G-E Electronic TUBE

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MOBILE

MODULATOR

10 Watt Modulator for the E-P Rig

ANTENNA SYSTEM

Antenna Coupling Network for Mobile & Emergency Work

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.

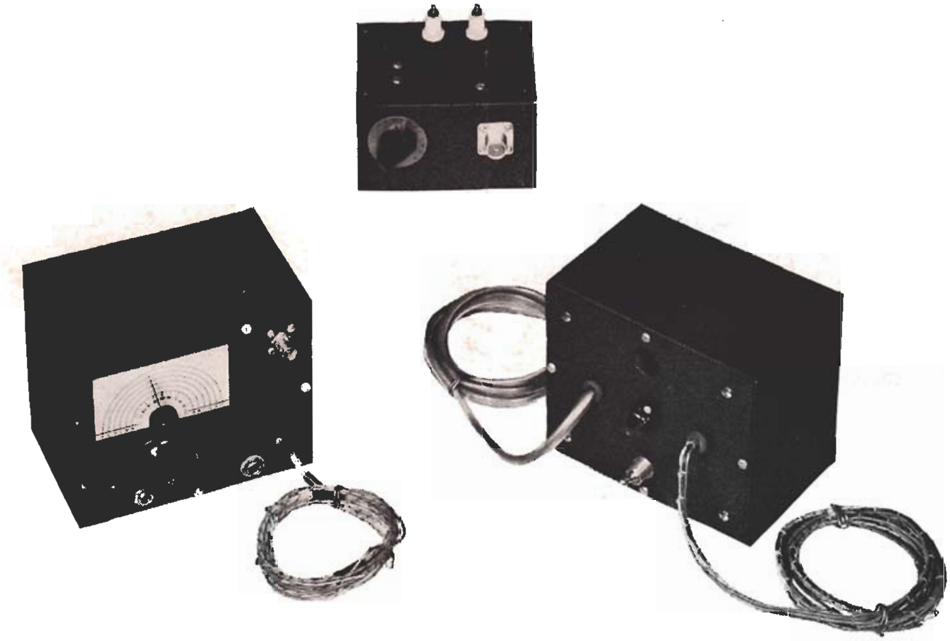


Fig. 1. Complete mobile and emergency outfit. The E-P Rig (see March-April 1950 *Ham News*) is on the left, the Mobile Modulator on the right, and the antenna coupler is in the center.

CONTENTS

MOBILE MODULATOR

GENERAL CONSIDERATIONS

Mention was made, in the E-P Rig description, that both the r-f and audio system would operate from a single 300 volt 100 ma vibrator power supply. Inasmuch as the E-P Rig B plus current drain totaled approximately 60 ma, the *average* current available for the modulator design is 40 ma.

In typical amateur practice, where push-pull class AB6V6 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 6V6 type of setup would be hard pressed to provide 10 watts of audio *output.*

Other experimenters, 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 AB6V6 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.

Strange as it seems, the 12AU7 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.

The static (resting) 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. 5) 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 ma) 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. Inasmuch 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 12AU7 modulator and the 12AT7 driver. Under zero-signal conditions the bias voltage from either pin 2 or 7 of the 12AU7 to ground will be 15 volts, and the voltage measured across either R_7 or R_8 (the bias for the 12AT7 driver) will be 7 to 8 volts, when a 22.5 volt bias battery is used.

ELECTRICAL CIRCUIT

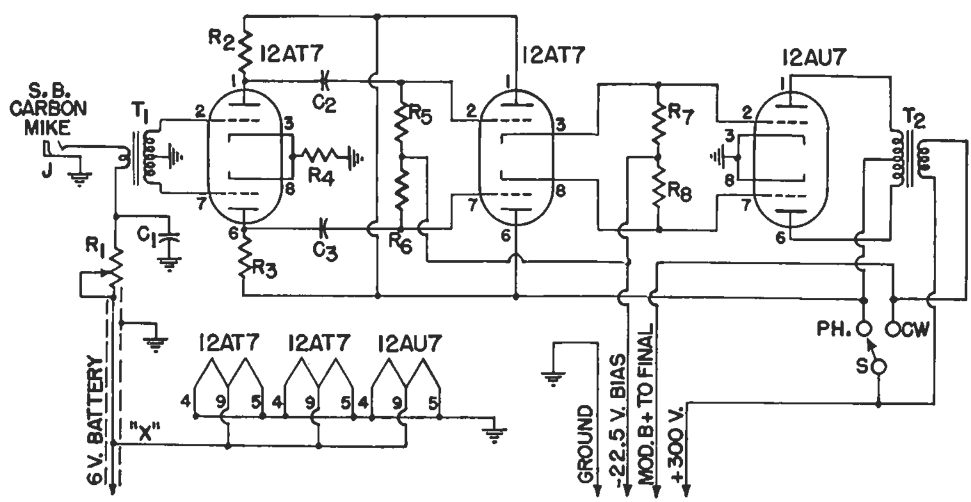


Fig. 2. Circuit diagram of the Mobile Modulator.

CIRCUIT CONSTANTS

(All resistors and capacitors ±20% tolerance unless specified otherwise)

C_1 .... 500 mf 15 volt electrolytic
C_2, C_3 .... 1000 mmf 500 volt ceramic or mica
J .... Open-circuit jack
R_1 .... 250 ohm potentiometer
R_2, R_3 .... 0.1 megohm, ½ watt
R_4 .... 2200 ohm, ½ watt
R_5, R_6 .... 0.47 megohm, ½ watt
R_7, R_8 .... 10,000 ohm, ½ watt
S .... SPDT toggle switch
T_1 .... S.B. mike to push-pull grids
T_2 .... Output transformer (see text)

Note that the cathode current for the 12AT7 driver flows through the bias battery, and therefore this battery actually supplies a 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 undue noise pickup.

Potentiometer R_1 (actually connected as a rheostat) serves as a gain control. Because it can only change the microphone current a small amount, it does not have 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 R_1, or add a fixed resistance in series.

A phone-cw 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 mike 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 4⅛ by 5⅛ inches. The spacers which support this piece are 1¼ inches long.

Fig. 5 indicates how the parts are mounted on the flat chassis and Fig. 3 shows the wiring on the underside of the chassis.

The shaft on resistor R_1 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-P Rig described in the March-April 1950 *Ham News.*

Referring to Fig. 3, the input 12AT7 is the bottom tube, the 12AT7 driver is the middle tube, and the top tube is the 12AU7 output tube. These same tubes can be seen in Fig. 5, 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. 5 transformer T_1 is on the right and transformer T_2 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 constants.

One part is worth discussing in more detail, however, and that is the output (modulation) transformer. Fundamentally, all that is required is a transformer with a primary plate to plate impedance of approximately 12,000 ohms and a secondary impedance of approximately 6000 ohms. This latter figure assumes that the modulator will be used with the E-P Rig, where the plate voltage on the final is 300 volts and the final plate current is about 50 ma.

The prime considerations in choosing an 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.

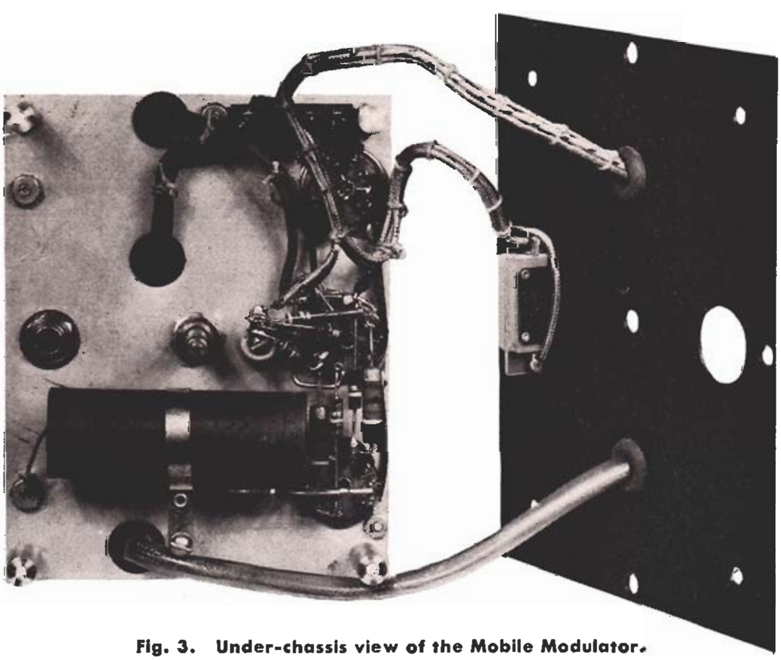


Fig. 3. Under-chassis view of the Mobile Modulator.

