This issue describes the companion units for use with the Emergency-Portable Rig which may be found described in the March/April 1950 Ham News. The E-P rig required only an antenna and a power supply to be a complete C-W transmitter. The modulator and antenna coupler described herein complete the mobile station setup.

Fig. 1. Complete mobile and emergency outfit. The E-P Rig (see March/April 1950 Ham News) is on the left, the Mobile Modulator on the right, and the antenna coupler is in the center.

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GENERAL CONSIDERATIONS

Mention was made, in the B-Pig description, that both the r-f and audio systems would operate from a single 300-volt 110 ma power supply. Framework of the B-Pig design has remained, however, and is approximately 60 ma, the average current available for the modulator design is 60 ma.

In typical amateur practice, where push-pull class AB/AB11 tubes are used as modulators, this figure of 40 ma would barely provide static current for one of the modulator tubes. Also, considering normal output transformer efficiencies, this 65% type of setup would be hard pressed to provide 10 watts of audio output.

Other experiments, striving for a low-drain modulator design, have gone to Class B modulators, realizing that this type of operation gives the lowest static current possible. For a given peak audio power output the peak d-c plate current to the modulator stage is relatively fixed, regardless of the type of operation. However, when considering speech waveforms, this peak value of plate current is of secondary importance; the average value of d-c plate current is relatively low compared to the peak value.

For example, the 6N7 in class B service is rated at about ten watts output, and the average plate current required is in the order of 35 to 40 ma. The driver required for this 6N7 would usually consume another 10 or 15 ma. This arrangement is a considerable improvement over the class AB85 approach, but falls seriously short of our 40 ma average current objective.

The problem was, therefore, to achieve further economy in both the modulator stage and the driver. The ideal class B tube for this service was found where it was least likely to be suspected—in the miniature tube line.

Brangie as it seems, the 13AU7 will give a peak speech output of well over ten watts and, stranger still, at a distortion level well under that accomplished by a class B operated 6N7, despite the fact that the 6N7 was originally designed for zero-bias class-B operation.

This static (rectifying) current of the 12AU7 in class B with 300 volts on the plate is approximately 15 ma! Further economies in both current and weight can be realized in the driver stage by employing a device already well-known to readers of the Ham News. By using a cathode-coupled driver (see Ham News Vol. 4, No. 3) operated class B no driver transformer is required and the driver itself adds only another 5 ma drain to the power supply.

The net effect of this design is a high-quality modulator (including a voltage amplifier stage drawing less than a milliamp that has a static drain of approximately 20 ma.

ELECTRICAL DETAILS

With reference to the circuit diagram, Fig. 2, it will be noted that the entire modulator is push-pull throughout. As such as the class B stage and driver must be push-pull, it was deemed desirable to carry this through to the input circuit in the same fashion, to avoid a phase inverter and to simplify construction. Note that only three condensers and eight resistors are used in the entire unit.

A bias battery is specified in order to provide the proper grid bias voltage for the 13AU7 modulator and the 12AU7 driver. Under zero-signal condition the bias voltage from either pin 2 or 7 of the 12AU7 to ground will be 15 volts, and the voltage measured across either R1 or R2 (the bias for the 13AU7 driver) will be 7 to 8 volts, when a 22.5 volt bias battery is used.

![Circuit Diagram](image)

**CIRCUIT CONSTANTS**

(All resistors and capacitors \( \pm 5\% 

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>( R_1 )</td>
<td>1000 ohm 10 watt ceramic or mica</td>
</tr>
<tr>
<td>( R_2 )</td>
<td>250 ohm potentiometer</td>
</tr>
<tr>
<td>( R_3 )</td>
<td>0.1 mfd condensers, 15 watt</td>
</tr>
<tr>
<td>( C_2 )</td>
<td>0.0025 mfd condensers specified otherwise</td>
</tr>
<tr>
<td>( R_4 )</td>
<td>2200 ohm, 1/2 watt</td>
</tr>
</tbody>
</table>

**Transistors**

- \( R_{17} \): 0.47 megohm, 1/2 watt
- \( R_{29} \): 15,000 ohm, 1/2 watt
- \( R_{18}, R_{19} \): .1 megohm, 1/2 watt
- \( B \): S.B.B.S. mica to push-pull grids
- \( T \): Output transformer (see text)
Note that the cathode current for the 12AT7 driver tubes passes through the bias battery, and therefore this battery actually supplies current in the order of a few milliamperes. In other words, the current does not tend to charge the battery, as in the usual bias case, but instead, tends to discharge it. However, this current is so slight that normal shelf life may be expected from the battery. This battery has no drain on it during stand-by or complete off periods, as current is drawn from it only when high voltage is applied to the modulator.
The first 12AT7 tube acts as a push-pull voltage amplifier. Because carbon microphones have a wide variation in output voltage, this first stage was added so that adequate gain would be available regardless of the microphone used. Voltage for the microphone is obtained from the car battery, and a single shielded lead is used to provide filament voltage and microphone voltage. This lead should be made of heavy wire to avoid ohmic loss due to the filament current, and it should be shielded to prevent under-tube pickup.
Potentiometer R1 (Actually connected as a rheostat) serves as a gain control. Because it can only change the microphone voltage, it is utilized for obtaining a wide range of control, but it is useful for adjusting the level when different people use the microphone.
If the microphone has too much gain, it will be necessary to increase the value of R1, or add a fixed resistance in series.
A phone wire switch is provided which removes all high voltage from the modulator and shorts the secondary of the output transformer when the switch is in the c-w position.
An external switch must be provided to turn the filament circuit on and off. With the circuit shown this switch will also shut off the mic current. Some microphones incorporate switch contacts which may be used to control a relay for power switching. There are many possible control schemes and the refinements of the control system are left to the individual.
CONSTRUCTIONAL DETAILS
The general nature of the mechanical work is shown in Figs. 3, 4, and 5. All of the parts, with the exception of the switch, are mounted on a piece of flat metal measuring 4½ by 1¾ inches. The spaces which support this piece are 1½ inches long.

Fig. 3 indicates how the parts are mounted on the flat chassis and Fig. 3 shows the wiring on the under-side of the chassis.
The shaft on resistor R1 is left long enough so that it projects through the front panel. The input jack is mounted on the chassis and a large hole cut in the front panel so that a mike plug can pass through. The switch is mounted on the front panel and the leads going to it are left a little long, as shown in Fig. 3, so that the chassis can be removed easily from the front panel.
The front panel is one of the removable 5 by 6 inch sides of a standard 4 by 5 by 6 inch cabinet. This is the same size cabinet used with the E-90 Rig described in the March-April 1950 Ham News.
Referring to Fig. 3, the input 12AT7 is the bottom tube, the 1AY7 driver is the middle tube, and the top tube is the 1AU7 output tube. These same tubes can be seen in Fig. 4, and the order of the tubes is the same, looking from right to left. Note that the input 12AT7 uses a shield. Also in Fig. 3, transistors P1 is on the right and transformer T1 is on the left.

COMPONENTS PARTS
There are no critical components used in the mobile modulator and all parts may be plus or minus 20%, as indicated under circuit equations.
One part is worth discussing in more detail, however, and that is the output (modulator) transformer. Fundamentally, all that is required is a transformer with a primary pair to plate impedance of approximately 12,000 ohms and a secondary impedance of approximately 4000 ohms. The latter figure assumes that the modulator will be used with the E-90 Rig, where the plate voltage on the final is 300 volts and the plate current is about 50 ma.
The prime considerations in choosing a output transformer for the Mobile Modulator are size, weight, efficiency and cost. A designer's concern over size, weight and cost is obvious, although concern over efficiency might not be.

Fig. 3. Under-chassis view of the Mobile Modulator.
If a transformer has a loss of 3 db (and this is not unusual) then one-half of the audio power is lost in the transformer. In other words, if 12 watts could be gotten out of the tubes in a modulator stage, then only six watts would be available out of the transformer. This means you have only a six, not a twelve watt modulator.

In class B systems another important but frequently overlooked consideration is that of the design of the transformer itself. An improperly designed transformer can contribute a large amount of distortion to the output signal. While the efficiency depends upon the primary to secondary coupling, the distortion is controlled largely by the tightness of the coupling between the two halves of the primary winding.

Obviously, any transformer of the proper impedance and power rating will serve, within the limitations mentioned, as Tc. Among the possible choices are Rancor A-3891, Thodarson T-211M12 and UTC S-18. (The transformer pictured is one which happened to be handy.) Some mechanical arrangement may have to be made, depending on the size of the transformer selected.

TESTING

There is very little that need be done when the unit is finished. As mentioned previously, it would be wise to check the bias values, and a meter reading of the resting current would also be a useful test.

Do not attempt to test the modulator with signal input unless it is connected to the final, or unless a dummy load is used. A 5000 ohm, 10 watt resistor across the secondary of the output transformer will serve as a dummy load.

OTHER USES

Even though the Mobile Modulator has been designed for mobile service primarily, it will make an ideal modulator for emergency work. The power drain is small and the unit is compact and reliable.

This modulator may also be used in the home station if a change is wanted. Wett "X" should be disconnected from the hot lead so that the filament may be connected to one of the 200 or 250 volt leads. The hot lead can then go to a small 4.5 or 6 volt battery which will supply more current.

Regardless of the use for which it is built, this high quality little modulator should find many uses around the shack.

Fig. 5. Rear view of the uncoated Mobile Modulator.
The antenna system about to be described is, in theory, not new, but in the practical application and it seems to be all but unknown to the average amateur. It is somewhat akin to the paper clip idea, being so simple yet so effective.

Antennas for low-frequency mobile or emergency work normally fall in the category of pieces of wire less than a quarter wave long. The big problem has been, and will be, how to make this short piece of wire look like a longer piece of wire.

This problem exists because normally it is easier to get efficient power transfer from feed to antenna when the antenna length is an appreciable portion of a quarter wave. However, a point that most amateurs do not fully appreciate is that, disregarding ohmic loss and directivity effects, one length of wire is as good as any other length of wire in radiating a given amount of power. In other words, a one foot piece of wire would be just as good a radiator, say, a hundred feet or one of 1000 feet as a one-quarter foot piece of wire if means were available to efficiently match its impedance.

No matter how you look at it, however, the piece of wire you are using for an antenna is the wire that serves as your radiator, so the problem becomes one of getting the most current into that piece of wire, because, other factors being equal, the more current in a radiator, the better the signal radiated.

This question of getting the most current into the wire is one involving impedance matching, and it has been discussed by practically every author of an article on mobile systems. Suffice it to say that the shorter the piece of wire (for a given frequency) the harder it is to get that antenna current to flow.

**THE TANK COIL**

At this point some of you are thinking that if this current is so important, why doesn't the final tank coil radiate, because if it is, almost as much current as any piece of wire in it is, right? Quite true; it does radiate as well as you with TVI may or may not notice it. But, it is radiates, but not too efficiently, because the shape of the coil is not conducive to efficient radiation. What about trying to do a fancy little job of getting voltage from the final tank into a network which then has to have another voltage which then must resonate this network with the coil to make the tank coil shape such that it will radiate?

This is exactly what has been done to make the antenna about to be described. In effect, a few turns of the final tank coil have been unravelled and straightened out to make a single large turn, or loop of wire. By getting this section of wire out of the tank coil, even though it is still part of the tank coil, we have caused it to become a relatively effective radiator.

Fig. 6. View looking into the antenna coupler.
THE LOOP

The best shape for this radiating piece of wire is a circular single-turn loop. Of course, this sort of antenna on, let us say the eighty meter band, is not as efficient as a properly matched half-wave antenna sixty feet in the air, but, on the other hand, does do a very fine job of radiating. It has surprised many hams who have tried it.

PRACTICAL APPLICATIONS

The length of the wire in the loop is not at all critical except that the longer it is, the better (because the ratio of radiation resistance to ohmic loss is greater). Obviously, the larger diameter conductor used, the better. The shortest piece of wire used in tests in W14FM's shack was twelve feet of #10. This means a loop with a diameter of about three feet, eight inches. The three circuits in Fig. 7 are designed to use any length of wire from twelve feet up to a quarter-wavelength. All data given is for 3.5 to 3 megacycle operation. The data would be similar for higher-frequency operation if scaled down in wavelengths.

Fig. 7C shows the practical method of using part of the tank coil as the antenna. In effect, C1 is across the entire tank coil, and the tube plate is tapped into the tank coil. This tapping arrangement is required in order to have control of the tube loading. To load more heavily, tap the tube plate down toward the ground end of the coil and vice versa to load more lightly. Note that shunt feed is used so that no positive d-c voltage is on the antenna.

The antenna network pictured in Fig. 6 is wired as shown in Fig. 7A. In this case a coaxial line is run from the transmitter to the matching network. No tricky matching stunts are involved. The short piece of wire fastens to the two feed-through insulators, C1 is tuned to resonance, and you are on the air. This arrangement is ideal for emergency work where no permanent installation is desired.

The schematic in Fig. 7B is especially for use with mobile rigs. It is identical electrically to that of Fig 7A, but the parts have been rearranged. The practical way to use the circuit of Fig. 7B is to mount a ten or twelve foot whip antenna on the rear bumper and connect the upper antenna lead to the base of the whip. The top end of the whip then connects to ground. This may be accomplished by bending the whip until the tip of it reaches the rain gutter or some other portion of the car body. As before, matching is no problem. Merely tune C1 to resonance.

While all of these circuits will resonate any length of wire from twelve feet on up, it is obvious that L0 has losses which should be kept to a minimum. Therefore, L0 should be made as low inductance as possible consistent with the length of antenna used and coupling necessary. In addition, large conductors and well-made connections will really pay off.

For radiators in the order of twelve feet long, use the constants specified, remembering that the smaller the wire used to wind L0, the less effective the antenna system will be. For appreciably longer radiators, reduce the inductance of L0 to as low a value as practical. If possible, wind L0 with copper tubing.

EFFECTIVENESS

It is difficult to state just how well an antenna works without taking a tremendous number of measurements. This has not been done, although a fair amount of experimental work has been completed.

For example, using a loop with twelve feet of wire, and the K-P rig on 80 meter c-w, W14FM has been able to work stations in a radius of a couple of hundred miles quite satisfactorily.

One precaution is in order. There is a null perpendicular to the plane of the loop. That is, the loop radiates the least energy in the direction that you would see if you looked through the loop. This null is extremely sharp, and should not cause much trouble, since the rest of the pattern is quite broad.
I have always been firmly convinced that we ama-
teurs are an intelligent and capable group. We must
be plumbers (in order to assemble rotary hammers);
electricians (to run power from the switch box to
handle our California kilowatts); ditch-diggers (for
those underground antennas); construction engineers
(who better to raise those eighty-foot poles); and of
course, we all have a working knowledge of radio.
Our neighbors and friends know that we are experts.
If you can judge by the many odd requests for assist-
ance that we get. Oh, to quote from a letter just re-
ceived from WSNMV.

"It is really fine to be able to call on someone for
assistance occasionally, especially when the neigh-
bors have the idea that a ham is a combination of
Bennetts, De Forest and Armstrong.

I don't know what experience you folks may have
had in trying to keep unshelled the name of ham radio,
but as for me, I have had to take on such bizarre
jobs as converting 1931 farm radio to AC, replacing
the linards of maltreated jewelry store superheats, ad-
vancing on chicken-coop wiring and checking the spark
of a reluctant model A Ford—just a few of the reasons
I appreciate a hand now and then."

John ends up by asking if I could supply him with a
circuit diagram for a Siemens electric blanket? This
is a little out of my line, but it just happened that such
a circuit was handy, so I sent it off to him.

How many of you have gotten involved in some
repair job because of your local reputation as an expert?
If you can recall any especially strange cases, let me
know about them, and I'll see that they are mentioned in
this column.

Sometimes it is desirable to refer to back issues of
publications. Many of us amateurs manage to save the
old issues of our ham magazines but most of us are
unable to keep a complete file of all electronic maga-
azines.

If you ever need information of this sort and it is
not available, you might keep in mind that The
Electronics Research Publishing Co., Inc., 480 Canal
Street in New York City, will probably be able to
help you.

This company has arranged with the various pub-
lishers of domestic and foreign scientific periodicals,
journals, proceedings, and technical house organs, to
supply back issues of their publications.

In the event that back issues of a publication are
not available, a photocopy of the article required
may be supplied. This service is restricted to those publica-
tions that have granted permission to reproduce their
material. A nominal fee is charged for this service.

All issues of the Ham News are on file with this
company (including a copy of that rare issue Vol. I,
No. 1) so that photographic copies can be made. So, if I
cannot supply you with back copies of the Ham News
(your issues are no longer available) you can at least
get photostats of them from The Electronics Research
Publishing Co.

Keeping up with the latest news on TV and tele-
vision picture tubes requires a lot of intensive reading
of the various technical magazines. Television is now
a gigantic industry in its own right, and every day
brings word of bigger and better television devices.

What brought this to mind is a recent news release
from General Electric which stated:

"A 24-inch television picture tube, which will pro-
duce a direct-view picture almost as large as your daily
newspaper page, has been made by the General
Electric Company here.

"For pictures this size it was previously necessary
to employ projection methods using a magnifying lens
system to enlarge the image as it appeared on the face
of a small picture tube. This method resulted in loss
of picture detail and brilliance, G.E. engineers say.

"Dr. W. R. G. Baker, G.E. vice president, said the
company plans limited production by fall."

The logical question at this point is—where do we
stop? Of course, I suppose it is always a possibility
that the TV set manufacturers will figure out a way to
put the chassis inside the picture tube.
TECHNICAL INFORMATION

12AU7

GENERAL DESCRIPTION

Principal Application: The 12AU7 is a miniature twin triode having characteristics similar to those of the 6SN7-GT. It consists of two medium-mu triode sections of which the cathodes are brought out to separate pin connections. This tube is suitable for a variety of applications including audio-frequency amplifiers, oscillators and multivibrators. A center-tapped heater permits operation of this tube from either a 6.3 volt or a 12.6 volt supply.

PHYSICAL DIMENSIONS

Terminal Connections

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<th>Pin</th>
<th>Name</th>
<th>Section Number</th>
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<tr>
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<td>Plate</td>
<td>2</td>
</tr>
<tr>
<td>2</td>
<td>Grid</td>
<td>3</td>
</tr>
<tr>
<td>3</td>
<td>Cathode</td>
<td>2</td>
</tr>
<tr>
<td>4</td>
<td>Heater</td>
<td>5</td>
</tr>
<tr>
<td>5</td>
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</tr>
<tr>
<td>9</td>
<td>Heater Center-Tap</td>
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</tbody>
</table>

Ham News
Available FREE from
G-E Electronic Tube Distributors

A Bi-monthly Publication

G E N E R A L  E L E C T R I C

BECTON, J. C. N.

GEO. H. HOLT, W5CET — EDITOR

FROM: