a horizontally polarized antenna is used to receive a vertically polarized signal.

A half-wave antenna, two half waves fed in phase stacked vertically, or an extended double Zepp, all will be satisfactory in WERS, and are very simple types to construct. Design details will be found in Chapter Ten. If the station is to be operated on a fixed frequency, the antenna length should be adjusted for that frequency. If the same antenna is to work on several frequencies, the length had best be chosen midway between the two extremes.

Transmission Lines — At nearly all fixed locations it will be necessary to use a transmission line between the antenna and the radio equipment, since the latter will be indoors where it is easily accessible while the former will be placed on the roof of the building to secure adequate height. Low-loss concentric

line is ideal for working into the center of a half-wave antenna, but there is little likelihood it can be obtained except in isolated instances. The alternative is an open-wire line having an impedance of 500 to 600 ohms. It is advisable to keep the spacing between wires small, to prevent radiation loss; 2-inch spacing is about right, provided the line can be installed fairly rigidly so that it will not swing in a breeze and cause the transmitter frequency to change. This close separation also requires a fairly large number of spacers — at intervals of perhaps three to four feet. Lacking more suitable materials, the spacers may be made of two-inch lengths of quarter- or half-inch wooden dowel or cut pieces of square section (preferably of maple), boiled in paraffin to make them waterproof. In paraffining the wood, take care that the temperature does not get high enough to scorch it. Such spacers will provide adequate insulation at the power levels permitted for WERS transmitters. Spacers may also be cut from scrap bakelite panels.

To make such a line non-resonant it will be necessary to install a matching stub at the antenna. The design and adjustment of such stubs also is covered in Chapter Ten. As an alternative, a multi-wire doublet antenna may be used to couple directly to a line having an impedance of the order of 500 to 600 ohms without special matching provisions. Such an antenna is shown schematically in Fig. 1647. It gives a 9-to-1 impedance step up at the line terminals, hence practically automatic matching to a 600-ohm line, assuming the normal doublet impedance of 70 ohms. In addition, it has a broad resonance characteristic and thus is well suited to working anywhere in the band.

To avoid the necessity for impedance matching, two-wire lines may be operated as tuned lines if desired. Such operation has been successful with lines up to at least 100 feet long. Since in most cases the coupling device at the transmitter or receiver is a single-turn coil, the simplest method of tuning the line is to adjust the feeder length until the current in the line is maximum when the transmitter is operating on the chosen frequency. A small dial light or flashlight bulb, con-

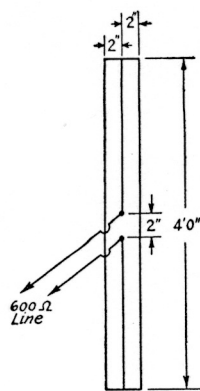


Fig. 1647 — Three-wire folded-doublet antenna for matching a 600-ohm line. The three conductors are connected together at the ends, as indicated. They may be made of wire, rod or tubing, and can be mounted on stand-off insulators on a wooden support.

nected in series with one side of the line right at the transmitter terminals, may be used as a current indicator. The transmission line should be made about four feet longer than necessary, its length being adjusted by cutting off an inch or two at a time until maximum bulb brilliancy is obtained.

From a constructional standpoint it is desirable to use the same antenna for both transmitting and receiving. The change-over switch for this purpose should have low capacity, and preferably should have low-loss insulation. The ordinary type of wafer switch is satisfactory, particularly if it is ceramic insulated. A small porcelain-base d.p.d.t. knife switch also may be used for this purpose. If possible, the antenna switch should be combined mechanically with the power-supply change-over switches for the transmitter and receiver so that all the necessary switching from transmission to reception can be done in one simple operation.

Mobile antennas — It is probable that most WERS networks will have one or more stations installed in cars, for dispatching to points which may be in urgent need of communication. The equipment previously described is readily adaptable to car installations; the transceiver, in particular, can be set up with little difficulty, and can get its power from the car broadcast receiver, if there is one. This would require only the installation of a suitable power socket in the car receiver, together with a switch to cut the power from the receiver when the transceiver is in use.

As in the case of antennas for the fixed stations, it is important that the car antenna be mounted as high as possible, to avoid screening effects of the car and to give maximum range. If the antenna cannot be mounted so that it is entirely above the top of the car, it can still be made to have a major portion of its length above the roof. Roadsters and coupés have a convenient spot for mounting the antenna on the deck in back of the rear window. The lead-in can be brought into either the luggage compartment or the driver's seat, depending upon the location of the radio gear. Sedans lend themselves more readily to mounting the antenna alongside the hood, or on the roof.

Either a quarter- or half-wave antenna may be used, depending upon conditions. The greater length of the latter will lead to better results, if the installation can be made conveniently. Flexible metal rod is generally used, so that the antenna will be self-supporting.

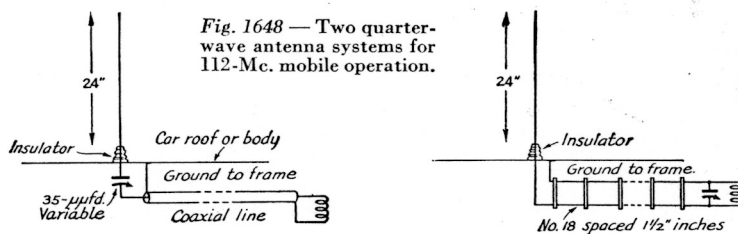


Fig. 1648 — Two quarter-wave antenna systems for 112-Mc. mobile operation.

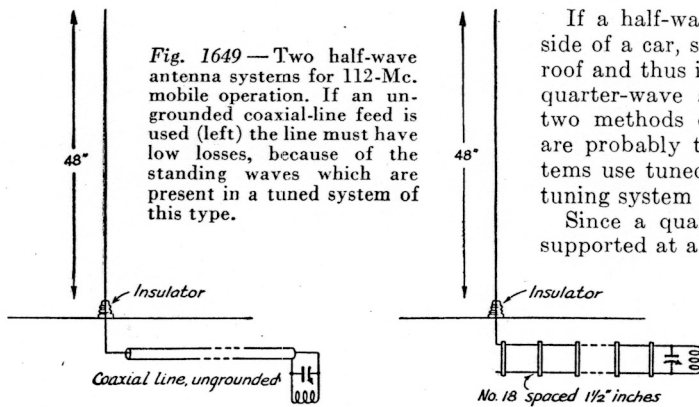


Fig. 1649 — Two half-wave antenna systems for 112-Mc. mobile operation. If an ungrounded coaxial-line feed is used (left) the line must have low losses, because of the standing waves which are present in a tuned system of this type.

If a quarter-wave antenna is to be mounted permanently on the car it should be located on the roof, otherwise it is likely that the radiation pattern will be quite irregular. The resulting directional effects will be a help on some occasions but a definite hindrance on others. The antenna can be fed by a tuned line or by a coaxial line, as shown in Fig. 1648. The coaxial line feed can be checked by observing its detuning effect on the transmitter — a good match will have been obtained when the detuning is a minimum. The antenna length should be about 22 to 24 inches, and this length and the capacity of the condenser should be varied until connecting the other end of the line to the transmitter causes a minimum of frequency change. Loading is controlled at the transmitter by adjusting the coupling coil, *not* by varying the condenser at the antenna. The coaxial line can be of the 70- or 100-ohm type.