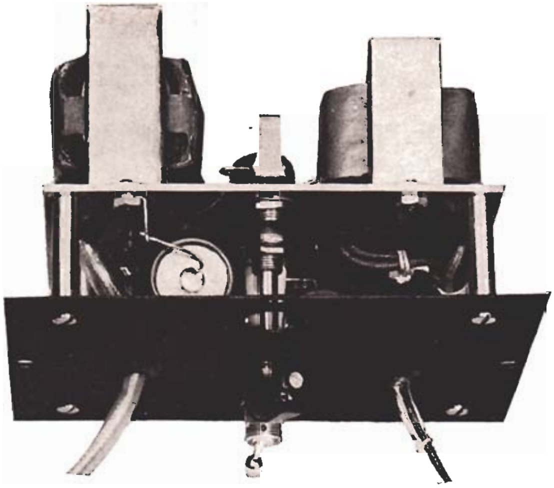


Fig. 4. Top view of the uncased Mobile Modulator.

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 T_2. Among the possible choices are Stancor A-3891, Thordarson T-21M52 and UTC S-18. (The transformer pictured is one which happened to be handy.) Some mechanical rearrangement 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 advisable.

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 made. Wire "X" should be disconnected from the hot lead so that the filaments may be energized by a 6.3 volt transformer. The hot lead can then go to a small 4.5 or 6 volt battery which will supply mike current.

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

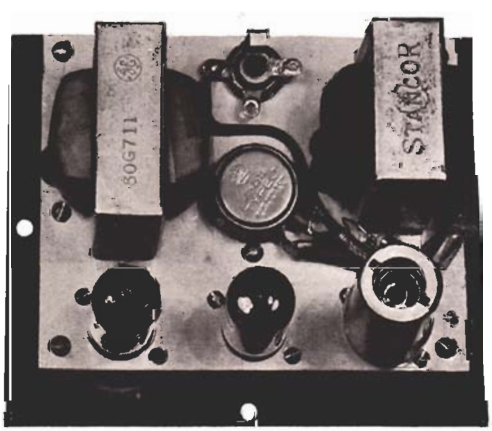


Fig. 5. Rear view of the uncased Mobile Modulator.

MOBILE AND EMERGENCY ANTENNA

The antenna system about to be described is, in theory, not new, but in the practical application end 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 final to antenna when the antenna length is an appreciable portion of a quarter-wavelength.

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 effective on eighty meters as a one-hundred 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 transmitters. 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 it has just about as much current as any piece of wire in the rig? Quite true, it does radiate as some of you with TVI may painfully recall.

It radiates, but not too efficiently, because the shape of the coil is not conducive to efficient radiation. But, here is an idea. Why bother trying to do a fancy matching job of getting voltage from the final tank into a network which then has to have another voltage which will produce our antenna current? Why not 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 unrolled 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.

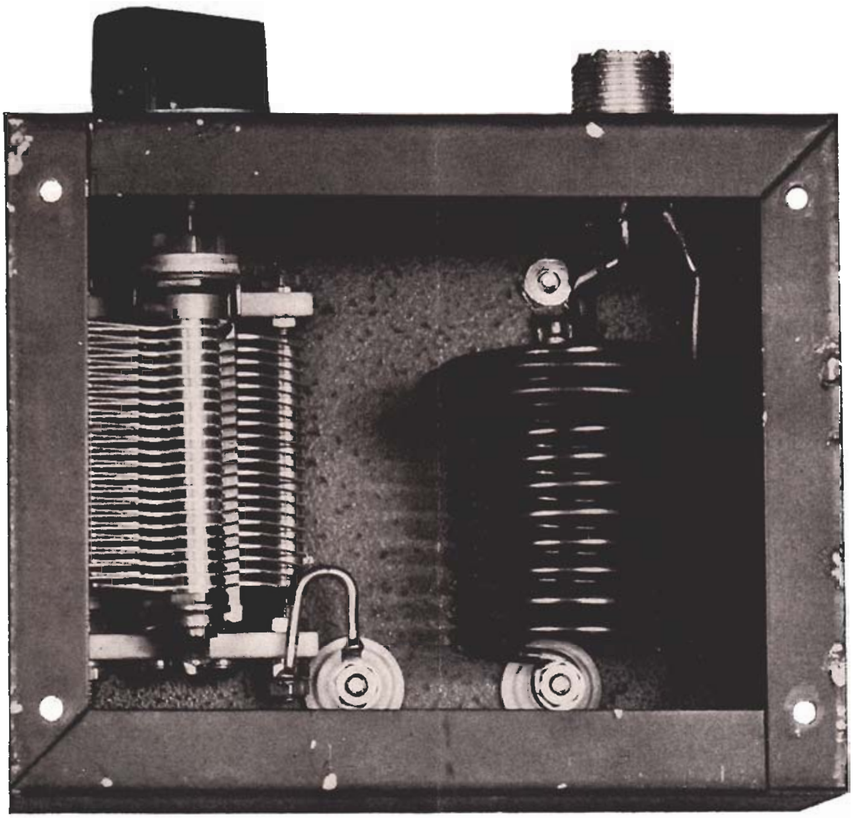


Fig. 6. View looking into the antenna coupler.