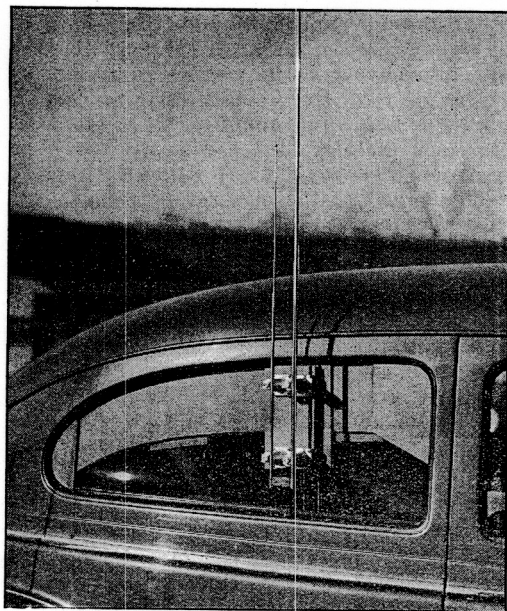


Fig. 1650 — A J-type antenna for 112-Mc. mobile operation can be mounted easily in the window of a car, allowing the radiator proper to be placed above the roof of the vehicle. The dimensions are given in Fig. 1651.

If a half-wave antenna is mounted on the side of a car, some of it will extend above the roof and thus it will give better results than a quarter-wave antenna similarly placed. The two methods of feeding shown in Fig. 1649 are probably the most convenient. Both systems use tuned feed lines, and thus require a tuning system at the transmitter end.

Since a quarter-wave antenna normally is supported at a low-voltage point, hard rubber insulators are satisfactory. However, a half-wave antenna will usually be supported at a high-voltage point and thus requires good insulation for best efficiency. Ceramic insulators usually can be obtained to fit any case. It is wise not to skimp on size because of the greater chance of breakage with the smaller units. The feed-through types and the stand-off types with metal base rings are least likely to break.

For a solid but easily detachable mounting, the arrangement shown in Fig. 1650 is suggested. It is held in place by a panel of wood, cut to the shape of the window, on which the antenna is mounted. By running up the window the panel is held firmly in place. The antenna is of the "J" type, shown in Fig. 1651. This type of installation places the radiator proper above the roof of the car, and has the advantage that it can be readily removed from the car when not in use or when needed elsewhere.

The unit shown is built of $\frac{1}{4}$ -inch plywood, since the usual thickness of the window glass in cars is $\frac{1}{4}$ inch. Run down the window of the car about half way, or enough to leave at least a 6-inch opening, and make a pattern of cardboard using the top edge of the window glass for the guide. Trim the cardboard to this shape, and then push it up in the window and use the edge of the glass to mark the bottom edge of the pattern. From the pattern, mark the piece of plywood and cut it out with a saw. Additional small pieces to form stops in the corners are fastened to the main piece with glue and brads. A piece of plywood about $6 \times 8\frac{1}{2}$ inches should be fastened to the large piece at the point where the antenna is to be supported, using glue and brads, and the four stand-off insulators which support the antenna bolted to this piece. If the insulators are not long enough for the antenna to clear the side of the car, they can be raised by wood strips.

Two small strips should be nailed along the inside of the main piece so that they extend down below the edge a few inches and form, with the outside pieces, a yoke to keep the assembly in the proper position on the window.

The feeder can be made of flexible rubber-covered wire (obtained by splitting a length of parallel lamp cord) separated by small plastic or dry wood spacers. The antenna ends of the wires are soldered to the heads of the large bolts in the upper stand-off insulators, and the wire is run out through holes in the wood.

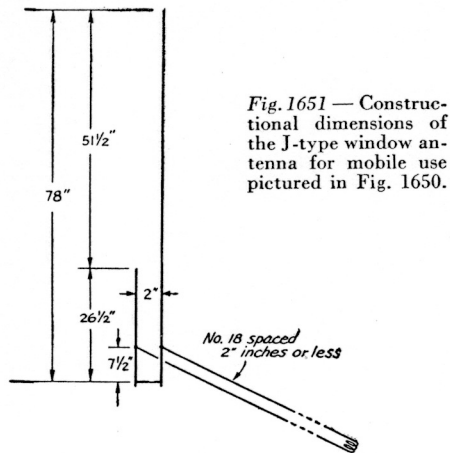


Fig. 1651 — Constructional dimensions of the J-type window antenna for mobile use pictured in Fig. 1650.

The antenna and matching-section rods are regular automobile whip antennas and are supported on the stand-off insulators by small loop-shaped metal clamps. The shorting bar is made along the same lines, with bars of heavy metal on both sides of the clamp loops.

Frequency Measurement

Under the WERS regulations provision must be made for measurement of frequency of the transmitters in the network, and for checking the carrier stability to make sure that the frequency deviation does not exceed that permitted in the section of the band in which the transmitter operates.

Probably the simplest means of measuring frequency is the Lecher wire system, which is a pair of parallel bare wires to which the transmitter or receiver can be coupled. The parallel wires form a transmission line along which standing waves appear, and the distance between consecutive current loops along the line gives the wavelength directly.

The Lecher wire line should be at least a wavelength long — that is, 9 feet or more — and should be entirely air-insulated except where it is supported at the ends. The wires can be stretched tightly between any two con-

venient supports. The spacing between wires should be about an inch to an inch and one-half. The positions of the current loops are found by means of a "shorting bar," which is simply a metal strip or knife edge which can be slid along the line to vary its effective length.

Building a Lecher-wire system — The wires can be used more conveniently and with greater accuracy if they are mounted up in fairly permanent fashion and provided with a shorting bar maintained at right angles to them. The construction shown in Figs. 1652 and 1653 requires a little time but the cost is negligible, and both are well repaid in operating ease. The support consists of two 12-foot pieces of "1 by 2" (actually about $\frac{3}{4} \times 1\frac{5}{8}$ inch) pine fastened together with wood screws to form a T girder, this arrangement being used to minimize bending of the wood when the wires are tightened. The anchors at the ends are also "1 by 2", cut and screwed together to make a block. The feet at each end keep the assembly from tipping over when in use. The wires terminate in airplane-type strain insulators at one end, and at the other in small turnbuckles for taking up the slack. The wire is bare solid copper antenna wire (hard-drawn) of about No. 16 gauge. The turnbuckles are held in place by a $\frac{3}{16} \times 2$ -inch bolt through the anchor block. This end of the line is thus short-circuited; it does not matter whether it is open or shorted, since the other end is the one connected to the pick-up loop.

The slider, also made from pieces of "1 by 2", serves the double purpose of holding the shorting bar and acting as a guide to keep the wire spacing constant. Sheet metal pieces screwed to the sides of the sliding block are bent under the horizontal member of the T to keep the block in place. At the back is a horizontal strip of bakelite to keep the wires pressed close to but not actually touching the shorting bar. This allows the block to slide freely, the wires being pressed down on the bar only when an actual reading is to be taken. A small piece of wood held in the hand can be used; it is an easy

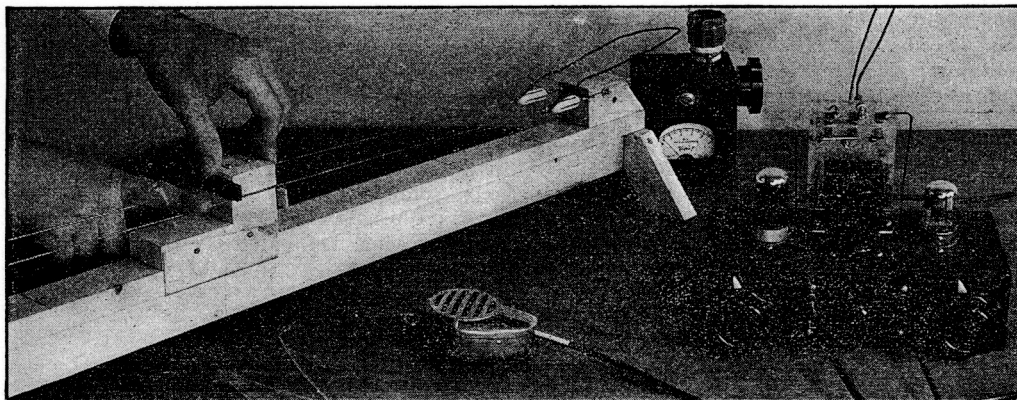


Fig. 1652 — A Lecher-wire system set up for frequency measurement, using a crystal-detector absorption frequency meter, loosely coupled to the oscillator tank, as a resonance indicator. Because only very loose coupling to the oscillator is required, this system will give more accurate results than coupling the wires directly to the transmitter tank.

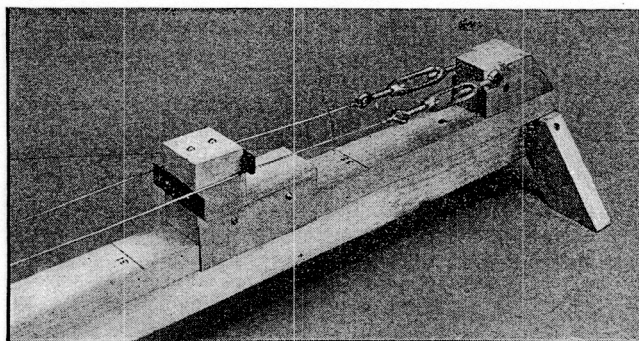


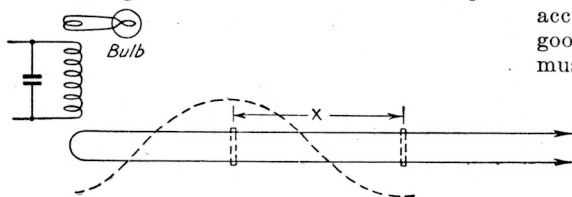
Fig. 1653 — One end of a typical Lecher-wire system. Turnbuckles are used for maintaining tension. The shorting bar is of brass with a sharp edge for better contact and more precise indication; the wooden slider keeps it at right angles to the wires. A horizontal strip of bakelite at the back of the slider keeps the wires tight against the shorting bar.

matter to regulate the pressure so that free movement is secured. A spring device could be arranged for the same purpose.

As it is convenient to measure lengths directly in the metric system used for wavelength rather than in inches, the top of the T beam is marked off in decimeter (10-centimeter) units. A 10-centimeter transparent scale (obtainable at 5 & 10 cent stores) can be cemented to the slider, extending out from the front, so that readings can be taken to the nearest millimeter. The difference between any two readings gives the half wavelength directly.

The T beam will tend to bow outward if the turnbuckles are tightened too much, which will bend the scale slightly out of parallel with the wires. It is best to use just enough tension to keep the wires fairly taut, but not enough to put an appreciable bend in the wooden member. This makes the slide move more freely and also helps avoid small errors in measuring.

Making measurements — Resonance indications can be obtained in several different ways. Let us suppose the frequency of a transmitter is to be measured. A convenient and fairly sensitive indicator can be made by soldering the ends of a one-turn loop of wire, of about the same diameter as the transmitter tank coil, to a low-current flashlight bulb, then coupling the loop to the tank coil to give a moderately-bright glow. A similar coupling loop should be connected to the ends of the Lecher wires and brought near the tank coil, as shown in Fig. 1654. Then the shorting bar should be slid along the wires outward from the transmitter until the lamp gives a sharp dip in brightness. This point should be marked (a piece of string can be tied on one of the wires) and the shorting bar moved out until a second dip is



obtained. Marking the second spot, the distance between the two points can be measured and will be equal to half the wavelength. If the measurement is made in inches, the frequency will be

$$F_{Mc.} = \frac{5906}{\text{length (inches)}}$$

If the length is measured in meters,

$$F_{Mc.} = \frac{150}{\text{length (meters)}}$$

A frequency of 112 Mc. corresponds to a length of slightly less than $52\frac{3}{4}$ inches (1.34 meters) and a frequency of 116 Mc. to $50\frac{2}{3}$ inches (1.29 meters).

In checking a superregenerative receiver, the Lecher wires may be similarly coupled to the receiver coil. In this case the resonance indication may be obtained by setting the receiver just to the point where the hiss is obtained, then as the bar is slid along the wires a spot will be found where the receiver goes out of oscillation. The distance between two such spots is equal to a half wavelength.

In either case, the most accurate readings result only when the loosest possible coupling is used between the line and the tank coil. After taking a preliminary reading to find the regions along the line in which resonance occurs, loosen the coupling until the indications are just discernible and repeat the measurement. Unless this is done the tuning of the line will affect the frequency of the oscillator and inaccurate indications will be obtained. As the coupling is loosened the resonance points will become sharper, which is a further aid to accurate determination of the wavelength.

In using the shorting bar, make sure that it is always at right angles to the two wires. A sharp edge on the bar is desirable, since it not only helps make good contact but also definitely locates the *point* of contact.

The accuracy with which frequency can be measured by such a system depends principally upon the technique of measurement. The necessity for using very loose coupling to the transmitter or receiver has already been mentioned. In addition, careful measurement of the exact distance between two current loops also is essential. Even if all other sources of error are eliminated, measurements within 0.1 per cent require an accuracy within 1 part in 1000, or 1 millimeter in one meter, in measuring the distance along the wires. This means that an accurate standard of length is necessary — a good steel tape, for instance — and that care must be used in determining the length exactly.

Fig. 1654 — Coupling the Lecher-wire system to a transmitter tank coil. Typical standing-wave distribution is shown by the dashed line. The position of the shorting bar at the current loops is indicated. X is equal to one-half wavelength.

When the frequency of an oscillator-type transmitter is given a final check, the antenna should be connected and the antenna coupling adjusted for normal operation. This is necessary because the frequency will be affected by the antenna coupling, so that a measurement made without an antenna (or with a dummy antenna) will not necessarily hold when the actual antenna and transmission line are coupled to the transmitter. The resonance indicator should be connected in series with the transmission line. If a flashlight bulb will not light under these conditions, a sensitive resonance indicator consisting of a 112-Mc. tuned circuit connected to a crystal detector and low-range milliammeter will give excellent results. Such a device is described in Chapter Nineteen. Its use is illustrated in Fig. 1652.

The measurement procedure involves very few additional operations. Tune the meter to resonance as indicated by maximum milliammeter reading, then move it as far as possible from the transmitter while still getting a reading of the order of 25 per cent of maximum. Couple the loop at the end of the Lecher wires to the coil and take a trial setting of the shorting bar. The resonance point will be given by a sharp dip in the meter reading. Slow variations as the bar is slid along simply mean that some detuning of the circuit is taking place. The resonance dip will be quite pronounced and the bar should not have to be moved more than a half inch or so to go completely through it. Once the resonance point is identified, loosen the coupling until the dip is just a small downward kick in the reading. From this point on, the measurement procedure is the same as before. By this method it is possible to avoid detuning of the oscillator by the Lecher wires, some amount of which usually takes place even with loose coupling when the line is coupled to the oscillator itself. This occurs because of the necessity for abstracting an appreciable amount of energy from the circuit to get a good resonance indication from a flashlight lamp or similar device. With the crystal detector, it is possible to work at least a foot or two from even a low-power oscillator.

Other methods — Even under good conditions, frequency determination by the Lecher wire method is subject to inaccuracy of the order of 0.1 per cent by the limitations of the means available for measuring length, as well as other small but avoidable errors. More accurate measurements require more elaborate equipment, although not necessarily equipment which is not already available or which cannot be constructed readily.

At lower frequencies it is customary to employ an oscillator whose fundamental frequency is such that harmonics appear at intervals of some multiple of 100 kc., the harmonics being used to provide calibration points for a receiver or heterodyne frequency meter. Methods of construction and calibration are fully described in Chapter Nineteen. If a regular

communications receiver is so calibrated it can readily be used for checking the frequency of 112-Mc. transmitters. A simple method, suggested by W1EAO, is shown in block-diagram form in Fig. 1655. An auxiliary oscillator capable of tuning over the range 14–14.5 Mc. (not necessarily band spread tuning) is required. Any simple oscillator circuit may be used, and it may be operated at any convenient plate voltage from 100 volts upward.

The method of measurement is as follows: Tune in, on the regular 112-Mc. receiver, the signal to be measured. Set the auxiliary oscillator frequency so that its 8th harmonic is heard beating with the 112 Mc. signal. Adjust to zero beat. Then tune the communications receiver to the fundamental frequency of the auxiliary oscillator. Adjust the receiver to zero beat and read the frequency as accurately as possible from the calibration curve. Multiplying this figure by 8 will give the 112-Mc. transmitter frequency.

Two initial precautions must be observed in using this method. First, it must be determined that the auxiliary oscillator is tuning over the 14–14.5 Mc. range. The chief cause of error here is the possibility of a spurious response (such as an image) in the communications receiver, which would result in a misleading frequency indication. For this reason the signal in the communications receiver must not be too strong. Only enough antenna should be used on the receiver to obtain a signal of moderate strength; in many cases no antenna will be necessary. Second, ascertain that the 8th harmonic is the one actually being used by giving the 112-Mc. receiver or transmitter an initial check with Lecher wires. The 14-Mc. frequency is used so that there will be no possibility of getting the wrong harmonic after the 112-Mc. band is known even roughly. The auxiliary oscillator dial should be marked with the 14- and 14.5-Mc. limits, so there will be no chance of tuning far off frequency and getting incorrect readings.

With this method, the accuracy of measurement depends upon the accuracy with which the auxiliary oscillator and communications receiver are set to zero beat, and on the accuracy of the receiver calibration. There should be no particular difficulty in securing an accuracy within 0.01 per cent with reasonable care. In zero-beating the oscillator harmonic to a

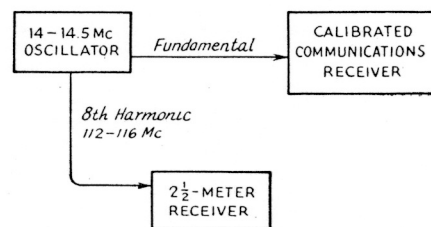


Fig. 1655 — Block diagram showing use of a calibrated communications receiver and auxiliary 14-Mc. oscillator for checking frequency of 1.12-Mc. WERS stations.

112-Mc. signal when a superregenerative receiver is used on the latter frequency, a whole series of beat notes will be heard as the auxiliary oscillator frequency is varied. However, one of these will be much stronger than the others and represents the true beat; it will not be difficult to identify the proper one.

Frequency-checking procedure — For the regular frequency-checking procedure, the best plan would seem to be to calibrate a bandspread receiver at the control station, using whatever frequency-measurement means is available, and then by means of the receiver to measure the frequency of each transmitter on the air as it checks into the network in test periods. With relatively little initial cut-and-try each station can be set on its proper frequency, after which only minor adjustments should be necessary even over quite long periods of time. Under this plan the frequency checking actually is continuous, since a frequency deviation in any of the transmitters reporting to the control station will instantly be observed because the transmitter will appear at a different setting of the receiver dial.

The receiver calibration should be checked at regular intervals — once a month, or oftener if convenient. This check should be made with the antenna connected to the receiver.

In general, it will not be possible to check the control station frequency by means of a calibrated receiver in the same station — at least not with the simple receivers likely to be used. However, in this case it is not inconvenient to measure the frequency of the transmitter directly, using the primary means of frequency determination provided for the system. This check can be made before the transmitter goes on the air at each regular test period.

References

The *QST* articles listed below deal with both the technical and operating aspects of WERS, and provide information supplementary to that contained in this chapter. Those marked with an asterisk (*) describe in somewhat more detail apparatus treated in this chapter.

Technical and Constructional

- *"A 112-Mc. Emergency Transmitter," Grammer, Dec., 1941.
- "A Compact Receiver for 112 Mc.," Chambers, Dec., 1941.
- "An Experimental 112-Mc. Receiver," Brannin, Dec., 1941.
- *"Power Supply for Emergency Equipment," Grammer, Jan., 1942.
- *"Receivers for 112-Mc. Emergency Work," Goodman, Jan., 1942.
- *"Antennas for 112-Mc. Mobile Work," Goodman, Feb., 1942.
- *"More Gear for Civilian Defense," Grammer, Feb., 1942.
- "Defense Network Control Station," Stiles, Feb., 1942.
- "Kinks for the DK-3 Transceiver," Hints & Kinks, Feb., 1942.
- "A Pack Set for 112-Mc. Defense Work," Chambers, April, 1942.
- "A Simple Transceiver for 2½," Hints & Kinks, April, 1942.
- "A 112-Mc. Transmitter-Receiver Combination," Brannin, May, 1942.
- "A Talkie-Walkie for Civilian Defense," Kopetzky, June, 1942.
- "Reducing Radiation from the MRT-3 Transceiver," Hints & Kinks, August, 1942.
- "Building WERS Gear from Salvaged B.C. Sets," Mix, Sept., 1942.
- "A Simple Method of Frequency Measurement for WERS," Woodward, Sept., 1942.
- *"A Transceiver for WERS," Grammer, Oct., 1942.
- *"A Simple Transmitter-Receiver for War Emergency Work," Rand, Nov., 1942.
- "WERS Gear, 1942 Style," Hieronymus, Nov., 1942.
- "A 25-Watt 2½-Meter M.O.P.A.," Bailey, Dec., 1942.
- "A 112-Mc. Transmitter-Receiver," Lynch, Jan., 1943.
- "Substitute for Transceiver Transformer," Hints & Kinks, March, 1943.
- "A Crystal Controlled Transmitter for WERS," Brooks, April, 1943.
- "Mica Trimmer Condensers in WERS Gear," Hints & Kinks, June, 1943.
- "An Economical Transmitter-Receiver for WERS," Magee, June, 1943.
- "Rebuilding TR4s for Non-Priority Tubes," Mix, July, 1943.
- *"Constructional Aspects of WERS Mobile Installations," Forster, August, 1943.
- "Notes on Commercial Gear for WERS," Hints & Kinks, August, 1943.
- "Notes Covering the WERS Transmitter-Receivers for Allegany County," Hints & Kinks, August, 1943.
- "Three-Element Directive Antenna for Portable 112-Mc. Work," Hints & Kinks, August, 1943.
- "Folding Car-Roof V.H.F. Antenna," Hints & Kinks, August, 1943.
- *"More Selectivity in WERS Reception," Grammer, Sept., 1943.
- "Handy Andy," Palmer, Sept., 1943.

Organization and Regulations

- "Civilian Defense" (editorial), Feb., 1942.
- "Westchester County Hams Are Prepared," Taylor, Feb., 1942.
- "The Green Light" (editorial), July, 1942.
- "The War Emergency Radio Service," July, 1942.
- "Planning WERS For Your Community," Huntoon, August, 1942.
- "Technical Aspects of the WERS Regulations," Grammer, August, 1942.
- "Operating Procedure in WERS" (Operating News), August, 1942.
- "We Must Not Fail" (editorial), Sept., 1942.
- "Massachusetts Civilian Defense Radio," Doremus, Sept., 1942.
- "Training Civilians for Wartime Operating," Huntoon, Sept., 1942.
- "Frequency Allocations in the WERS," Ling, Oct., 1942.
- "Training Auxiliary Operators for WERS," Huntoon, Oct., 1942.
- "WERS Licensing"; "WERS Agreements" (Operating News), Oct., 1942.
- "WERS License Applications" (Operating News), Nov., 1942.
- "WERS Needs You Too" (editorial), Dec., 1942.
- "Akron and the WERS," Brown and Moody, Dec., 1942.
- "OCD Announcement" (Operating News), Dec., 1942.
- "Amateur Radio and the Civil Air Patrol," Fraim, Jan., 1943.
- "WERS Application Discrepancies" (Operating News), Jan., 1943.
- "The Tri-Part Plan," Hart, Feb., 1943.
- "The Fifth Regional WERS," Gibbs, Feb., 1943.
- "When Disaster Strikes" (editorial), April, 1943.
- "Some New Thoughts on WERS," Hart, April, 1943.
- "WERS in the New Haven Warning District," Fraser and Keating, May, 1943.
- "CD-WERS in the State of Maryland," McNulty, June, 1943.
- "Operating Procedure" (Operating News), July, 1943.
- "WERS Is Making Progress" (editorial), August, 1943.
- "Message Handling in WERS," Russell and King, August, 1943.
- "More Rule Changes" (Operating News), August, 1943.
- "More on the New Rules"; "Transfer of Equipment"; "Operator Permits"; "Experimental Data"; "Identification"; "Operating Discrepancies" (Operating News), Sept., 1943.
- "WERS for Seven Million People," Long and Kenney, Oct., 1943.
- "Visiting Mobiles"; "Keeping Up Interest"; "What Constitutes Rag-Chewing?" (Operating News), Oct., 1943.

General Rules and Regulations Governing All Radio Stations in the War Emergency Radio Service

(FEDERAL COMMUNICATIONS COMMISSION, WASHINGTON)

Part 15.—Rules Governing War Emergency Radio Service

DEFINITIONS

15.1. *War Emergency Radio Service.* The term "War Emergency Radio Service" means a temporary radio communication service intended solely for emergency communication in connection with the national defense and security.

15.2. *Civilian Defense Stations.* The term "Civilian Defense Station" means a station operated by a municipal government for emergency communication relating directly to the activities of the United States Citizens' Defense Corps¹ or other equivalent officially recognized organization.

15.3. *State Guard Stations.* The term "State Guard Station" means a station operated by a State for communication in connection with the activities of the State Guard or equivalent officially recognized organization.

15.4. *Civil Air Patrol Stations.* The term "Civil Air Patrol Station" means a station used exclusively for essential communications relating directly to the activities of the Civil Air Patrol.⁷ A civil air patrol station used on a mission for and under the direction and control of the military shall not be deemed subject to these rules.

15.5. *Control Unit.* The term "control unit" means any station unit licensed in the War Emergency Radio Service and designated by the licensee, with the approval of the radio aide or communications officer, to direct the use and operation of other station units of the same licensee which, together with the control unit so designated, constitute a coordinated communication system.

APPLICATIONS

15.11 *Applications for Station License.* Applications for authorizations in the war emergency radio service shall be submitted on the prescribed form.² A blanket application may be submitted for an authorization to cover the operation of all fixed, portable, mobile, and portable-mobile transmitters proposed to be used in a single coordinated communication system.

OPERATING SPECIFICATIONS

15.21. *Frequencies.* The following frequency bands are available for assignments to stations operating in the war emergency radio services:

112,000–116,000 kc.
224,000–230,000 kc.
400,000–401,000 kc.

15.22. *Types of Emission.* All stations in the war emergency radio service are authorized to use the following types of emissions: A-0, A-1, A-2, A-3, or special for frequency modulation.

15.23. *Selection of Frequency.* Licensees may select operating frequencies within the available bands provided the equipment is capable of meeting the frequency stability requirements specified in Section 15.25.

15.24. *Non-exclusive Use of Frequencies.* No licensee of any station in the war emergency radio service shall have the exclusive use of any frequency. In the event mutual interference occurs between stations operating simultaneously, the licensee shall coordinate the operation of

the stations so as to minimize interference, and make the most effective use of the frequencies available.

15.25. *Frequency Stability.* (a) Transmitting equipment used in the war emergency radio service must be capable of maintaining the operating carrier frequency (without readjustments during operation) within the limits set forth in the table:

<i>Operating frequencies within the bands (Kilocycles)</i>	<i>Maximum deviation</i>
112,000–114,000	0.1 of one per cent
114,000–116,000	0.3 of one per cent
224,000–227,000	0.1 of one per cent
227,000–230,000	0.3 of one per cent
400,000–401,000	0.2 of one per cent

(b) Notwithstanding the maximum frequency deviation permitted, all emissions, including those resulting from keying or modulating a transmitter, shall be confined within the frequency band in which the transmitter is authorized to be operated in accordance with the provisions of Sec. 15.25 (a).

(c) Spurious radiations shall be reduced or eliminated in accordance with good engineering practice.

15.26. *Frequency Measurement Procedure.* The licensees of stations in the war emergency radio service shall provide for measurement of the transmitter frequencies, shall establish a procedure for checking them regularly and shall maintain adequate records of such measurements. The measurement of the transmitter frequencies shall be made by means independent of the frequency control of the transmitter, and shall be of sufficient accuracy to assure operation within the maximum deviation permitted under Sec. 15.25.

15.27. *Changes in Equipment.* The licensee of a station in the war emergency radio service may make any alterations in components of the licensed equipment that are deemed necessary or desirable unless specifically prohibited from doing so by the terms of the license, provided that:

(a) All changes be made with the full knowledge and consent of the radio aide or the communications officer.

(b) Emissions are not radiated outside the authorized frequency band.

(c) The operating frequency does not deviate more than that specified in Sec. 15.25.

(d) Plate power input does not exceed that authorized in Sec. 15.28.

15.28. *Power.* (a) All stations in the war emergency radio service are authorized to use a maximum unmodulated power input of 25 watts to the plate circuit of the final amplifier stage of an oscillator-amplifier transmitter or to the plate circuit of an oscillator transmitter.

(b) No station shall be operated at any time with a power in excess of that necessary to render satisfactory communication service. In no event shall operations be conducted with power in excess of the authorized power or in excess of the maximum obtainable carrier power output of the transmitter consistent with satisfactory technical operation.

15.29. *Modulation Limits.* (a) The transmitted carrier of stations in the war emergency radio service using amplitude modulation shall be modulated not more than 100%.

(b) The transmitted carrier of stations in the war emergency radio service using frequency modulation shall be modulated so that the total frequency swing arising from modulation shall not exceed 100 kilocycles.

15.30. *Who May Operate Stations.* All stations in the war emergency radio service shall be operated only by a radio operator holding a valid war emergency radio service operator permit, provided, however, that when such stations use radiotelephony, the licensee may permit such persons as the radio operator deems essential to the emergency, to transmit by voice, on condition that the duly licensed operator maintains control over the transmission by listening and turning the carrier on and off when required, and signs the station off after the transmission has been completed.

¹ The United States Citizens' Defense Corps is an organization of enrolled civilian volunteers established within the Office of Civilian Defense to implement the passive defense.

² FCC Form No. 455.

⁷ The Civil Air Patrol is an organization established by the Director of the U. S. Office of Civilian Defense pursuant to Executive Order No. 8757, as amended. Further information pertaining to the organization of the Civil Air Patrol can be obtained from the National Commander, Civil Air Patrol, Washington, D. C. To facilitate consideration of applications for such authorizations, they should be forwarded first to the National Commander who in turn will submit them to the Commission.

15.31. *Logs.* The station licensee shall maintain written records concurrently with the operation of each station with respect to the following:

- (a) Location of station during operation.
- (b) Date and time of operation in local standard (war) time.
- (c) Identity of station worked and type of communications handled.
- (d) Operating frequencies employed.
- (e) Names and official titles of persons transmitting by voice over the station whenever such voice transmission is actually carried on by other than a duly licensed operator.³
- (f) Name of operator on duty.
- (g) Signature and title of person maintaining log record.

Provided, however, that operation in a blackout or during an emergency endangering safety of life or important property, such record of operation shall be reduced to writing at the earliest opportunity and in such detail as may be practicable.

IDENTIFICATION OF STATIONS

15.41. *Identification of Transmitters.* The call letters and unit number assigned in the license shall be permanently affixed to the transmitter by the licensee.

15.42. *Transmission of Call Letters.* Stations in the war emergency radio service shall identify themselves by the call letters and unit number assigned to the transmitter at the beginning and end of each complete exchange of communications. When communications are carried on with any other station licensee, stations in the war emergency radio service shall identify themselves as herein required, and in addition, shall announce the call letters, unit numbers, and the class of the station with which they are communicating.

LICENSES

15.51. *Control of Equipment.* All equipment for which a license is granted must be owned by or in the possession of the station licensee at all times. No license will be granted permitting the operation of a specific transmitter by more than one station licensee in the war emergency radio service.

15.52. *Cancellation Without Notice or Hearing.* A license authorizing the operation of a station in the war emergency radio service is granted upon the express condition that said grant is subject to change or cancellation by the Commission at any time without advance notice or hearing, if in its discretion such action is deemed necessary for the national security and defense and successful conduct of the war.

15.53. *License Period.* (a) Station licenses normally will be issued for a period of one year unless otherwise stated therein.

(b) Dates of expiration of licenses shall be in accordance with the following:

(1) For stations in the states of Alabama, Arizona, Arkansas, California, Colorado, Connecticut, District of Columbia, Delaware and Florida the first day of February of each year.

(2) For stations in the states of Georgia, Idaho, Illinois, Indiana, Iowa, Kansas and Kentucky the first day of March.

(3) For stations in the states of Louisiana, Maine, Maryland, Massachusetts, Michigan, Minnesota, Mississippi, Missouri and Montana the first day of April.

(4) For stations in the states of Nebraska, Nevada, New Hampshire, New Jersey, New Mexico, New York, North Carolina and North Dakota the first day of May.

(5) For stations in the states of Ohio, Oklahoma, Oregon, Pennsylvania, Rhode Island, South Carolina and South Dakota the first day of June.

(6) For stations in the states of Tennessee, Texas, Utah, Vermont, Virginia, Washington, West Virginia, Wisconsin and Wyoming, and for stations in the territories and possessions, the first day of July.

(c) Unless otherwise directed by the Commission, each application for renewal of station license shall be filed on the proper form⁴ at least sixty (60) days prior to the expiration date of the license sought to be renewed.

15.54. *Availability of Station License.* The original license shall be associated with the station unit normally in control of all station units covered by the license, and photo-

copies of the original license provided by the licensee shall be associated with each of the other station units covered by the license. The original and all photocopies shall be readily available for inspection at any time by an authorized government representative.

15.55. *General Limitations.* Stations in the war emergency radio service shall not be operated on board any vessel unless such operation has been approved by appropriate naval authority.

15.56. *Service for U. S. Government.* During emergencies endangering the safety of life or property, the licensee of any station in the War Emergency Radio Service may use any licensed unit of such station to provide essential communication for the United States Government, when requested to do so by the government department or agency concerned, *Provided,* That a written notice of such operation, including designation of the source of the request, is sent within twenty-four hours after the commencement of such operation to the inspector in charge of the radio district in which the station is located, and a copy of such notice is sent to the Federal Communications Commission in Washington, D. C.

CIVILIAN DEFENSE STATIONS

STATION LICENSEES

15.61. *Eligibility for Station License.* Authorizations for civilian defense stations will be issued only to municipal governments, such as cities, towns, counties, etc.

15.62. *Supplementary Statements.* The applicant shall submit with the application complete and detailed information on the following:

- (a) The proposed plan of operation including:
 - 1. General operating procedure.
 - 2. The scope of service to be rendered.
 - 3. Type of messages to be transmitted.
 - 4. Methods to be used in monitoring, supervising, and controlling the operation of all stations for which license is requested, including method of compliance with Restricted Order No. 2.
 - 5. Methods used to measure the operating frequencies of the transmitters.
 - 6. Provisions for frequent inspection of the equipment.
 - 7. Source and distribution of the equipment.
- (b) The area in which the stations are to be operated:
 - 1. If service is to be rendered to adjacent municipalities, the applicant must submit sworn copies of agreements made between the applicant and the adjacent municipalities. Such agreements shall show that the applicant is required to furnish service and the adjacent municipalities agree to accept such service and not to request individual authority, and that such agreements shall provide notification to the Commission sixty (60) days prior to termination thereof.
- (c) Methods used to ascertain the loyalty and integrity of radio station operating personnel.
- (d) Plans for enlisting radio operating personnel, and whether they will serve on a paid or voluntary basis.

SCOPE OF SERVICE

15.63. *Service Which May Be Rendered.* (a) Civilian defense stations may be used during emergencies endangering life, public safety, or important property, for essential communication relating to civilian defense or national security. Civilian defense station licensees, when requested in specific instances by the licensee of any State Guard station or the licensee of any Civil Air Patrol station, may use their licensed civilian defense stations for essential communication with such State Guard or Civil Air Patrol station(s), during emergencies endangering life, public safety, or important property. Civilian defense stations shall not be operated on board any aircraft unless specific authority for such operation has been granted by the Commission upon showing of need therefor.

(b) Upon application and showing of need therefor, individual control units may be authorized to communicate during the first 15 minutes of each hour with control units of the same licensee or other licensees, and with other units of the same licensee, for the exclusive purpose of handling essential communications preparatory to any anticipated emergency involving the safety of life or important property in connection with civilian defense or national security. Units other than control units may transmit, for this purpose, only when directed to do so by an authorized control unit of the same licensee. When operating under this pro-

³ This provision does not eliminate the requirement of a licensed operator on duty at the transmitter location who is responsible for the operation thereof.

⁴ FCC Form No. 405.

vision, each unit shall comply with operating instructions given by the authorized control unit. The use and operation of control units as provided in this subsection shall be discontinued during such periods as may be deemed necessary by the licensee in order to avoid interference to any tests or drills being conducted in accordance with Sections 15.75 and 15.76 of these rules.

15.64. *Communication with Other Stations.* Within the scope of service permitted under Sec. 15.63 and during tests and drills, civilian defense stations may be used to communicate with stations in the war emergency radio service, with stations in the emergency radio service (police, forestry, special emergency, and marine fire stations), and with United States Government stations, in those cases which require cooperation or coordination of activities. Transmissions not directed to authorized stations are prohibited.

SUPERVISION AND CONTROL

15.66. *Operational Supervision.* The operation of civilian defense stations shall be directed at all times by a duly qualified "radio aide," provided, however, that the delegation of such supervision shall in no way relieve the licensee of the ultimate responsibility for the proper operation of the stations in accordance with the terms of the station license.

RADIO AIDE

15.71. *Definition.* The term "radio aide" means the official designated by the station licensee to direct and supervise the operation of all of the radio stations to be covered in the license for which application is made.

15.72. *Qualifications.* The radio aide shall

(a) Hold a valid operator's license of any class granted by the Commission except a restricted radiotelephone operator's permit; and shall

(b) Have been investigated and certified by the station licensee as to his loyalty to the United States and recognized integrity.

15.73. *Certification.* The station licensee shall submit to the Commission, on a prescribed form,⁵ the name and address of the initial radio aide and his successor(s), together with a statement from the radio aide that he has accepted such appointment, and the station licensee shall certify:

(a) That the radio aide has been duly investigated by the licensee and is believed to be loyal to the United States and is of recognized integrity; and

(b) That his technical and administrative qualifications are adequate for the proper performance of his duties.

15.74. *Duties.* The duties of the radio aide shall include among others:

(a) The direction and supervision of all radio stations to be covered in the license to assure strict compliance with the terms of the station license.

(b) The provision for the adequate monitoring of all transmissions of the stations under his supervision to assure compliance with the rules and regulations of the Commission, and to guard against the improper use of the radio stations and intentional or inadvertent transmission which might be of value to the enemy.

(c) Inspection of the equipment periodically to insure satisfactory technical operation.

(d) Certification of the names of proposed radio operators after a thorough investigation has been made relative to their loyalty to the United States and their known integrity.

TESTS AND DRILLS

15.75. *Tests.* The licensees of civilian defense stations are permitted to make such tests as are necessary for the purpose of maintaining equipment, making adjustments to insure that the apparatus is in operating condition, training personnel, and perfecting methods of operating procedure, *Provided*, That such tests shall be conducted only during the following periods:

Time Zone	Eastern	Central	Mountain	Pacific
Mondays...	9 PM-11 PM	8 PM-10 PM	8 PM-10 PM	7 PM-9 PM
Wednesdays...	9 PM-11 PM	8 PM-10 PM	8 PM-10 PM	7 PM-9 PM
Sundays...	5 PM-7 PM	4 PM-6 PM	3 PM-5 PM	2 PM-4 PM

All times given are local standard (war) time.

15.76. *Drills.* Licensees of civilian defense stations may conduct drills during practice alerts, practice blackouts,

⁵ FCC Form No. 455 (a).

practice mobilizations or other comparable situations as may be initiated and ordered by the proper military authority or local civil defense authority, provided that a notice, by mail, of such operations is sent within twenty-four hours after the drill to the Inspector in Charge of the radio district in which the stations are located, and a copy to the Federal Communications Commission in Washington, D. C.

STATE GUARD STATIONS

LICENSEES

15.81. *Eligibility for License.* Authorizations for state guard stations will be issued only to the official state guard or comparable organizations of a state, territory, possession, or the District of Columbia.

15.82. *Supplementary Statements.* The applicant shall submit with the application complete and detailed information on the proposed plan of operation including:

(a) General operating procedure.

(b) Scope of service to be rendered.

(c) Type of messages to be transmitted.

(d) Methods to be used in monitoring, supervising, and controlling the operation of all stations for which the license is requested.

(e) Method used to measure the operating frequencies of the transmitters.

(f) Provisions for frequent inspection of the equipment.

(g) Source and distribution of the equipment.

SERVICE

15.83. *Scope of Service.* (a) State guard stations may be used only (1) during emergencies endangering life, public safety, or important property, or (2) for essential communications directly relating to state guard activities in instances in which other communication facilities do not exist or are inadequate.

(b) State guard stations may be used to communicate with stations in the war emergency radio service or in the emergency radio services (police, forestry, special emergency, and marine fire stations) in those cases which require cooperation or coordination of activities. Transmissions not directed to a specific authorized station are prohibited.

SUPERVISION AND CONTROL

15.84. *Operational Supervision.* The operation of state guard stations shall be directed at all times by an officer in charge of communications or communications officer provided, however, that the delegation of such supervision shall in no way relieve the licensee of the ultimate responsibility for the proper operation of the stations in accordance with the terms of the station license.

COMMUNICATIONS OFFICER

15.85. *Definition.* The term "communications officer" means the official designated by the station licensee to direct and supervise the operation of all radio stations to be covered in the license for which application is made.

15.86. *Duties.* The duties of the communications officer shall include, among others:

(a) The direction and supervision of all radio stations to be covered in the license to assure strict compliance with the terms of the station license.

(b) The provision of the adequate monitoring of all transmissions of the stations under his supervision to assure compliance with the rules and regulations of the Commission, and to guard against the improper use of the radio stations and intentional or inadvertent transmissions which might be of value to the enemy.

(c) Inspection of the equipment periodically to insure satisfactory technical operation.

(d) Certification of the names of proposed radio operators after a thorough investigation has been made relative to their competence.

TESTS

15.87. *Tests.* The licensees of state guard stations are permitted to make such routine tests as are required for the proper maintenance of the stations and the communication system, provided that steps are taken to avoid interference with other stations, and provided further that such testing shall not exceed a total of four (4) hours per week.

CIVIL AIR PATROL STATIONS

LICENSEES

15.91. *Eligibility for Station License.* Authorizations for

civil air patrol stations will be issued only to the duly appointed Wing Commanders of the Civil Air Patrol.⁷

15.92. *Supplementary Statements.* The applicant shall submit with the application for station license complete and detailed information on the proposed plan of operation, including:

- (a) General operating procedure.
- (b) Scope of service to be rendered.
- (c) Type of messages to be transmitted.
- (d) Methods to be used in monitoring, supervising and controlling the operation of all stations for which the license is requested, including method of compliance with Restricted Order No. 2.
- (e) Method used to measure the operating frequencies of the transmitters.
- (f) Provisions for frequent inspection of the equipment.
- (g) Source and distribution of the equipment.

SERVICE

15.93. *Scope of Service.* (a) Civil air patrol stations may be used only during emergencies endangering life, public safety, or important property, or for essential communication directly relating to civil air patrol activities, when other communication facilities do not exist or are inadequate.

(b) Civil air patrol stations may be used to communicate with stations in the war emergency radio service; and with stations in the emergency radio service (police, forestry, special emergency, and marine fire stations), or with United States Government stations, in those cases which require cooperation or coordination of activities. Transmissions not directed to authorized stations are prohibited.

SUPERVISION AND CONTROL

15.94. *Operational Supervision.* The operation of civil air patrol stations shall be directed at all times by an officer in charge of communications, formally designated as "Communications Officer," *Provided, however,* That the delegation of such supervision shall in no way relieve the station licensee of the responsibility for the proper operation of the stations in accordance with the terms of the station license, and all pertinent rules and regulations.

COMMUNICATIONS OFFICER

15.95. *Definition.* The term "Communications Officer" means the official formally designated by the station licensee to direct and supervise the operation of all radio stations authorized by the related station license.

15.96. *Duties.* The duties of the communications officer shall include, among others:

- (a) Direction and supervision of all radio stations authorized by the station license, to assure strict compliance with the terms of such license.
- (b) Provision for adequate monitoring of all transmissions of the stations under his supervision to assure compliance with the rules and regulations of the Commission, and to guard against the improper use of the radio stations and intentional or inadvertent transmissions which might be detrimental to the national defense and security.
- (c) Inspection of the equipment at frequent intervals to insure satisfactory technical operation.
- (d) Certification of the names of proposed radio operators after a thorough investigation has been made relative to their competence.
- (e) Whenever civilian defense stations are requested to communicate with civil air patrol stations in accordance with the provisions of Section 15.63, the communications officer, on behalf of the Wing Commander, shall promptly notify in writing the Commission in Washington, D. C., and the Inspector-in-Charge of the district in which the involved civilian defense stations are located. Such written notice shall include the following information:

- 1. Name of civilian defense station licensee(s).
- 2. Date(s) of such communication.
- 3. Location(s) of involved civilian defense and civil air patrol stations.
- 4. Brief description of the situation necessitating such intercommunication.

TESTS

15.97. *Tests.* The licensees of civil air patrol stations are permitted to make such routine tests as are required for proper maintenance of the stations and the communication system, *Provided,* That adequate precautions are taken to

avoid interference with other stations, *And provided further,* That such testing shall not exceed the minimum transmission necessary to insure the availability of reliable communication.

RULES AND REGULATIONS GOVERNING OPERATORS OF STATIONS IN WAR EMERGENCY RADIO SERVICE

15.101. *Licensed Operators Required.* The actual operation of any station in the War Emergency Radio Service shall be carried on only by a duly qualified radio operator holding a War Emergency Radio Service Operator Permit (See Sec. 15.30). The permit shall be in the possession of the operator at all times while on duty, and shall be produced for inspection when requested by an authorized representative of the government or the station licensee.

15.102. *Eligibility.* To be eligible for a war emergency radio service operator permit an applicant shall:

- (a) Hold a radio operator license or permit of any class issued by the Commission.
- (b) Have complied with the provisions of Commission Order 75 (fingerprints, proof of citizenship, etc.).
- (c) Be approved by the station licensee and be properly certified for participation in the activities of the organization.

15.103. *Application Requirements.* An application for each War Emergency Radio Service Operator permit shall be submitted on the prescribed form⁶ through the station licensee. This application shall include the name and address of the station licensee together with the name and address of the proposed radio operator, and the class of operator license held by the applicant, and shall be certified to by the radio aide or communications officer that:

- (a) The proposed operator has been duly investigated and is believed to be loyal to the United States, and is of recognized integrity.
- (b) His technical qualifications are adequate for the proper performance of his duties.

15.104. *Validity of Permit.* (a) The war emergency radio service operator permit authorizes only the operation of the stations licensed to a particular licensee, and is valid for the duration of the war and six months thereafter, but in no event to exceed a period of five years from date of issuance.

(b) The war emergency radio service operator permit is valid only when the photograph and signature of the holder have been affixed thereto.

(c) A photocopy of such permit will not be recognized for the operation of any station in the war emergency radio services.

15.105. *Cancellation of Permit.* (a) A war emergency radio service operator permit is granted upon the express condition that said permit is subject to change or cancellation by the Commission at any time without advanced notice or hearing, if in its discretion such action is deemed necessary for the national security and defense and the successful conduct of the war.

(b) The holder of a war emergency radio service operator permit shall surrender such permit to the Commission for cancellation at the request of a station licensee or upon termination of the operator's connection with the station licensee with whom he was previously affiliated.

15.106. *Duplicate Permit.* An operator whose permit has been lost, mutilated or destroyed shall immediately notify the Commission. Any operator permittee applying for a duplicate permit to replace an original which has been lost, mutilated or destroyed shall submit to the station licensee for transmittal to the Commission such mutilated license or affidavit attesting to the facts regarding the manner in which the original was lost or destroyed. If the original is later found, it or the duplicate permit shall be returned to the Commission for cancellation.

15.107. *Renewal of War Emergency Radio Service Operator Permit.* A war emergency radio service operator permit may be renewed upon proper application which should be submitted to the Commission through the station licensee as in the case for an original permit.

15.108. *Suspension of Operator License.* The war emergency radio operator permit may be cancelled and any other class of license held by the operator may be suspended for the violation by the operator of any provisions of law, treaty, rules or regulations of the Commission.

⁶ F.C.C. Form No. 457.