ELECTRICAL CIRCUIT

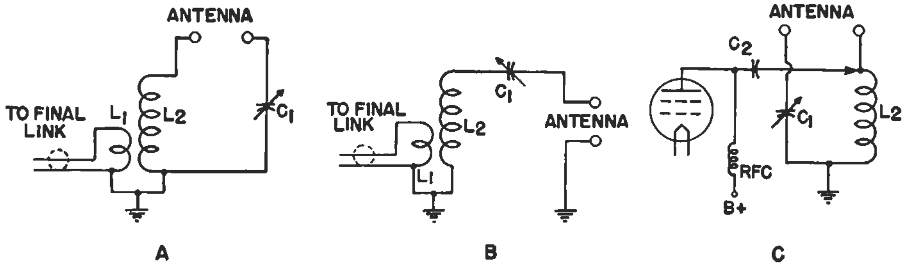


Fig. 7. Circuit diagrams of the mobile and emergency antenna.

CIRCUIT CONSTANTS

C_1 .... 335 mmf variable (National STH-335)
C_2 .... 0.005 mf blocking condenser
L_1 .... Two turns #12 wire
L_2 .... Eleven turns #10 wire, 1½ inches in diameter, wound to cover two inches (approx. 2½ microhenrys)

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, it 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 W2FZW'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 4 megacycle operation. The data would be similar for higher-frequency operation if scaled down in wavelength.

Fig. 7C shows the practical method of using part of the tank coil as the antenna. In effect C_1 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, C_1 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 C_1 to resonance.

While all of these circuits will resonate any length of wire from twelve feet on up, it is obvious that L_2 has losses which should be kept to a minimum. Therefore, L_2 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 L_2, the less effective the antenna system will be. For appreciably longer radiators, reduce the inductance of L_2 to as low a value as practical. If possible, wind L_2 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 E-P rig on 80 meter c-w, W2FZW 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.

Sweeping the Spectrum

I have always been firmly convinced that we amateurs are an intelligent and capable group. We must be plumbers (in order to assemble rotary beams); electricians (to run power from the switch box to handle our California kilowatts); ditch-diggers (for those underground antennas); construction engineers (the 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 assistance that we get. Or, to quote from a letter just received from W3NMV:

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

"I don't know what experience you folks may have had in trying to keep unsullied the name of ham radio, but as for me, I have had to take on such bizarre jobs as converting 1931 farm radios to AC, replacing the innards of maltreated jewelry store superhets, advising 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 Simmons 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 magazines.

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 publishers 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 photostat of the article required can be supplied. This service is restricted to those publications 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. 1, No. 1) so that photostatic copies can be made. So, if I cannot supply you with back copies of the ***Ham News*** (four 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 television 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 produce 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.

—*Lighthouse Larry*

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.

Cathode: . . . . . Coated Unipotential

	Series	Parallel	
Heater Voltage	12.6	6.3	Volts
Heater Current	0.15	0.3	Ampere

Envelope: . . . . . T-6½ Glass

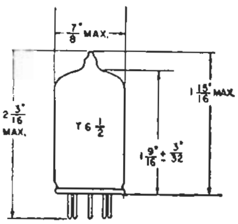
Base: . . . . . E9-1 Small Glass Button 9-Pin

Mounting Position: . . . . . Any

Direct Interelectrode Capacitances

- Grid to Plate (Section Number 1) . . . . . 1.5 μμf
- Grid to Plate (Section Number 2) . . . . . 1.5 μμf
- Input (Section Number 1) . . . . . 1.6 μμf
- Input (Section Number 2) . . . . . 1.6 μμf
- Output (Section Number 1) . . . . . 0.50 μμf
- Output (Section Number 2) . . . . . 0.35 μμf

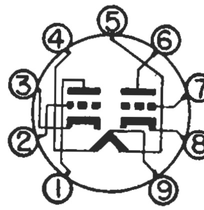
PHYSICAL DIMENSIONS



TERMINAL CONNECTIONS

Pin 1—Plate (Section Number 2)
Pin 2—Grid (Section Number 2)
Pin 3—Cathode (Section Number 2)
Pin 4—Heater
Pin 5—Heater
Pin 6—Plate (Section Number 1)
Pin 7—Grid (Section Number 1)
Pin 8—Cathode (Section Number 1)
Pin 9—Heater Center-Tap

BASING DIAGRAM



RMA 9A
BOTTOM VIEW

Electronic TUBE

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FROM: