The Impoverished Radio
EXPERIMENTER

Tricks, tips, and secrets to help the builder of simple radios and electrical gear achieve high performance at minimal cost!

6

Loose-Coupler!
Active Long Wire Antenna!
Regenerative Loop Receiver!
Transmitter Experiments!

EXPERIMENTER

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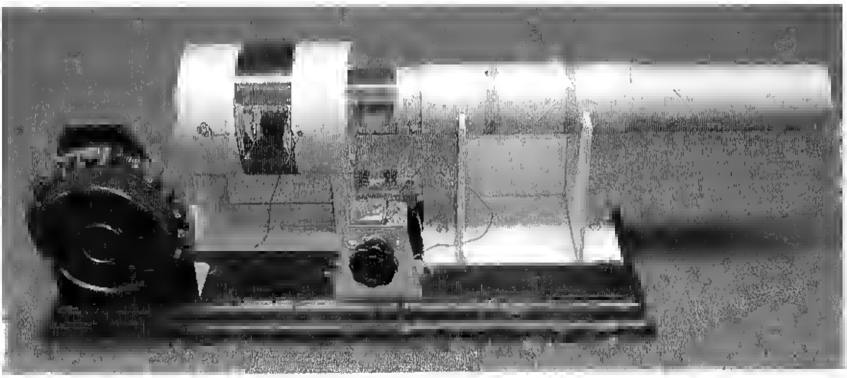

Loose Coupler

If you haven't tried a loose coupler on your crystal set or your regenerative receiver, it's worth experimenting with. To build one, you create two tuned circuits, that is, coils and condensors, in a way that allows you to vary the magnetic coupling by moving the coils closer or farther apart from one another. No, it won't allow you to pull in stations a million miles away. In fact, the process of adding more circuitry will actually decrease the volume of distant stations because of the added loss. But if you live near a number of high power AM radio stations, the loose coupler can add noticeable selectivity, eliminating unwanted stations. If nothing else, you should build one to become acquainted with how the circuit works.

Again, a loose coupler is a doubly tuned circuit with variable coupling. It goes back to the earliest days of wireless. A modern form of loose coupler with fixed coupling is the IF transformer. You can build a fancy coupler from hardwood, bakelite, fancy brass wiper switches, binding posts and all the rest, but you can make one that works just as well out of cardboard tubes. And it will take you longer to find the components than it will to build it.

What you see here is built from a cardboard tube salvaged from a roll of kitchen plastic wrap, and a larger tube that originally held 3" clear plastic tape. The smaller of the two tubes telescopes into a slightly larger third tube that acts as a support bushing. Dig through that box of cardboard tubes you've been saving all along and see what you can find.

Next, wind a coil on each tube.

The Impoverished Radio Experimenter Volume 6

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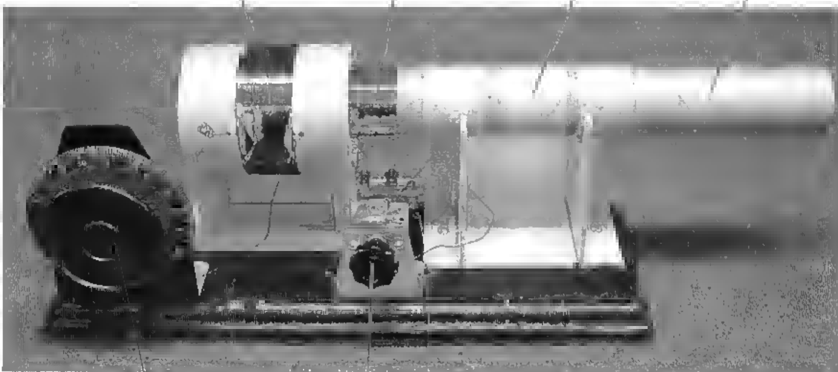


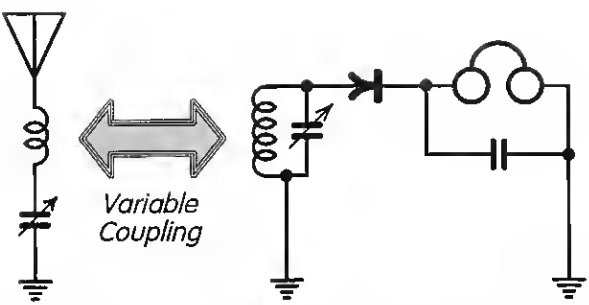
The loose coupler is more carpentry than electronics. It's a very simple device but can produce surprising results.

How many turns? You'll have to figure it out. To use the formula (EXPERIMENTER 2 page 23) you need to know the diameter of the tube being used and the size of the variable capacitor to be used with that coil. You can measure the tube diameter with a ruler, and the capacitor value with a bridge (EXPERIMENTER 3). The larger the diameter, the fewer turns you'll need. You have the formula. Each coil should resonate with its respective capacitor at the same frequency, and preferably when the capacitor plates are meshed about the same. In other words, when both capacitors are 50% meshed, each with its respective coil should tune to the same frequency. You can measure the resonant frequencies of each tank circuit with a grid dip oscillator (EXPERIMENTER 2). The bridge can be used to measure the inductance of each coil, but interwinding capacitances may mess up your calculations a little bit. It would be instructive to measure both coils you've wound with a bridge and compare inductances.

The coupler shown here uses two concentric tubes, one of which slides inside the other to vary the coupling much as was done in the old days. It's a system that works well. You could just as easily put two coils on tubes of the same diameter and vary the coupling by swinging one away at an angle. That was used on amateur radio transmitters to vary the antenna loading back before pi-network output circuits became popular. Another type of mechanical arrangement might work as well. Experiment! You have nothing to lose but a few cents worth of copper wire.

The coupler show here is also a crystal set. By adding a germanium diode and a common bypass capacitor soldered to a 1/4" phone jack, the whole machine becomes a classic crystal set.

The theory behind the doubly tuned circuit is described in detail in almost any radio book of any impor-



A loose coupler receiver is very simple. The antenna circuit uses a series tuned resonant circuit because power off the antenna is low impedance, that is, low voltage but high in current.

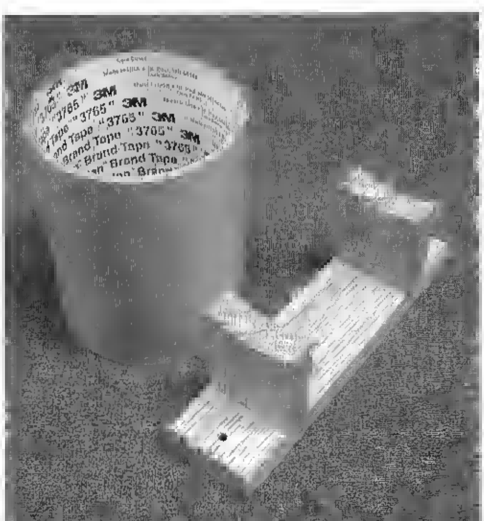
Changing the distance between the coils changes the amount of coupling between the tuned circuits and affects the selectivity and energy transfer.

The detector tank circuit is parallel resonant because this side of the radio is high impedance, that is, the headphones need lots of voltage and little current.

The loose coupler itself acts not only as tuning circuit but also as a step-up transformer and can offer improved performance over some other types of circuits.

tance. You'll find descriptions in the Radio Amateur's Handbook, and one excellent article, The Double-tuned Circuit: An Experimenter's Tutorial by Wes Hayward, W7ZOI appearing in QST December 1991, and reprinted in QRP Power, 1996, by the ARRL.

Build one and try it. You'll find that the capacitors will behave in different ways depending on the coupling. At one setting of coupling the antenna capacitor might actually have more tuning effect than the detector capacitor. By adjusting the coupling you can sharply tune your crystal set. Just remember that the greater number of components you place between the antenna and your



The 3" diameter main tube comes from a roll of 3" wide clear plastic tape. There is nothing sacred about the sizes used here. Use what you can find. It would probably work as well if you taped and glued together a tube with a square cross section 3" or more on a side. Use a plastic tube if you want. Perhaps a water bottle of some type. Look around you. You'll find all types of forms. The fancy cradle for the tube was cut from small pieces of oak that I happened to have on hand. Create a cardboard cradle if you want. Don't be afraid to experiment.

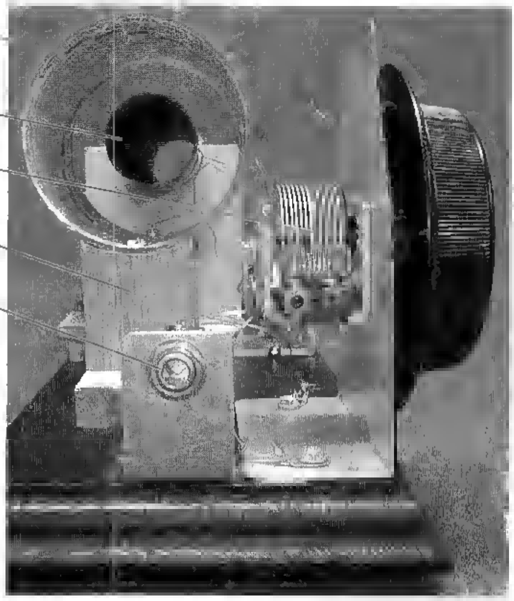
detector coil form

antenna coil

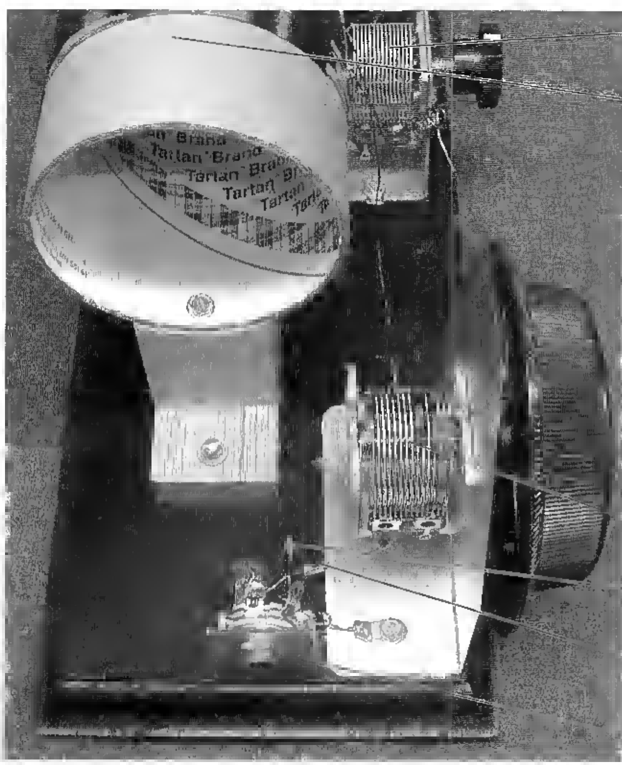
detector capacitor

detector coil cradle

1/4" phone jack



End view of the loose coupler crystal set. A pine board with a fancy edge and black paint becomes a breadboard chassis. Wood, cardboard, and aluminum form the mounting brackets needed. My usual #6-3/8" hex head sheet metal screws secure everything to the breadboard.



antenna capacitor

detector coil

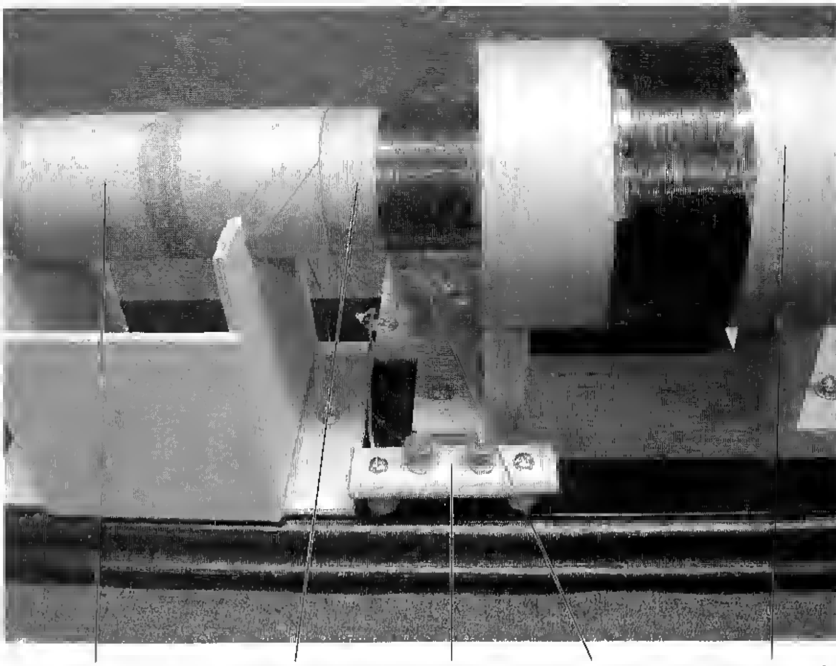
This view shows the loose coupler's "complicated" detector circuit consisting of a bypass capacitor and a germanium diode. If you want to use a cat whisker on galena, do it. Other detectors have been used successfully.

detector capacitor

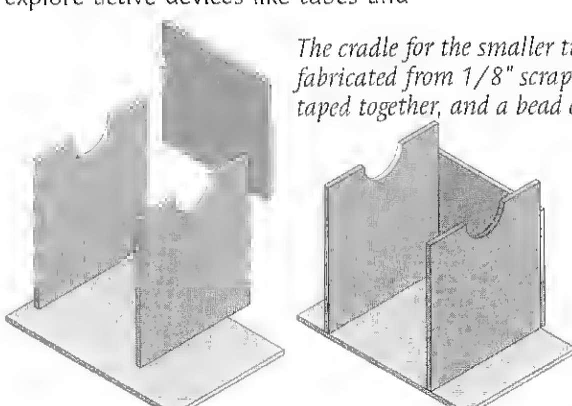
bypass capacitor

germaninum diode (1N34)

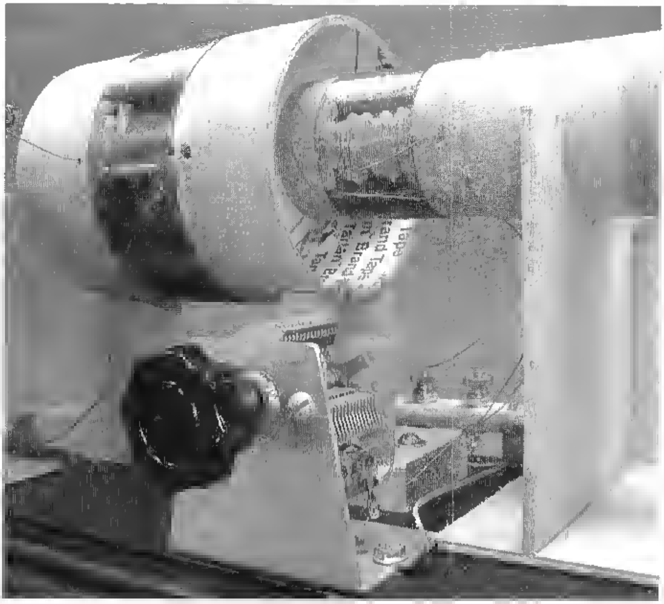
1/4" phone jack



headphones, the less energy that will get transferred. Each component is less than 100% efficient and consumes some of the energy. If you get to the point of obsessing about high Q by using exotic materials, it's time to explore active devices like tubes and transistors. Back in the earliest days, active devices were either nonexistent or beyond the reach of the amateur radio builder. The loose coupler was, therefore, an important step forward in performance.



The cradle for the smaller tube telescoping tube was fabricated from 1/8" scrap cardboard. Pieces were taped together, and a bead of white glue run into the corner seams much like a weld bead. The tape was then removed. The actual dimensions you use will depend on the tubes you use. You won't be able to determine how high to make this cradle until you build the detector tube assembly.



The long leads to the coils are no problem for this crystal set, but you wouldn't want to use them on a shortwave regenerative receiver. They would cause wild instability. You may want to put the antenna on the fixed coil form and use the movable coil for detector. Try it!

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CONSTRUCTION OF RECEIVING APPARATUS FOR A MODERN WIRELESS STATION

W. C. Getz

In presenting this final article of the series dealing with the construction of a modern wireless station and the necessary instruments, it has not been found possible to introduce any especially new features of importance, but merely to treat of the best practice in modern instrument design, and to furnish suitable data that will enable the experimenter to construct the instruments described.

As stated in previous issues of this magazine, a general form of all receiving circuits is a fixed or variable capacity connected to a fixed or variable inductance, containing in the circuit a wave-detecting device which will actuate a suitable indicator, such as a pair of telephone receivers, and while there are various methods in which the capacities and inductances may be combined, they nevertheless follow the general form stated above. In this respect the experimenter should be warned against the danger of having too many pieces of apparatus connected in. Certain wireless "experts" have evolved many beautiful diagrams fairly bristling with inductances, variable and fixed capacities, promiscuously distributed over the landscape, and for which it is claimed will eradicate all the existing evils of static, interference, etc. While these may accomplish what is claimed for them, they frequently give the operator so many things to adjust and fool with, that by the time he tunes the sending station in, it has half finished the message. Wherever possible, make your circuits simple, as you will be able to work much better than where you have to be continually adjusting a number of devices, each of which requires several seconds attention.

The Inductive Tuner

The inductive tuner or oscillation transformer has been adopted as the most efficient and satisfactory type for the present installation. There are a number of prominent and well-made types of inductive tuners sold by the various dealers in wireless supplies. In Fig. 1 is shown the recent "Navy Type" of inductive tuner brought out by the Clapp-Eastham Co. The variation of

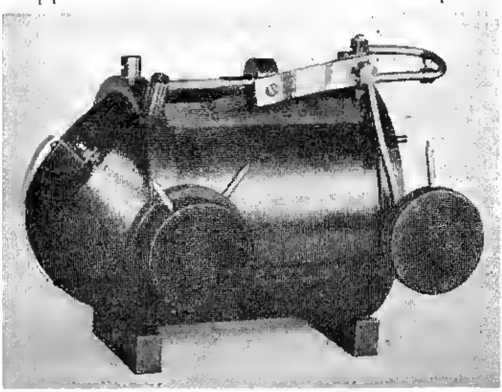


Fig. 1. Navy Type Tuner

coupling in this tuner is accomplished by rotating the plane of the secondary coil from a position parallel to a position at right angles to the primary winding. This is an exceedingly well-constructed device, and gives excellent results.

The Wm. J. Murdock Co., have also brought out a very good tuner. This is shown in Fig. 2, and the writer has been in a number of experimental stations where this instrument was giving extremely fine results.

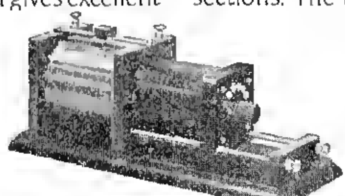


Fig. 2. Receiving Transformer

In Fig. 3 is given a view of an inductive tuner of familiar appearance, that was constructed by Lieut. J. O. Mauborgne, in the Signal Corps Laboratory, at Fort Leavenworth, Kansas. As this instrument was easily constructed, and very successful in operation, a brief description will be given of same: The primary consisted of 100 turns of No. 18 enameled wire wound on a cardboard mailing tube 4-3/8 in. outside diameter, and with a 1/8 in. wall. One sliding contact is provided for the primary winding. The secondary consists of 300 turns of No. 24 single silk-covered magnet wire wound on another cardboard tube 4 in. outside diameter, and with a .2 in. wall. The secondary was brought out in taps as follows: 1st, at beginning of winding; 2d, at 40 turns; and 3d, at 300 turns, the end. The detector is mounted on the base of the coil and the condenser (fixed) concealed beneath the base in a pocket.

In all of the above-mentioned types of tuners, the amount of wire on the secondary winding is a fixed quantity. Now, referring to Fig. 4, I have given a drawing of an inductive tuner, the secondary of which is built on the "unit" plan, in sections. The top views in this drawing show the left end and the side elevation of the tuner. The lower views show the right end, the assembly of the secondary, with the appearance of the faces of the secondary sections.

As seen from the sketch, this tuner is similar in many respects to that shown in Figs. 2 and 3. The primary consists of No. 16 B. & S. gauge enameled wire, and is wound on a tube 2-3/4 in. inside diameter, and 3 in. outside diameter. This gives a 1/8 in. thickness of wall. The tube may be of either cardboard or fiber. The primary tube is 8-3/4 in. long, and on each end is fitted an oak end piece 3-1/2 in. square and bored out to fit the tube. This will leave a winding space of 8 in., which will accommodate about 145 turns of the No. 16 enameled wire. Approximately 1 lb. of this wire will be needed for this winding.

The sliding contact rod *K* is mounted on top of the coil in the center of the ends as shown. This rod, as given in detail in Fig. 5, is of square brass tubing, 5/32 in. square inside, and 1/4 in. square on the outside. One end of this is drilled with a No. 29 drill and tapped for an 8-32 machine screw stud, which supports the binding post shown in the side elevation.

The sliding contact *A*, details of which are given in Fig. 5, consists of a brass slide cut and bent as shown, with a hard rubber handle on top. Through each of the "legs" of the slide, brass studs are passed which hold the contact maker. This consists of two pieces of No. 18 spring brass wire, each bent as shown in the sketch, and soldered together at the bottom, If correctly made as shown in the drawing, this slide will be found superior to any other type, as it is easy to manipulate, exerts a steady pressure, does not cut the winding, and makes a positive contact with one convolution at a time.

To support the secondary winding properly, the extension rod *I* is used.

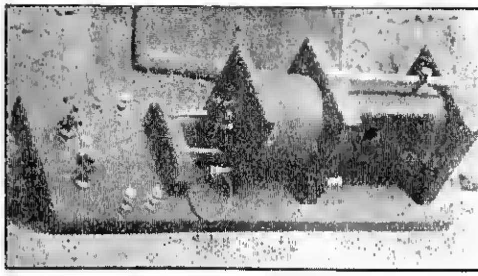


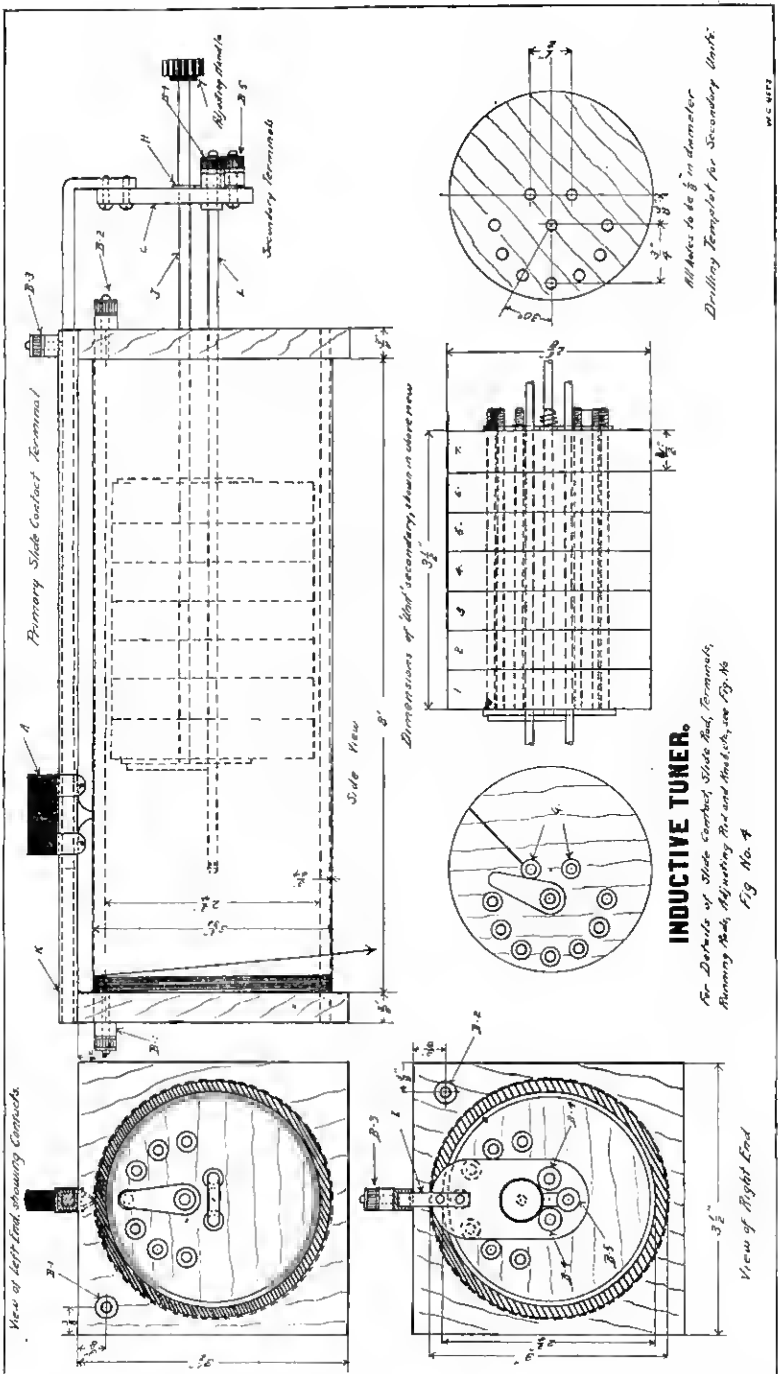
Fig. 3. Inductive Tuner

This rod is of 5/32 in. solid brass bar, and is bent down at one end for a distance of 5/16 in. The straight length of the bar is 8-3/4 in. The bent end is drilled and tapped for two 8-32 machine screws, as shown in the sketch. This rod slides into the sliding contact rod *K*, thus allowing the secondary to be withdrawn for a considerable distance from the primary where very loose coupling is desired, and at the same time it can be telescoped for convenience in portability.

To *I* is fastened the insulating plate shown at *C* on Fig. 5. This is made of 1/4 in. hard rubber and is drilled with a number of 1/8 in. holes in the positions shown. It is 2 in. long and 1 in. wide, with rounded ends. In the two lower off center holes the ends of the running rod L are placed.

As in the detail drawing, the rod L is bent so that the ends are parallel to each other, 1/2 in. apart, between centers. The ends are threaded with 8-32 threads, for 1/2 in. from end. In fastening this to plate *C* a nut is placed on each end of the rod and screwed down as far as it will go. Then the plate *C* is put in position, and the binding posts screw on the projecting ends of the rod, holding same rigid. The rod is of 1/8 in. round brass.

Before placing the rod in position we must assemble the secondary. As stated, the secondary consists of a



INDUCTIVE TUNER.

For Details of Slide Contact, Slide Rod, Terminals, Running Rods, Adjusting Rod and Knob, etc., see Fig. No

Fig No. 4

number of sections. In Fig. 4 is shown the plan of a unit of seven sections. Each section consists of 30 turns of No. 26 B. & S. gauge enameled magnet wire, wound on a wooden disk 2-5/8 in. diameter and 1/2 in. thick. For the seven sections about 1/4 lb. of No. 26 wire is needed.

The wood should be made of the same material as the ends of the sections, and should be smoothly and accurately finished. In each disk are bored a number of 1/8 in. holes, as shown on the drilling templet in the right-hand corner of Fig. 4. The two holes on the center line are for the running rod *L*. The seven holes on the 3/4 in. radius are for the connecting studs, and the center hole of these is for the adjusting rod and switch arm.

Seven studs, size 8-32, as shown at F in Fig. 5, should be obtained. On the end of each stud is placed a threaded washer, as shown at *G*, and when the end of the stud is screwed flush with the face of the washer, they should be soldered together. With a file remove any excess solder, so that there will be a smooth surface for the switch arm to make contact with. The studs are then slipped in the respective holes of the first section, the washers being on the left side.

Now the left end of the winding on the first section will be carried to the bushing *G*, shown on the front view of the secondary unit in Fig. 4. This makes contact with the running rod *L*. It is merely one of the small washers bored sufficiently large to allow the 1/8 in. rod *L* to slide easily through it.

Referring to the diagram in Fig. 6, the following may be better understood. The right end of the winding of section 1 is on the side next to section 2. This and the left end of the winding on section 2 are carried down and connected to stud 1, between sections 1 and 2. In a like manner, the end of 2 and the beginning of 3 are connected to stud 2 between 2 and 3; 3 and 4 to stud 3; 4 and 5 to stud 4; 5 and 6 to stud 5; 6 and 7 to stud 6; and the end of 7 to stud 7.

If it is desired, only one or two of these sections may be placed on, as at a later time additional sections can be easily added. And another thing, units with different sizes of wire my be substituted without unwinding any sections or unsoldering any connections.

After all the sections that it is desired to use are in position, threaded washers are placed on the other ends of the studs and tightened up until the entire unit is perfectly solid and even.

In the center hole is placed the adjusting rod *J*. On one end of this rod is the switch arm *E*, shown in Fig. 5, and on the other end, the insulated handle *D*. The rod is of 1/8 in. brass, and is 9 in. in length. The switch arm is of 1/16 brass, and is 1-1/8 in. long. The knob is of hard rubber, 5/8 in. in diameter. Both the knob and the switch arm are threaded to fit the thread on the rod. The switch arm should be soldered to the end of the rod. To protect the switch arm from getting shoved away from the contact ends of the studs) it is necessary to place a washer reamed out to fit over the rod *J* on it, opposite the switch end. Against this washer should be placed a small compression spring. The spring may be made as follows: Drill a 1/32 in. hole in the rod *J* about 1/4 in. to the right of the washer, which is up against the right side of section 7. In the hole slip the end of a length of spring brass wire,

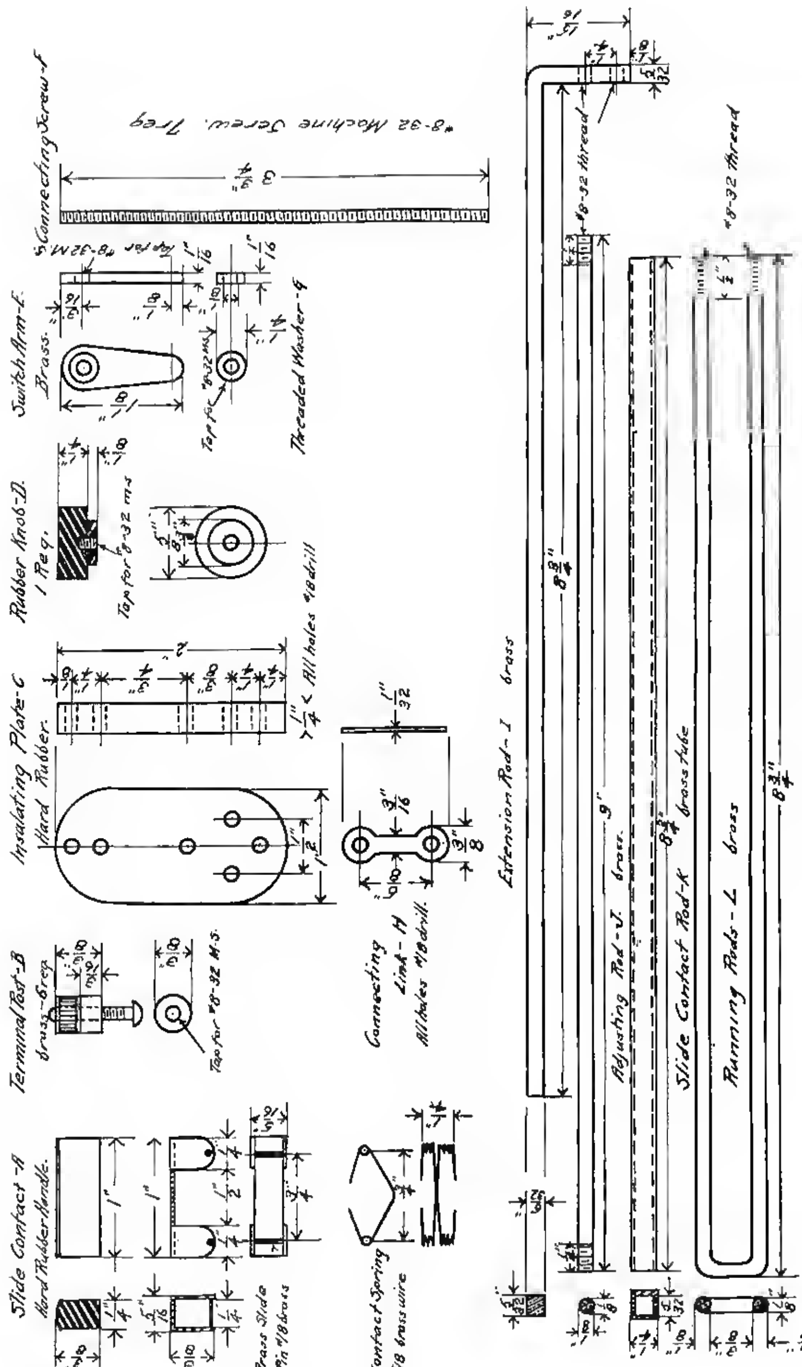
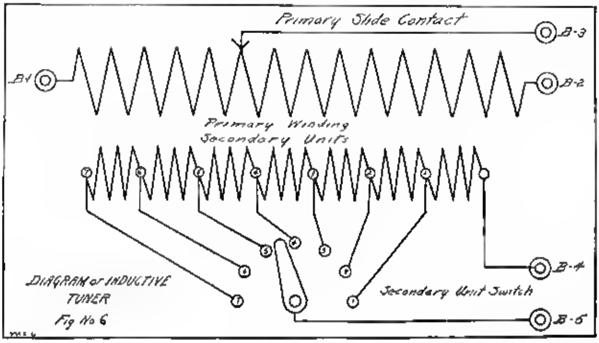


Fig. 5. Inductive Tuner Details



allowing two important operations to be simultaneously performed.

The one sliding contact on the primary is ample for all purposes. A binding post is placed at each end of the primary for convenience in wiring, and to allow a greater range of coupling, by selecting the post near or away from the secondary for the ground connection.

and slowly wind the wire on the rod, until within 1/16 in. of the washer. Cut the wire off, and spread the resulting coil to bout 1/2 in. in length. This will exert sufficient pressure to keep the switch arm in good contact with the studs.

As the adjusting rod slides through he rubber plate *C*, it is necessary to make a connecting link as shown at *H* to preserve the circuit between the rod and the lower binding post. This link is of 1/32 in. brass, as shown in the detail sketch, and is drilled to fit the rod snugly. In the view of the right end of the assembly in Fig. 4, this link is shown plainly.

The terminal posts used on this tuner are of the style shown in B on Fig. 5. On the ends of the running rods on plate *C* two binding posts are placed, where the electrical conditions only require one. The second post adds a symmetrical appearance, as well as strengthens the joint at this point.

To sum up the advantages of this tuner: (1) the secondary can be- easily changed for various sizes of units; (2) it can be separated widely from the primary to obtain extremely loose coupling; (3) the adjusting rod controls both the distance of the secondary from the primary, and also the number of sections cut in,

Tracing the circuit of the primary, we find that the oscillations enter through the terminal *B3*, from the antenna, thence to the slide contact via the sliding contact rod; then to the primary winding and out through either terminal *BI* or *B2*, whichever is used. In the secondary, the circuit is, starting at the terminal *B5*, through the connecting link; the adjusting rod *J*, thence to the switch arm; from this to the studs, and through the sections included by the switch arm; then through to the running rod *L*, and to the terminal *B4* on the plate.

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The Wiring Diagram

There are a number of ways of connecting up the receiving instruments, but in this article only one diagram will be given. It employs the inductive tuner, variable and fixed condensers, the crystal rectifying detector, and the telephone receivers.

In Fig. 17 we have the wiring diagram of this set. The oscillations coming down the antenna pass to the binding post *B3* of the sliding contact, thence to the primary and through the rotary condenser (or direct) to ground.

It will be noticed that a key switch is inserted between the ends of the primary and the ground. This is to allow the adjustable condenser to be placed in series or in multiple with the primary. To shorten the wave length, the condenser should be placed in series with the primary winding; to lengthen the wave length, place it in multiple, or bridged across the primary.

The type of key selected is the No. 515 key made by the Sterling Electric Co. The sketch in the lower right-hand corner, gives an approximate appearance of the side and front views.

When the key is thrown to the left (looking at side view and wiring diagram) the center contact springs *s* and *r* connect with the left contact springs *o* and *m*. This places the adjustable condenser which is connected to *s* and *r* across *o* and *m*. The point *o* is not connected to anything as the side *s* of the condenser is permanently connected to ground. Thus, when to the left, the adjustable condenser is in series between the ground and the primary of the tuner.

When thrown to the right the contacts *s* and *r* engage the contacts *p* and *n* respectively. The point *p* is permanently connected to the point *m*, and, as stated, the side *s* of the condenser goes to ground. As n connects to the primary terminal, *B1*, at the other end of the winding, by throwing the switch to the right, connects the terminal *B2* direct with the, ground terminal *A*, and bridges the condenser to *B2* and *B1*, in parallel with the primary. This makes an exceedingly convenient and easy device to change from a low to a high wave length.

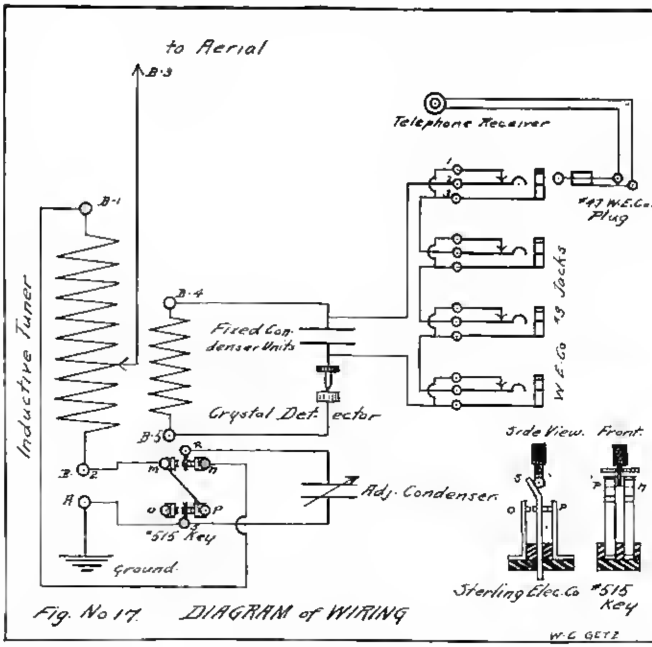


Fig. No 17 DIAGRAM of WIRING

The secondary of the tuner connects from its terminal *B4* to one side of the fixed condenser unit. The other side of the fixed condenser unit goes to the detector, and from the detector, back to the terminal *B5* of the secondary.

Across the fixed condenser unit is connected a set of four telephone jacks. These are the Western Electric Co.'s No. 3 jacks, which correspond with the same company's No. 47 plug. In many stations the experimenter has more than one set of telephone receivers, and when his friends are present he likes to cut in additional telephones so that they can "listen in." This is a great nuisance, if the telephone cords have to be connected together with old binding posts or short pieces of wire, and even when connected, frequently in the midst of a message someone moves and breaks the connection, leaving all the instruments dead.

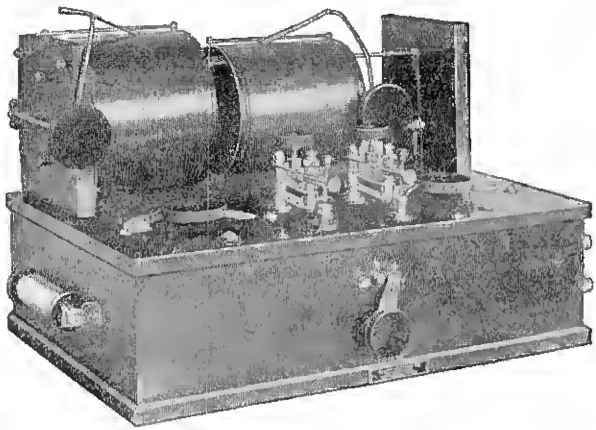


Fig. 18. Clapp-Eastham Receiving Set

With this jack, the spring 1 is normally in contact with the spring 2. When the plug is inserted in the jack the "tip" of the plug engages spring 2 and forces it away from spring 1, thus opening the connection previously existing here. But at the same time the "sleeve" side of the plug makes connection with the collar of spring 3, thus placing the telephone receiver connected to the plug in series with spring 1 and 3. When several of these jacks are used as shown, spring 1 is connected to spring 3 in each jack, and spring 3 connects to spring 2 of the following jack. Thus, when only the first plug is inserted, the circuit is closed through the following jacks. Inserting a plug in any of the other jacks places the second receiver in series with the first one instantly, and without interfering in any way with the operating of the first one. In a like manner, a receiver may be removed from the circuit, and the instant the plug leaves contact 2, the spring makes contact with 1, and the circuit is closed through.

This will be found a great convenience in not only experimental but also in all commercial stations, as it eliminates the interruption to business that is bound to occur when it is necessary for a second operator to cut in.

These jacks, while they come mounted singly, can also be had in a strip of four, on what is known as the W. B. Co. No. 99-30 mounting strips. It will be this style of strip that I shall designate for the assembly drawing, to be given later. The list price of these jacks is 17 cents, and with the No. 99-30 (special) would probably be about 45 cents, so that the set of four would cost $1.80. The No. 47 plugs also list at 45 cents, thus making $3.60 for the complete set of plugs, jacks and mounting. As this is the list price, there may be some reduction from same.

The Assembling of the Receiving Instruments

Many experimenters like to assemble their receiving instruments

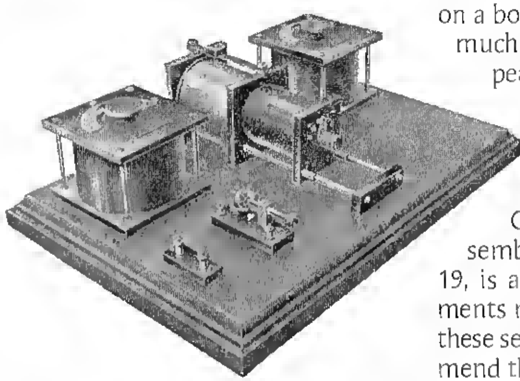


Fig. 19. Murdock Receiving Set

on a board or in a case, as it makes a much more compact and neater appearance than having them lying loosely all over the operating table.

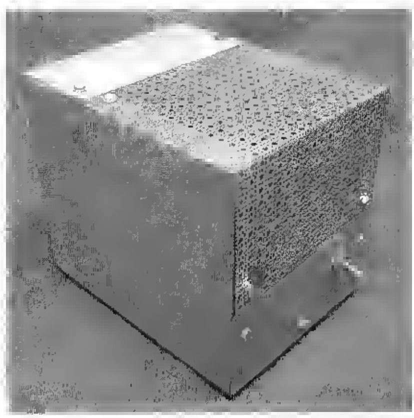
In Fig. 18 is a receiving set made by Clapp-Eastham Co., the apparatus being assembled in a compact case. In Fig. 19, is a set of the Murdock instruments mounted on a board. Both of these sets have many features to commend them to the experimenter...

More on Power Supplies

Trying to power a tube radio with batteries is, at the very least, expensive. A solid, stable power supply makes tube radio building fun. You build, attach the power leads, and fire it up.

Power supplies are not difficult build. In fact, compared to radios, they're so easy to build, that they're boring. The only substantial difficulty is getting a power transformer. Transformers with old-time voltages like 320-0-320, 6.3, and 5 are still available but can cost $50 on up. With so few sold today, the high price is necessary. Transformers offering just 6.3 volts are readily available and inexpensive. But higher voltage transformers are not needed in large quantities in this day of low voltage transistors.

Another solution can be found in catalogs from such firms as Mouser and Digi-Key. There you'll find transformers with four identical 115 volt windings. They're sold as step-up, isolation, or step-down transformers depending on how you connect the windings. If you connect the primary pair of coils in series, being careful that they don't "buck" or fight one another, you end up with a single 230 volt winding. The same can be done with the secondary windings.



An inexpensive, high performance power supply

If you connect the windings in parallel, here again being careful not to buck the windings, you get a single winding that handles 115 volts. Same for the secondary windings.

So if you have a primary and secondary with either 115 volt or 230 volt windings, that means you can create four different combinations: 115 in &

115 out; 115 in and 230 out; 230 in and 115 out; and 230 in and 230 out. Although I haven't tried it, it should be possible to connect two secondary and one primary winding in series to give 345 volts out with 115 volts in.

If we take the 115-in-and-230-out combination and run the 230 volts through a rectifier and into a capacitor input filter, we find we get pulsating DC greater than 230 volts. That's because the 230 volts AC is measured in RMS volts (kind of a fancy average), but the capacitors will charge up to peak voltage which for a 230 RMS winding is actually about 325 volts. And in practice you'll probably get close to 350 volts under no load conditions.

We can use the 115-in-and-230-out combination as a power transformer and create a power supply that, with minimal load, will provide voltages over 300. That sounds great, but the problem is that when you start drawing current, the value drops down closer to 230 volts. This change in output voltage is called poor regulation. With a receiver it's not too big a problem as long as you put a regulator tube like an OA2 in the local oscillator circuit so that the receiver doesn't jump to a different frequency when your air conditioner kicks on. The IF and/or audio sections are not so sensitive to voltage variations. But a good power supply that provides direct current at stable, predictable voltages with little hum is always desireable.

The neatest little solution to the problem of regulation is to use a modern MOSFET (metal oxide semiconductor field effect) transistor. These amazing tiny devices which are very much like a triode can withstand hundreds of volts, and when fully on, conduct 10, 15, 50 amps or more. And they only cost a dollar or so. What you do is use the MOSFET as a valve to regulate the output voltage so that it won't change regardless of whether you draw 10 ma or 500 ma from the supply. The MOSFET will make the necessary adjustments so that the output voltage remains the same.

For example, a high dc voltage is applied to the regulator, one that varies from 270 to 340 volts depending on load. A chunk of that voltage disappears across the regulator transistor and out comes a rock solid, unchanging 250 volts, or whatever you need.

If you draw very little current, say 10 ma, the input voltage will rise to 340 volts. But the output stays at 250. The difference is 90 volts. So what happened to the electrical power? It turned to heat. How much? Calculate: the power through the transistor .01 A (10 ma) times voltage, 90 volts, to get 9/10 watt turned to heat.

If we draw, say, 125 mA, the input power to the regulator is now 270 volts. Again we get 250 volts out. The current is way up but the voltage drop across the transistor is only 20 volts (270 less 250). Now the wattage is .125 (125ma) x 20 volts = 2.5 watts.

Let's suppose a wild worst case. Lets suppose we want 150 volts out of the regulator while we're drawing 200 ma of current. And lets suppose the voltage into the regulator is 385 volts. 200 ma = .2 A. An input of 385 less 150 out gives a drop of 235 volts. How much heat will be generated inside the transistor? Watts = .2 A x 235 v = 47 watts.

The question is whether or not we'll burn up the MOSFET. In this particular regulator I chose an IRF730 that cost about a dollar. It has a breakdown voltage of 400, so it can withstand the input voltage. This thing can handle 5-1/2 amps! So .2 A is within limits, too. And it can dissipate 100 watts, so that's

(continued on page 18)

TRIAD **CHASSIS MOUNT - WORLD SERIE**

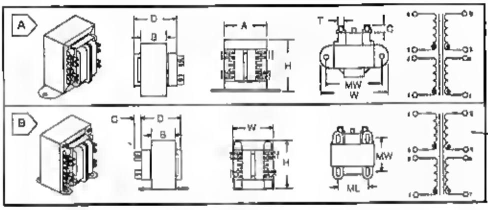
Specifications:
- Quick connect terminals
- Hi-pot tested @ 4,000VRMS
- Primary: 115/230V, 50/60Hz

For quantities greater th

MOUSER STOCK NO.	Fig.	VA	Secondary	
			Series	Parallel
553-VPS122000	A	25	12.6VAC CT @ 2.0A	6.3VAC @ 4.0A
553-VPS123400	A	43	12.6VAC CT @ 3.4A	6.3VAC @ 6.8A
553-VPS126300	B	80	12.6VAC CT @ 6.3A	6.3VAC @ 12.6A
553-VPS161600	A	25	16.0VAC CT @ 1.6A	8.0VAC @ 3.2A
553-VPS162700	A	43	16.0VAC CT @ 2.7A	8.0VAC @ 5.4A
553-VPS165000	B	80	16.0VAC CT @ 5.0A	8.0VAC @ 10.0A
553-VPS241000	A	25	24.0VAC CT @ 1.0A	12.0VAC @ 2.0A
553-VPS241800	A	43	24.0VAC CT @ 1.8A	12.0VAC @ 3.6A
553-VPS243300	B	80	24.0VAC CT @ 3.3A	12.0VAC @ 6.6A
553-VPS247300	B	175	24.0VAC CT @ 7.3A	12.0VAC @ 14.6A
553-VPS36700	A	25	36.0VAC CT @ 0.7A	18.0VAC @ 1.4A
553-VPS361200	A	43	36.0VAC CT @ 1.2A	18.0VAC @ 2.4A
553-VPS362200	B	80	36.0VAC CT @ 2.2A	18.0VAC @ 4.4A
553-VPS230110	A	25	230.0VAC CT @ 0.11A	115.0VAC @ 0.22A
553-VPS230190	A	43	230.0VAC CT @ 0.19A	115.0VAC @ 0.38A
553-VPS230350	B	80	230.0VAC CT @ 0.35A	115.0VAC @ 0.7A

Sample listing from a Mouser catalog. Mouser is not the only source, and Triad is not the only manufacturer. Stancor, Magnecraft, and others have their own verisons.

All primaries are 115/230 volts with a variety of secondaries provided. The last line shows the voltages we need with with a power capacity of 80 watts (or VA, volt-amps).

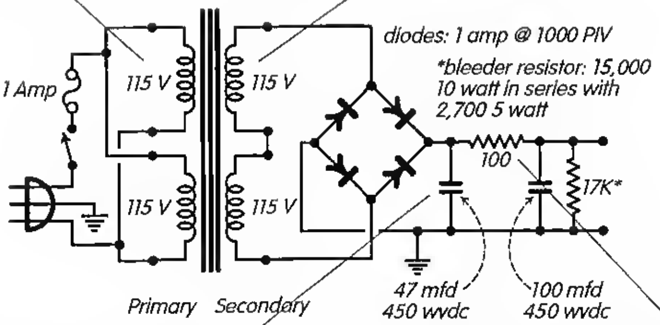


Here we see the physical dimensions of the transformer, and the windings available.

VA	Dimensions (In.)							Mounting	
	H	W	D	A	B	C	T	MW	ML
25	2.3125	2.8125	1.93750	2.0000	1.125	.3125	.1875	2.3750	....
43	2.6875	3.1250	2.00000	2.3125	1.125	.3125	.1875	2.8125	....
80	3.0000	2.5000	2.31250	....	1.375	.3125	.1875	2.0000	2.250
175	3.7500	3.1250	2.81251	....	1.625	.3750	.2500	2.5000	2.500

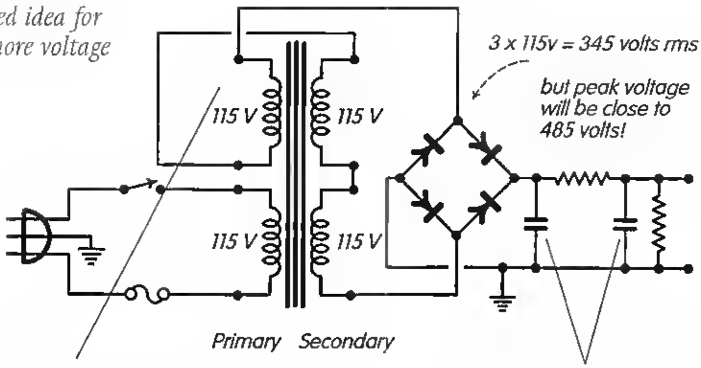
Primaries wired in parallel – 115 volts at 700 ma (see specs above)

Secondaries wired in series – 230 volts at 350 ma (see specs above)



Don't make this too much larger in capacity, or it may draw so much charging current when you turn the power supply on that it pops the fuse or melts the diodes

Lots of heat here. wattage = $i^2 \times R$. here .1A x .1A x 100Ω=1 watt so use at least a 3 watt resistor (see Experimenter No. 4 for more on power supply design) *untested idea for even more voltage*



Secondaries and one primary winding connected in series to provide 345 volts rms. Power is limited by 115v primary winding: 115v @ .35a, or 40 watts (VA). This means max output current will be no more than 117 mA at 345 V.

If you try this supply, be sure your capacitors can withstand the higher voltages. And higher voltages are more dangerous. Ground and fuse everything properly as always.

more than double what we'll generate under worst-case conditions.

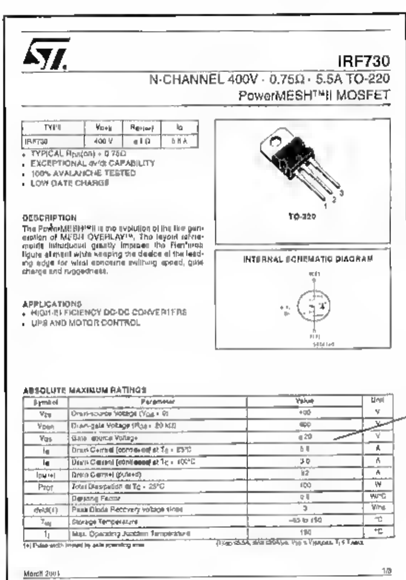
This information comes off the spec sheet for the IRF730 downloadable through the internet from the manufacturer, STMicroelectronics. One important maximum that cannot be violated is the Gate-Source Voltage of ±20 volts. Should the voltage measured between gate and source ever get to 20 volts more more, you'll probably blow the transistor. That could happen if you make a mistake building or using the power supply. To prevent damage, put a zener having a turn-on voltage a bit lower than the maximum specified between the gate and source. Here, I used a 18 volt 1/2 watt zener. If voltage gets to 18, the zener will turn on, and hold the voltage at 18 never allowing it to go higher.

It's very important to realize you don't have to use the IRF730. Use whatever you can find at whatever price you can afford. Get a spec sheet for it. Be sure that you're not going to apply more voltage than the rated maximum drain to source voltage, that you're not exceeding the maximum current (very hard to do), that you're not exceeding the maximum dissipation in watts, and that you can protect the gate-source against overvoltage.

These transistors were built to be power switches, that is, to be turned completely on or completely off. And they're built to get from one condition to the other very quickly. We can use them in a linear circuit like the regulator so long as we're careful not to push them too hard. We do that by choosing a transistor with specs that are greater than our needs and by mounting the transistor on a sheet of aluminum insulated from the rest of the electrical circuit. A piece of aluminum, say, 3" x 5" will suck the heat out of the transistor and release it into the air. Without the aluminum heat sink, you have only a matter of minutes (or less) before the semiconductor melts. And it's best to use some of that nasty, white, sticky heat-conducting grease to ensure an efficient transfer of heat from the transistor body into the aluminum heat sink.

The regulator operates in a very simple manner. One zener diode, or more in series, creates a solid, unchanging reference voltage that turns on the normally-off transistor. (The IRF730 is an enhancement mode n-channel device.) That zener-stablized voltage is also effectively compared with the output voltage, and the gate voltage is changed accordingly to bring the output voltage up or down to keep it at the desired value. Generally speaking, a 150 volt zener will give you 150 volts output. A series of zeners and a selector switch could give you a range of voltages. Or like the unit I built here, a pot allows continuous adjustment.

One other thing. Regulators need some mininum voltage drop across them, say, 20 volts. The exact amount varies from one regulator design to the next. If our regulator has a drop-


![ST logo]

IRF730

N-CHANNEL 400V - 0.75Ω - 5.5A TO-220
PowerMESH™II MOSFET

TYPE	V_{DSS}	$R_{DS(on)}$	I_D
IRF730	400 V	< 1 Ω	5.5 A

- TYPICAL $R_{DS}(on)$ = 0.75Ω
- EXCEPTIONAL dv/dt CAPABILITY
- 100% AVALANCHE TESTED
- LOW GATE CHARGE

TO-220

DESCRIPTION
The PowerMESH™II is the evolution of the first generation of MESH OVERLAY™. The layout refinements introduced greatly improve the Ron*area figure of merit while keeping the device at the leading edge for what concerns switching speed, gate charge and ruggedness.

APPLICATIONS
- HIGH-EFFICIENCY DC-DC CONVERTERS
- UPS AND MOTOR CONTROL

INTERNAL SCHEMATIC DIAGRAM

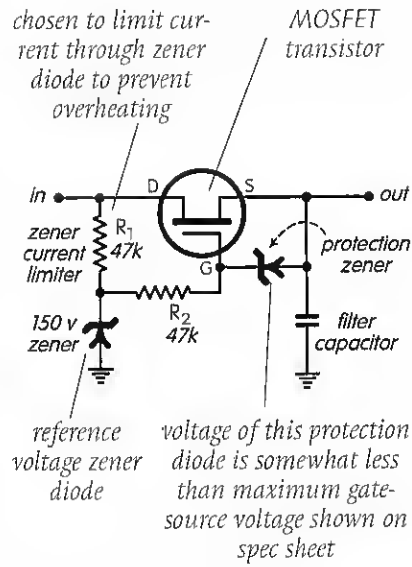
ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
V_{DS}	Drain-source Voltage (V_{GS} = 0)	400	V
V_{DGR}	Drain-gate Voltage (R_{GS} = 20 kΩ)	400	V
V_{GS}	Gate- source Voltage	± 20	V
I_D	Drain Current (continuous) at T_C = 25°C	5.5	A
I_D	Drain Current (continuous) at T_C = 100°C	3.5	A
I_{DM}(•)	Drain Current (pulsed)	22	A
P_{TOT}	Total Dissipation at T_C = 25°C	100	W
	Derating Factor	0.8	W/°C
dv/dt(1)	Peak Diode Recovery voltage slope	3	V/ns
T_{stg}	Storage Temperature	-65 to 150	°C
T_j	Max. Operating Junction Temperature	150	°C

(•) Pulse width limited by safe operating area
(1) $I_{SD} \le 5.5A$, di/dt ≤ 90A/µs, $V_{DD} \le V_{(BR)DSS}$, $T_j \le T_{JMAX}$

March 2001 1/8

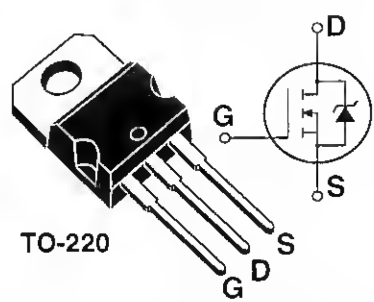
Basic FET Voltage Regulator



out voltage of 20, and we want 250 volts out, we'll have to put no less that 250 + 20, or 270 volts, at all times. More is okay. But less than 270 will prevent the regulator from functioning properly.

In the last days of vacuum tube

(continued on page 23)

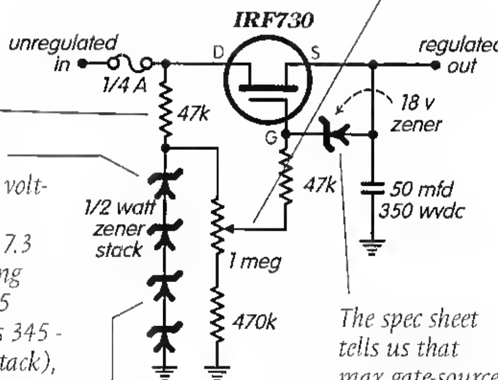


Download a spec sheet. Here, on STMicroelectronics spec sheet for the IRF730 you'll find maximums specified first:
max drain-source voltage
max gate-source voltage
max current
max dissipation

The circuit used in the supply shown.

The 1 meg pot (don't use anything much less) and the 470K resistor supply a reference voltage to the gate that can be varied between 254 volts and 81 volts. The output voltage will vary by about the same amount.

47K is about the right value to get the 18 volt protection zener to fire if necessary. Under normal operation, almost no current flows through this resistor. Any wattage is okay.



Maximum current allowed through the stack will be watts ÷ voltage for the largest voltage zener.

Here, .5w ÷ 68v = .0073a or 7.3 ma. The maximum voltage coming from the power supply will be 345 volts. Voltage across the resistor is 345 - 254 volts (the total of the zener stack), or 91 volts. Ohms law: 91 volts ÷ 7.3 ma = 12,466 ohms. That's the smallest value allowable.

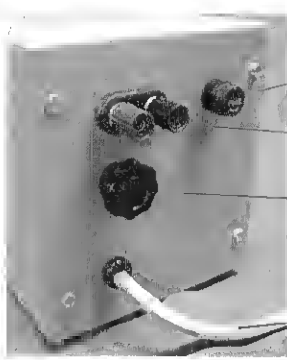
How about 47K? 91 volts ÷ 47K = 1.9 ma. That's a safe, low value, but still enough current to be sure the zeners are working properly.

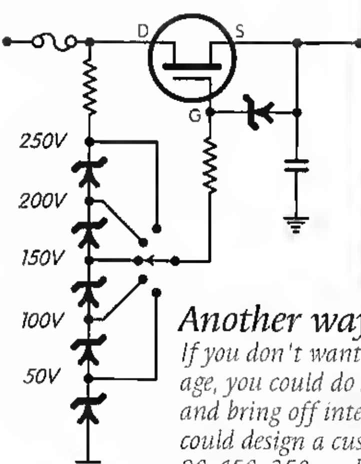
What wattage? watts=V²/R, or 91 x 91 ÷ 47K= .18 watts. A quarter watt (.25) resistor will be adequate. eighth watt (.125) will not do.

From the junk box I used two 25 volt and three 68 volt 1/2 watt zeners in series to get a 254 reference voltage.

The spec sheet tells us that max gate-source voltage is 20. So we use something a bit less here. 18 volts is good.

rear panel

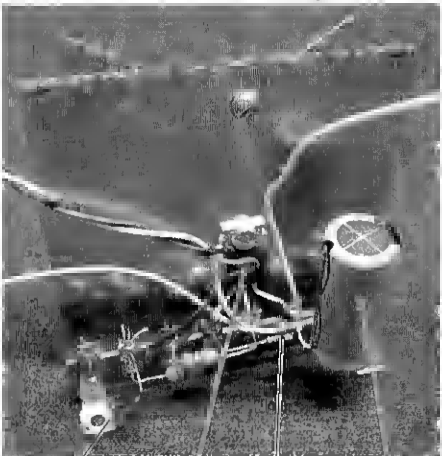




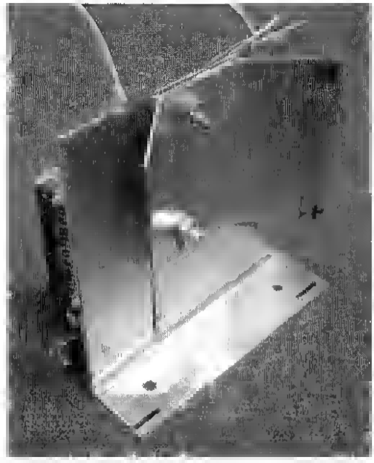
Another way to approach the problem.

If you don't want or need a continuously variable output voltage, you could do something like this. Stack a variety of zeners and bring off intermediate voltages to a selector switch. You could design a custom stack to deliver common tube voltages: 45, 90, 150, 250, and 300 volts.

Front of Heat Sink and MOSFET subassembly

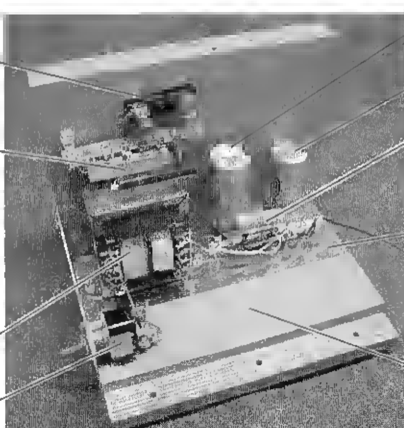


Rear of Heat Sink and MOSFET subassembly



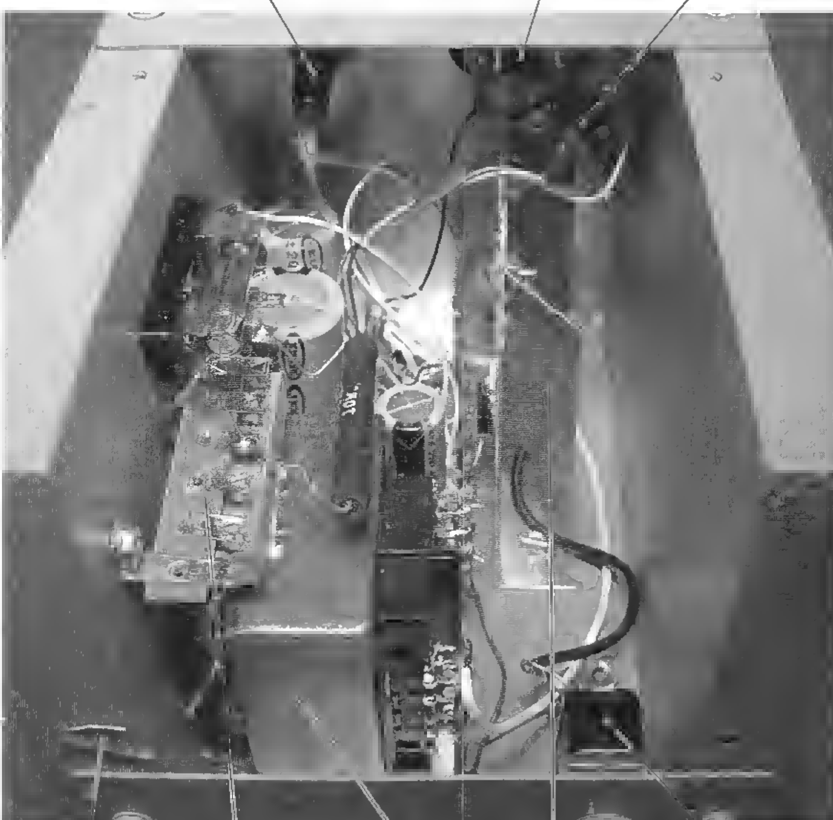
One of the machine screws holds the transistor tight against the aluminum plate and secures a second wing plate to help dissipate heat. This heatsink must NOT come in contact with ground or any other part of the power supply circuit since it is electrically connected to the transistor drain and will be at high voltage at all times. AND! Be sure to enclose your power supply in some kind of protective enclosure so that you don't accidentally touch the heat sink while the power supply is on.

(below) A simple case was built from common dimension lumber and painted. A front aluminum plate holds the power switch. A rear panel anchors everything else. Aluminum cane metal from the hardware store is wrapped over the top. It is important that all three panels be grounded for safety.



Looking into the completed power supply

After the regulator assembly is installed, the remaining wooden side and aluminum end panel are attached and wired up. Only the cane metal top needs to be installed.



production, a low-noise, high-sensitivity triode built for television tuners might have a transconductance of 15,000 or more (which is very high). This one dollar field effect transistor, when conducting heavily, has a transconductance of almost three million! That's 200 times more sensitive. Here, since we don't drive the transistor nearly as hard as it can be, we might only get one million. That sensitivity is what allows the regulator to react so quickly to changes in input voltage, so fast in fact, that the regulator will remove hum (known as ripple) that sits on the dc. The extremely high conductance of a MOSFET switch allows us to use a resistor where, in the past, we would have installed a large filter choke. No choke means smaller size and less expense.

To simplify construction, subassemblies are created around terminal strips, and then installed. Here are the rectifiers, filter capacitors and 100 Ω pass resistor. The bleeders are on another assembly.

You can put a regulator on your existing power supply for very little money – just a couple of dollars – and turn a mediocre supply into a top rate performer!

An Artificial Long Wire Antenna

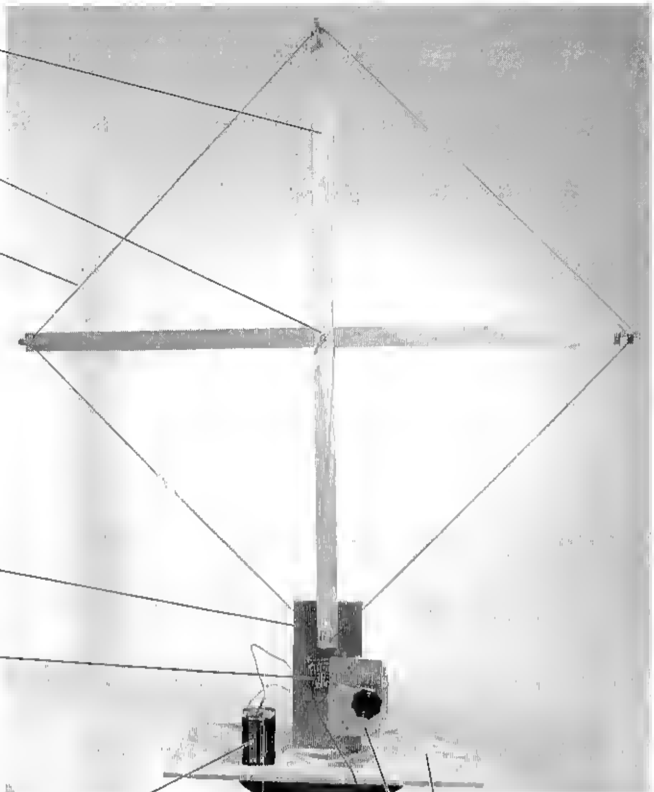
If you live in an apartment or have a small lot and can't string up a really good long wire for your crystal set, then it's time to consider an active loop antenna. It's easy to build, inexpensive, and can lead to a whole new area of experimentation.

The reason why loop antennas work is based on complex electromagnetic theory. You can dig into it if you want. And it's worth doing. But you don't have to understand it to have fun with the antenna.

We can greatly simplify the complexity by saying that a lower frequency transmitter such as an AM radio station transmits electric and magnetic waves at right angles to one another. They usually come off the antenna at a particular angle called polarization but not always. For lower frequencies the waves hover near the ground and follow the curvature of the earth. These are ground waves. And because they're so close to the ground, the ground, being a conductor, in essence acts like a filter. About the only part of the wave that will reach your radio intact at any distance from the transmitter antenna will be vertically polarized. That means your loop antenna must be vertical and aimed in the direction of the transmitter for it to respond.

Loop antennas respond to lower frequency ground waves from distant transmitters and are relatively immune to local electrical noise. And because they can be made resonant they will respond strongly to a particular wave

a simple active loop antenna for indoor use



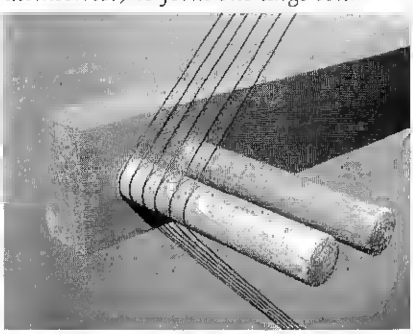
length. And! They can ignore radio signals coming from other directions, because of their strong directional characteristics. If you attach a two transistor rf amplifier to the resonant antenna, you can drive a crystal set to surprising volume. You can use this simple device as a substitute for a long wire.

The first loop antenna I put together was made from a pair of four foot long sections of standard 1"x2" dimension lumber joined in the middle with a simple lap joint and a bolt. This, in turn, was bolted to a dimension lumber bracket attached to a particle-board base to provide stability.

At the end of each arm I drilled a pair of 1/2" holes and inserted sections of 1/2" diameter hardwood dowel. Only one peg at each end is needed, but I wanted to try different winding techniques. The photos will show you there is nothing at all complicated involved.

Six turns of #28 enamled wire were wound around the outer pegs. There is nothing special about #28. Use what you have. No. 12 might be a bit too large in diameter and too stiff to wind easily, but it will work. No. 32 might be so small that it breaks easily. Almost any insulated wire will do. Each of the four arms measured about 33-1/4" in length, resulting in

Two pegs were installed at the end of each arm to allow for experimentation, but only one is really needed. Here, wires are bundled closely together. Some experimenters use multi-conductor cable or computer cable to wind a single turn. The wires at the ends of the cable are wired to one another (not to themselves!) to form one large coil.



Here, the six strands of No. 28 are spread apart to see how much the natural frequency of the coil would rise by eliminating part of the inter-winding capacitance. By taking measurements and by using the basic resonance formula, I found that a six turn close wound coil had an inductance of 149 μh with 47 pfd of capacitance and a Q of about 90. Spreading the wires produced an inductance of 117 μh with 36 pfd. Each coil seems to work equally well, but you can see just a small amount of spacing will have an effect on the tuning of your loop.

about eleven feet of wire needed per turn. So for six turns, you need about sixty-six feet.

The turns needed will depend on the length of the arms you decide to create. For this size loop I found that putting a 27 pfd capacitor across the coil made it resonate at 1170 khz. That was with the wires close together. Putting 300 pfd across the coil resulted in a resonant frequency of about 700 khz. With the wires spread apart, the 300 pfd capacitor produced a resonant frequency of 800 khz indicating that spacing the wire will reduce the inter-winding capacitance as expected.

Six turns for this first loop might be too much. It won't cover the whole broadcast band with a standard 365 pfd capacitor. Taking off a turn will decrease the inductance, requiring more capacitance for resonance, but the capacitor will have a far greater effect on changing the frequency. If you decide to build a loop with these dimensions, try six turns at first. The coil formulas don't work well for loop antennas, so the only way to find the right number of turns is cut and try.

A better solution is to use a large capacitor. A double or triple section 365 pfd variable capacitor salvaged from an old radio (they're common) with the sections wired in parallel will give you a total variable capacity of 730 pfd or 1095. I ended up using an old General Radio 1500 pfd variable capacitor designed for laboratory use. They'll usually provide a capacitance between 80 and 1500 pfd, and work beautifully with this a lower frequency loop. They can usually be found at flea markets and on the internet auction sites. They're quite common, so don't pay too much. At a flea market a few years ago, I acquired a brand new 1000 pfd Cardwell variable for $8, and a National velvet vernier dial drive for

(above) dimension lumber bracket attached to base board (below) details of the tuning capacitor.

it for another $5. But General Radio is top of the line equipment.

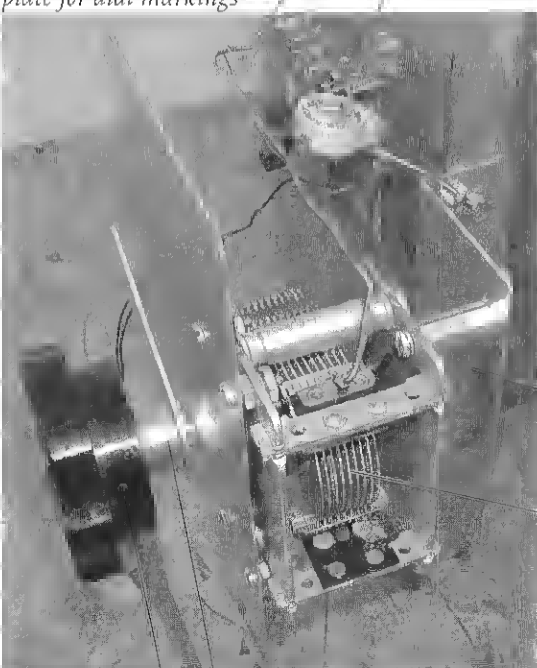
In building an antenna, you don't even have to do any carpentry if you don't want. I wound ten turns around a cardboard box. Each turn had two sides about 18" long and two sides about 9" long. With about 100 pfd the "antenna" resonated at about 1500 khz. Such an antenna will provide signals, but a larger antenna can capture more energy from the magnetic waves. Here, bigger IS better.

The RF Amplifier

The RF amplifier is a simple little circuit that has been kicked around in long wave circles for a good many

plate for dial markings

Ceramic variable capacitor across the coil. Adding or removing a single turn from this loop will have a major impact on the resonant frequency. To get the loop on frequency, you wind it to a slightly higher frequency needed and then pull it down with a padding capacitor like this. Just a small amount of capacitance pulled this loop down into the middle of the AM broadcast band.

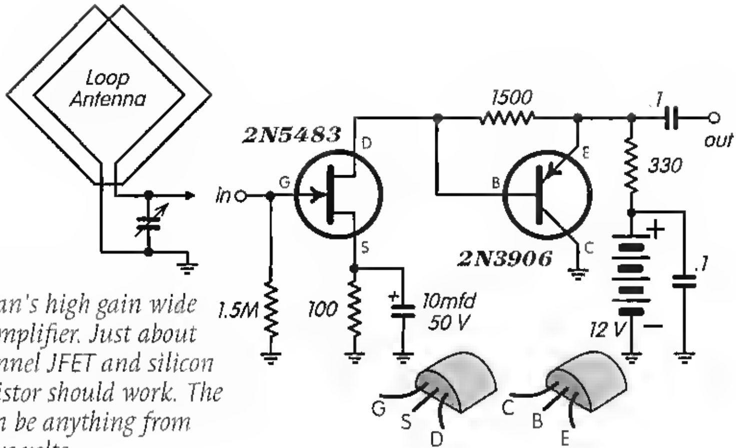


support bracket for variable capacitor

400 pfd variable dial drive chosen because it has a built-in vernier dial drive about 3 to 1

bakelite knob

aluminum pointer attached to a shaft collar with machine screws

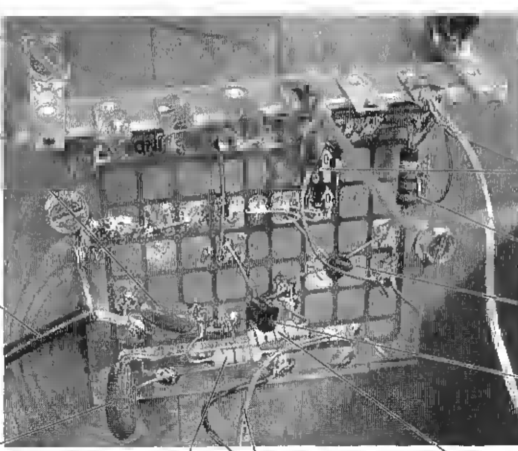


Ralph Buran's high gain wide band RF amplifier. Just about any N-channel JFET and silicon PNP transistor should work. The battery can be anything from six to twelve volts.

years in somewhat different forms. I first saw it in The LF EXPERIMENTER'S SOURCE BOOK, compiled by Peter Dodd, G3LDO, and published by the Radio Society of Great Britain. It contains reprints of articles from various sources covering the technical aspects of transmitting and receiving on frequencies below our AM band.

In his article, ***Active Antenna Coupler for VLF,*** HAM RADIO, October 1979, Ralph W. Burhans discusses active low-frequency and very low frequency antenna preamps with some details for extending the the frequency to 10mhz and above. He describes a simple two transistor circuit that could be water-proofed and mounted at the

(below) The entire rf amplifier is easily built on a 2" x 3" piece of surplus printed circuit board that has been etched with pads. The board is anchored with #6 x 3/8" sheet metal screws. The eight lug strip anchors leads from the antenna and variable capcitor.

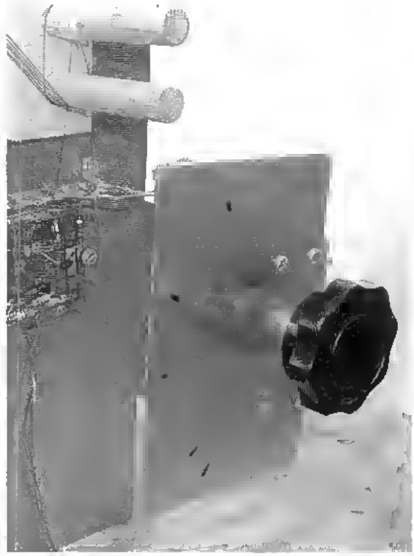


base of the antenna located out in the "back forty". Using chokes and capacitors, direct current can be fed through the coax to the amp from the house, while the amp feeds radio signals from the antenna back to the house without the two currents interfering with one another.

Nine components and a battery are all you need. The base of a field effect transistor is connected across the loop and its resonating capacitor. Here, I used a 2N5483 which is a common and inexpensive n-channel JFET. If you don't have that particular transistor, try another. There is nothing magical about this particular type. And we're dealing with frequencies so low that frequency response is not an issue.

The JFET feeds a common PNP bipolar transistor like the common 2N3906 used here. Again, others will work. But be sure that it is PNP or the circuit won't work. And be sure it's a relatively modern transistor that has reasonable gain or the bias in this direct coupled circuit could be upset.

I used a six-volt lantern battey because I had one. A simple nine-volt battery would probably do as well. Don't be afraid to substitute. One of the most self-defeating attitudes beginning experimenters have is they must have



(above) I used a Sharpie™ permanent marker to note positions where local radio stations can be found. The markings can easily be removed with a tissue dampened with lacquer thinner.

(above) A general radio 539B capacitor is a convenient variable capacitor to use for lower frequency experimentation. Zero on the numbered dial corresponds to about 50 pfd, and 100 corresponds to about 1050 pfd, to give a total range of 1000 pfd. The top plate is 1/4" aluminum, and the entire capacitor is lined in a copper foil shielded solid walnut box.

This ancient General Radio capacitor probably dates to the late 20's. The original dial was gone and the hard rubber top broken beyond repair. But the capacitor inside (below) was undamaged. The price was quite reasonable. The gear reduction drive allowed very precise adjustment of the instrument.

A new top was fabricated from hardwood plywood, a dial added, the capacitor was put back into experimental service. A great help in LF and VLF development.

EXACTLY the values called for. That usually isn't true. Especially in simple circuits. You can be successful with the components you can find.

To use the loop and amplifier, just connect the output terminal to the antenna terminal of your crystal set. Now the "fun" begins. You have three adjustments to make, two critical and one not so critical. The not-so-critical adjustment means turning the antenna into the wind, well... aiming it at the radio station you want to receive. The loop forms a plane. The plane must be in line with the direction to the transmitter. Don't aim the flat plane to the signal path. With the loop in my basement I only had to roughly position the antenna within about 45° either side of ideal to pull in weak stations 75 miles away. At other sizes in other locations, the directivity can be very sensitive.

The two critical adjustments are merely those of tuning the loop antenna and the crystal set to the same frequency as the station. If you have experience with your crystal set you probably already know where to find a station. Set the dial on your radio to the station. Aim the antenna, and then use the variable capacitor on the antenna for maximum volume. You may have to "play" with the two, peaking one and then another, until you can get them to both hit on a

A cardboard box will make a useable loop antenna if it is large enough. This 12x18 box wound with 10 turns provided an inductance of 142 µh with 39 pfd and a Q of 61. Attaching the General Radio capacitor I found at a setting of 10 (about 118 pfd) the antenna would resonate at about 1075 khz and with about 220 pfd a frequency of 830 khz could be achieved. Although you can put it on the desired frequency, this box antenna will not work nearly as well as the larger 1x2 antenna.

signal simultaneously. It didn't take me more than a minute or two to get the "feel" of it.

The real problem you get into is if your loop antenna won't at all tune the station you're looking for because you have too much or too little capacity or because you don't have the right number of turns on the antenna. Now you're shooting in the dark to some degree. In such a case, try removing a turn from the antenna rather than adding one. Try finding a station by tuning the receiver and the antenna. No luck? Try a bigger variable capacitor, perhaps a two or three section 365 pfd variable salvaged from an old broadcast receiver. Put the sections in parallel. Putting that on the antenna will allow you to vary the resonant frequency all over the map. It shouldn't take long to close it on a station. Once you have one station, you can vary both up or down in frequency to log other stations. Getting the first one is always the most difficult.

If all else fails, use the alignment oscillator built in Experimenter 5 together with the audio generator from Volume 2. That should give you a signal at about 400 khz. Or remove one of the capacitors from the alignment oscillator to shift its frequency upward into the AM radio band. That will give you a very loud signal with which to test your antenna and crystal set.

Other ideas, findings, notes, and suggestions accompany the illustrations here. Loop antennas are easy to build and perform exceptionally well.

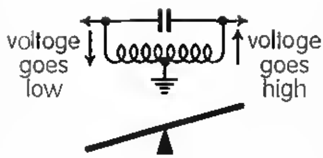
A Loop Regenerative Receiver

So we have a resonant loop. Directional. Sensitive. Relatively small in size. How can we turn it into a regenerative receiver to increase amplifications and selectivity? We can use the resonant loop as the main tuning circuit but we have to add feedback. Taping the coil to create a Hartley circuit would be quite difficult. Winding a tickler coil, almost impossible. The tickler would most likely have one turn too many or too few and could not easily be adjusted. But there is another way.

First, some basic oscillator theory. To make a transistor or tube oscillate you have to reinforce the signal on the grid. If the voltage on the grid drops, you want to take the output of the tube and put it back on the grid so that the voltage drops even more. That's positive feedback.

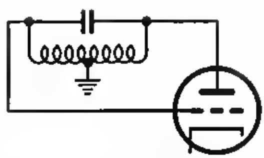
If the voltage on the grid drops, the plate voltage will increase. You can't just feed it back to the grid because it's the wrong polarity. This is negative feedback. You could feed a falling plate voltage back to the grid, but the voltage here is rising.

One simple, classic method used to change the polarity is with a tuned circuit. In a coil-capacitor tuned tank circuit, the electrical energy runs back and forth from the capacitor to inductor at a rate determined by the size of these two components. At any given moment one end of the tank circuit will be at one polarity and the other end at the opposite polarity. Wait half a cycle the polarity will reverse.



Usually a tank circuit is used to provide the necessary change in polarity to make an amplifier circuit oscillate.

If we tap the coil and ground it, we can think of the tank circuit as being a lever. When one end is up, the other end must be down. We can use this circuit as a polarity reverser if we feed the signal off the plate into one end of the tank circuit and take the signal coming out of the far end and channel it to the grid. This will work if the plate is hitting the tank circuit with the frequency it needs. And it is. After all, the tube is just amplifying the signal coming from the tank circuit. This circuit will oscillate. And, in fact, it's generally called a Hartley oscillator named after the Bell Laboratory inventor.


In a Hartley oscillator this is what the AC signal would see. To make this a practical circuit we need to add components to put the right DC voltages on the tube elements.

There are other configurations, the Colpitts, the Meissner, and others. And there's the Armstrong tickler feedback method. But we want to avoid taps and ticklers.

The solution to our regenerative loop antenna design problem is to use the same basic oscillator circuit we built in EXPERIMENTER 5 to test IF transformers (page 46). It's called a Franklin oscillator, although I tend to think of it as a astable multivibrator stabilized with a tank circuit. To achieve the necessary polarity reversal, we add a second tube or transistor.

In the diagram on page 32, suppose we have a voltage dropping on the grid of the first tube. The plate voltage rises. If we take this rising voltage and feed it to the grid of the second tube, the plate voltage on the second tube will drop. Since it is now of the correct polarity, we can feed it back to the first grid, where it reinforces the original dropping voltage. If the overall gain of the pair of tubes is more than one, the circuit will oscillate.

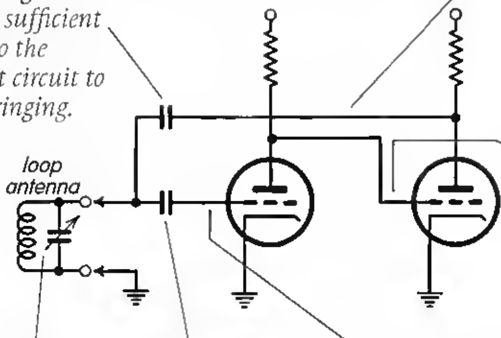
We don't even need a tank circuit with a circuit like this. It will oscillate if conditions are appropriate at a frequency determined by the size of the components in the circuit. By reducing the feedback to a minimum and attaching a tuned circuit to the input grid, we can get the circuit to oscillate at

Franklin Oscillator - Block Diagram

This capacitor is very small – just large enough to transfer sufficient energy to the resonant circuit to keep it ringing.

Feedback can be controlled by varying the size of the feedback capacitor or by varying the gain of the tubes.

3. Feeding the changing voltage from the second plate to first grid will give us the positive feedback we need to create and maintain oscillation



2. If the AC voltage is falling on the second grid, the AC voltage coming off the second plate will be rising.

The loop antenna, being a resonant circuit, sets and stabilizes the frequency of oscillation.

This capacitor is very small so that the first grid can only "hear" the very loud signal on the resonant circuit.

1. If the AC voltage is at some point in time rising on the grid, the AC voltage coming off the plate will be dropping.

whatever frequency we tune the tank circuit to. The tank circuit is like a bell ringing. The tubes amplify the ringing and feed back some of the energy which keeps hammering the bell.

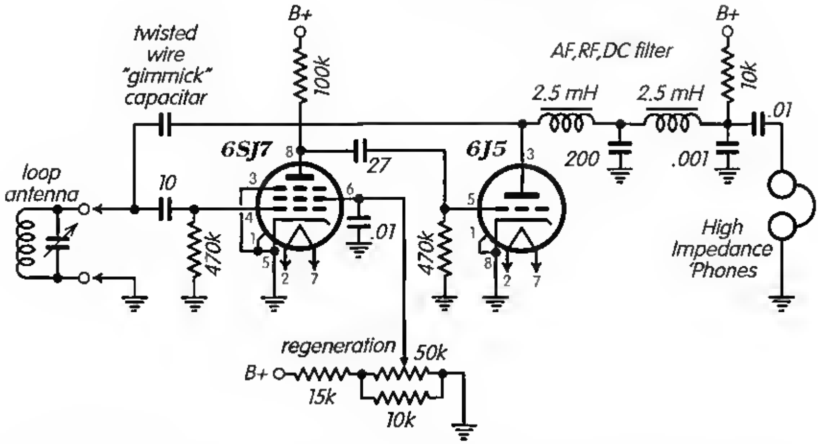
What this all means is that we can use our resonant loop as the main frequency determining component in a regenerative receiver without taps. If we get the gains of the two tubes about right, not too much, not too little, and feed just a little RF signal back through a "gimmick" capacitor of just a few picofarads we should have the makings of a regenerative receiver.

The big problem is controlling what's called the loop gain. We have to get the oscillator shut down to a point where it's just ready to oscillate. A signal coming in will supply the tiny amount of electrical energy needed to push the oscillator over the edge. As the incoming signal changes, the circuit goes into and out of oscillation. If we monitor the electrical energy we feed into the tube plates (the direct current) we'll see that it varies in proportion the incoming signal. So in effect, a regenerative receiver that balanced on the verge of oscillating will essentially extract the information on an incoming signal. That information will appear as an audio frequency superimposed on the direct current coming from the power supply.

In designing such a receiver we have to find a way to delicately balance the overall gain, and find a way to extract the audio frequency riding on the d.c. It it seemed the quick and dirty thing to do is take a standard pentode regenerative circuit whose gain is controlled by varying the screen voltage, and feeding the output signal to a simple triode that could act as the

Basic Receiver Circuit

The gimmick capacitor is a couple of 2" pieces of hook up wire twisted together. Untwist the ends as you adjust the screen grid voltage. When the oscillation stops, put a little twist back in. That should make the regeneration control very sensistive.

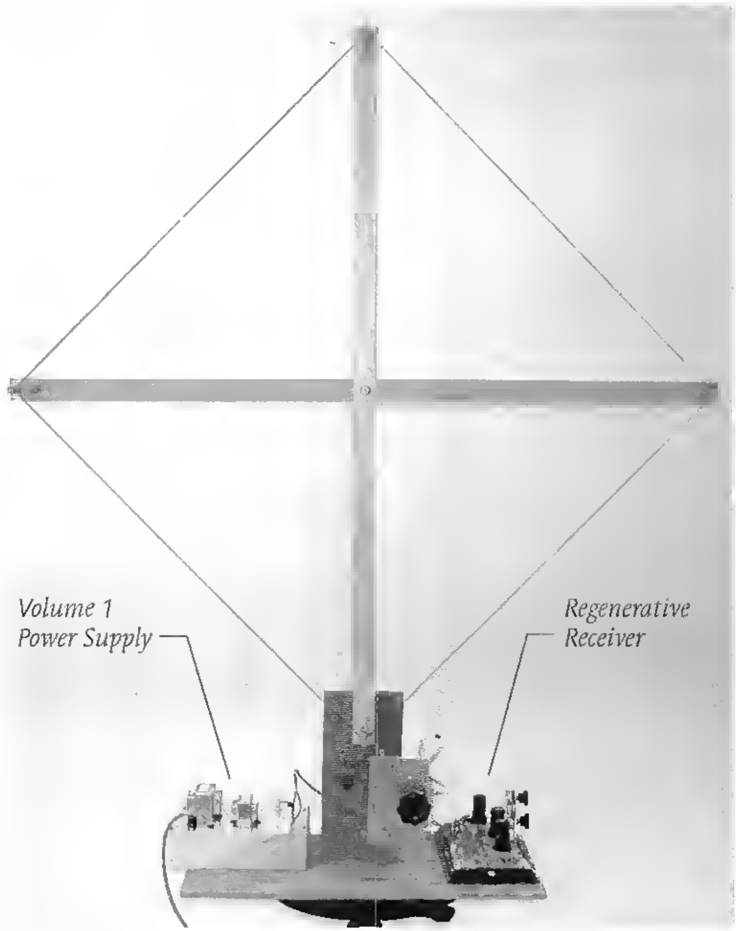


A working Franklin oscillator regenerative receiver for the broadcast bands. The two tubes shown, a sharp-cutoff pentode and a high-frequency triode, are common metal octal tubes. Other tubes will work quite well. You might try a 6AU6 and a 6C4 if you want miniatures. You might want to experiment with changing the gain of the first tube by switching to a remote-cutoff pentode and changing its bias with a cathode resistor as was done on the RF stage of the TRF described in Vol 4.

polarity inverter. And it worked. Not very well on first attempt, because all regenerative receivers must be adjusted so that they balance just on the edge of oscillation.

Since I have scores of metal octal vacuum tubes, I pulled out a standard 6SK7 pentode and wired it up with a standard grid leak bias and a 100KΩ plate resistor. A 27 pfd capacitor, very small for broadcast frequencies, moved the signal from the first plate into the grid of a 6J5 triode, another common tube. On the plate of the 6J5 can be found direct current, radio frequency currents (RF), and the audio frequency (AF) extracted from the signal. The only thing needed is a filter system to sort out the three components and feed the AF to a pair headphones.

What follows are details about a working receiver that is really a hot performer, at least for the AM radio bands. I've discovered low-powered daytime AM stations 75 to 100 miles away that usually don't come in on tube radios because of interference from other stations. This ol' loop receiver can focus in on the small ones! Try it. It's easy, and it will open a whole new line of experimentation for you.



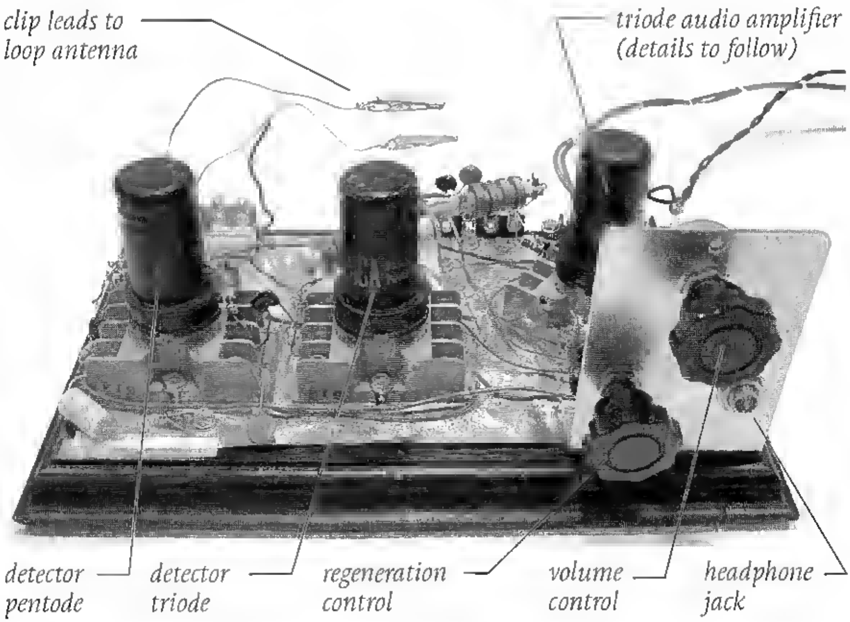
Here we see the experimental receiver set up and running. The receiver shown has an additional audio stage added (described later on.) And despite having to power three tubes, the simple power supply built in Volume 1 is more than adequate to drive headphones to very loud volume.

Regenerative receivers radiate signals. The oscillating detector acts as a weak transmitter feeding signals back out to the antenna. It can be a problem for powerful tubes on shortwave bands, but here we have a small tube, small power levels, very loose connection to the antenna, and a poorly radiating antenna. Loops like these are great for receiving but never very good for transmitting. The interference created by this little set should be minimal.

The Franklin Regenerative Receiver

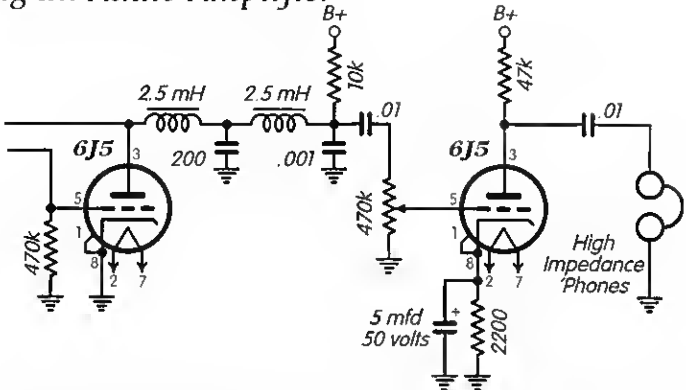
The receiver was put together on a pine board cover with aluminum foil acting as a ground plane. (The foil has wrinkled here because the dry winter air has caused the board to shrink significantly.) Inexpensive relay sockets are used.

Layout is not critical at broadcast frequencies. If you intend to take this receiver up in frequency, you may find stability difficult to achieve because of strange and unexplainable interactions between components and wiring. If you want to take the machine down in frequencies to longer waves that few people ever explore, you shouldn't have any problems, although you may have to increase the feedback capacity a bit.



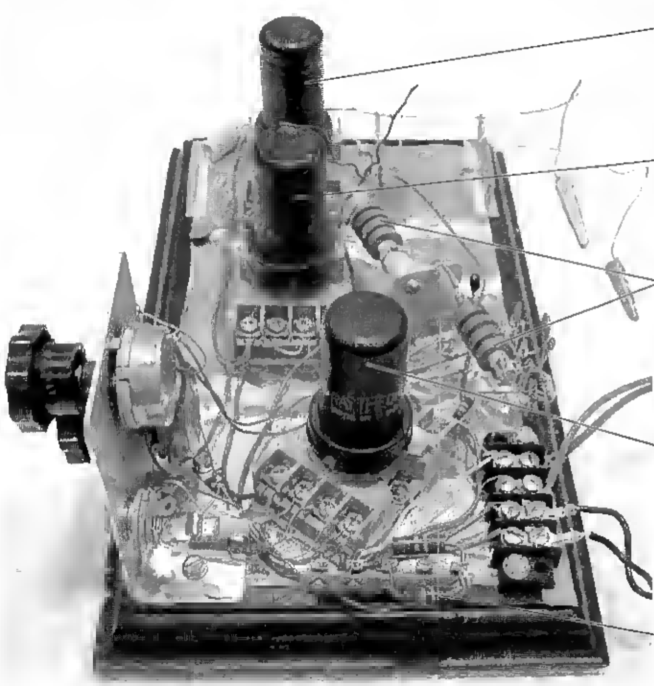
Two junk box 5 mh chokes were mounted on a single aluminum bracket and wired in series to give a total of 10 mh. You may want to put four 2.5mh chokes in series or some other combination. More is better.

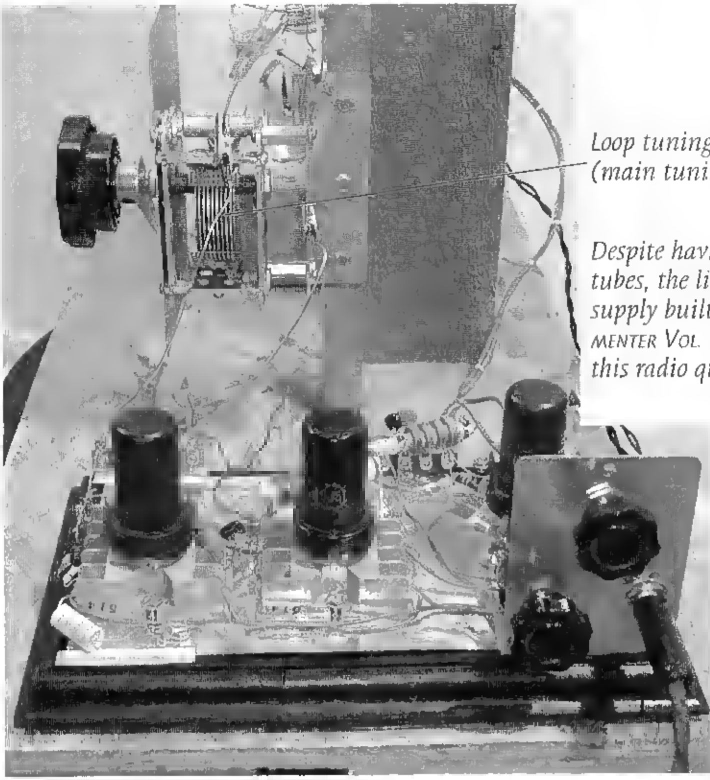
Adding an Audio Amplifier



If you want a bit more gain from your receiver, add a common triode. Here, I've used a 6J5 in common configuration. A half-meg pot was added to act as a volume control. You could probably use a pot as low as a 100K or as high as a megohm. Don't stray too far from the cathode and plate resistor values, or you may end up with distortion and/or improper plate current values.

The cathode capacitor is not critical. Just about anything from 5 to 100 mfd should work. Just be sure it has a working voltage above 15 volts. Modern capacitors made for solid state applications will work fine. Get the polarity right, though.





Extracting the Signal

A regenerative detector is merely an oscillator carefully balanced as the point where it is not quite oscillating. An incoming signal of the same frequency as the natural frequency of the circuit will push the oscillator over the edge into oscillation. So you should be able to use any oscillator as a detector if you can make it stay balanced on that knife-edge, and can find a way to extract the signal that is detected.

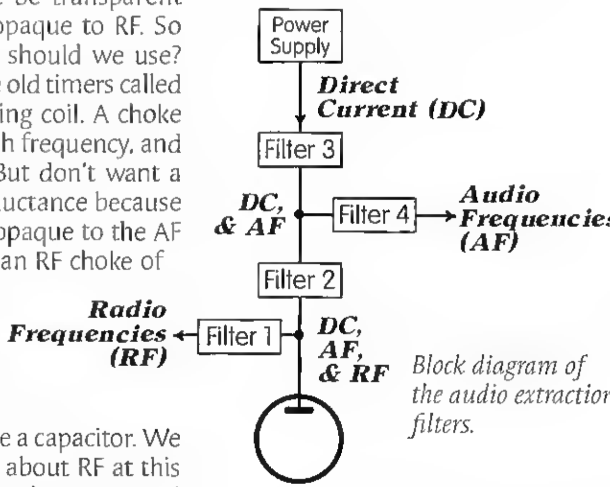
On the plate of the detector you'll find alternating currents of very high frequencies (radio frequencies, RF), lower frequencies (audio frequencies, AF), and of zero frequency, or direct current. The RF needs to stay in the detector circuit with a small amount being fed back to the input. We don't want RF in the audio section, and we want to keep it out of the direct current power supply. Yet we need to get the audio frequencies out of the detector while keeping them from the power supply. And we want the direct current to get to the detector plate relatively unimpeded. In other words, we need a bunch of fences to keep the livestock separated. To do that we use filters.

We can start to design the circuit by drawing a block diagram (next page). Filter one must be transparent to radio frequencies but opaque to AF and DC. What component would do that? A small capacitor. A capacitor looks like a dead short to high frequency, but is open for DC. In between, it impedes the flow of current to a degree somewhere between those two extremes. The impedance is called capacitive reactance and is measured in ohms.

Filter two must be transparent to AF and DC, but opaque to RF. So what component(s) should we use? An inductor, or as the old timers called it, a choke or retarding coil. A choke is opaque to very high frequency, and transparent to DC. But don't want a choke with great inductance because that would make it opaque to the AF as well. So we'll use an RF choke of some type.

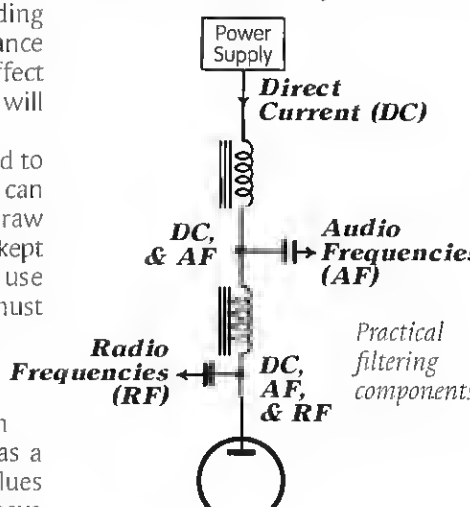
At filter four we need something that will pass AF, but block DC. That, quite simply would be a capacitor. We don't need to worry about RF at this point because filter two has prevented it from getting this far. The capacitor needs to be large. If you are feeding the audio to the base of a bipolar transistor for amplification, you'll need a large capacitor in the range of 10 mfd or more because of the low input impedance. If you're feeding headphones or the high-impedance grid of a tube or gate of a field-effect transistor, then .01 will do. No DC will get through.

Finally, at filter three we need to allow to DC through so that we can supply the detector tube with the raw material it needs, but we want AF kept out. The obvious method is to use another inductor, only this one must be large so that it impedes the flow of AF. In the old sets like the SW-3 the choke would be about 300-500 henries, although some sets used chokes as high as a thousand henries. These high values are necessary because pentodes have very high plate resistances, and to get maximum gain you must provide an equally high plate load. But here, we can use a resistor since the tube we're extracting audio from is a triode with a plate resistance of about 10kΩ.



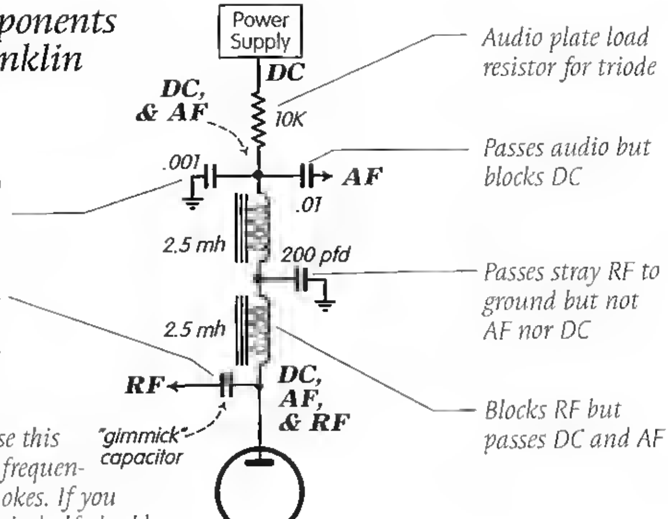
Block diagram of the audio extraction filters.

There is no RF present. And there is no extremely high plate resistance that we must match in order to get high gain. Here, we can use common old resistor, although a large inductor will work as well... if you have one.



Practical filtering components

Actual components used in Franklin receiver.



(If you plan to use this receiver on lower frequencies, use larger chokes. If you cut the frequency in half, double the size of the chokes.)

Resistors are easier to find, cheaper, and weigh much less!

Filter one becomes a twisted-wire gimmick capacitor. It needs to be just a few picofarads in size. It can be adjusted by running the regeneration control up to 30 to 40 volts of screen grid voltage, and then untwisting the capacitor until regeneration just stops. Then you can add back in a twist. At that point the regeneration control should allow you to delicately balance feedback.

Filter two becomes somewhat of a problem. Inductive reactance can be calculated –

$$X_C = 2\pi fL = 2 * 3.1416 * khz * mh$$

If we tune our receiver to 1000 khz in the broadcast band, the reactance of a common 2.5 mh choke becomes

$$X_C = 2 * 3.1416 * 1000 * 2.5$$

$$= 15{,}708 \text{ ohms}$$

The problem is that 15,700 ohms isn't really enough. What we'd really like is something between 50 and 100 kohms. If we quadruple the inductance to 10 mh, the reactance will quadruple to 62,832 ohms. A 2.5 mh choke will probably work, but not as well as you'd want. And! I wanted to be able to take this receiver down to frequencies below the broadcast band, so a larger choke is better. My solution was to dig through the choke box and find a couple of larger than normal chokes. Putting them on the bridge (Vol 3), I found they were 5 mh each. So putting two in series would give me 10 mh. Between the two I put small 200 pfd capacitor to drain off what RF could get through before passing the signal on up the line. After the second choke, about the only signal that remains is AF and DC. A simple .001 capacitor will remove any remaining RF, but not affect the AF significantly.

Filter 3 is simply a 10K resistor. It keeps the AF out of the power supply. It's a simple solution. How big would a inductor have to be if we chose to use one? Use the inductive reactance formula to solve for 10K of plate load:

$X_C = 2\pi fL$ or rearranging...

$$L = \frac{ohms}{2\pi * htz}$$

$$= \frac{10k\Omega}{2\pi * 1000} = 1.57 \text{ henries}$$

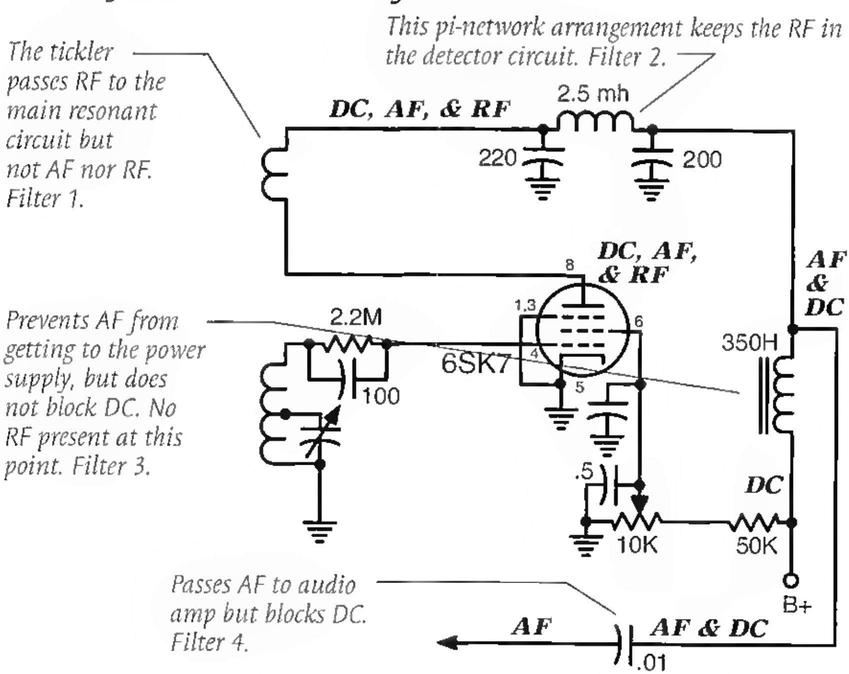
If you have a 1000 cycle tone, you'll only need a choke of about 1.6 henries. But to get 10kΩ of reactance at 200 cycles, 1/5 the the frequency, you'll need five times the inductance or about 6.5 henries. These kinds of chokes are not that hard to find. The primary of an audio output transformer may very well supply the inductance, but you could use a power supply choke if you have one. I would use any choke of five henries or more.

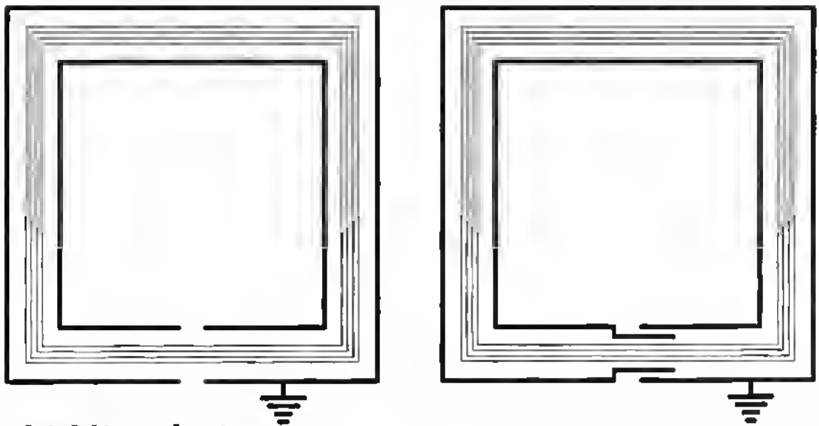
To match a pentode like a 6AU6, you need a million ohms of load. This load is a hundred times greater so we'll need a hundred times the inductance or at least five hundred henries for a 200 cycle tone.

Filter 4 is merely a .01 capacitor feeding the audio either to earphones or to the grid of an audio amplifier tube.

These filters are found in any functioning regen receiver although you might not recognize them as such at first. But they're there. And you can use these ideas to adapt almost any oscillator circuit to come across to become a regenerative detector.

Filters found on a tickler feedback circuit–



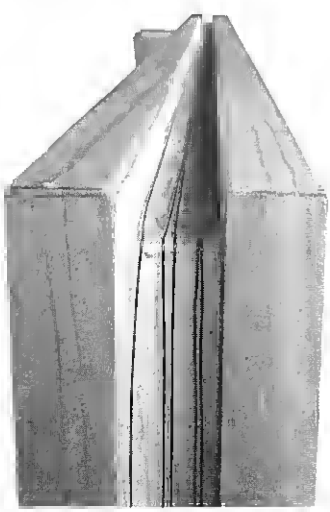


Shielding the Loop

One of the great strengths of a loop antenna is the ability to completely shield the antenna from local electric fields which carry enormous amounts of noise at lower frequencies.

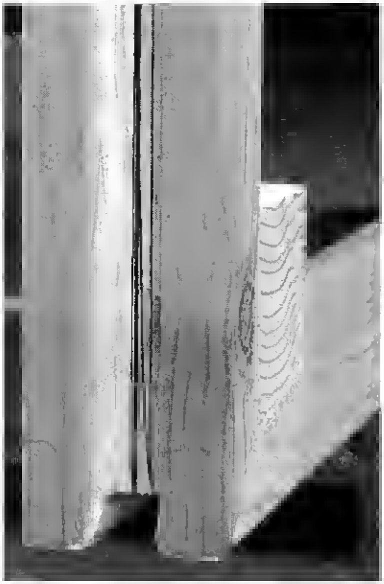
You wind your loop antenna and then surround it with a metal shield of some type which is grounded. Noise is intercepted and sent to ground. As long as you leave a gap at some point in the shielding, electromagnetic waves from the radio transmitter of interest will get through the shield to the antenna. With most of the noise now short circuited to ground, weaker long wave stations can be more clearly heard. Often the improvement is stunning.

If you want to use complete shielding, you can telescope one end of the shielding inside the other. But! It's extremely important that the telescoping sections are insulated from one another. If you do not leave a gap, you will have have created, in effect, a shorted turn. And that will prevent the electromagnetic waves of interest from getting to the antenna windings.



In a shielded loop you should try to keep the windings away from the metal foil used as shielding. If the windings get very close to the shield, capacitance to ground will increase dramatically, and the coil which you have wound and perfected will change in characteristics and tune quite differently.

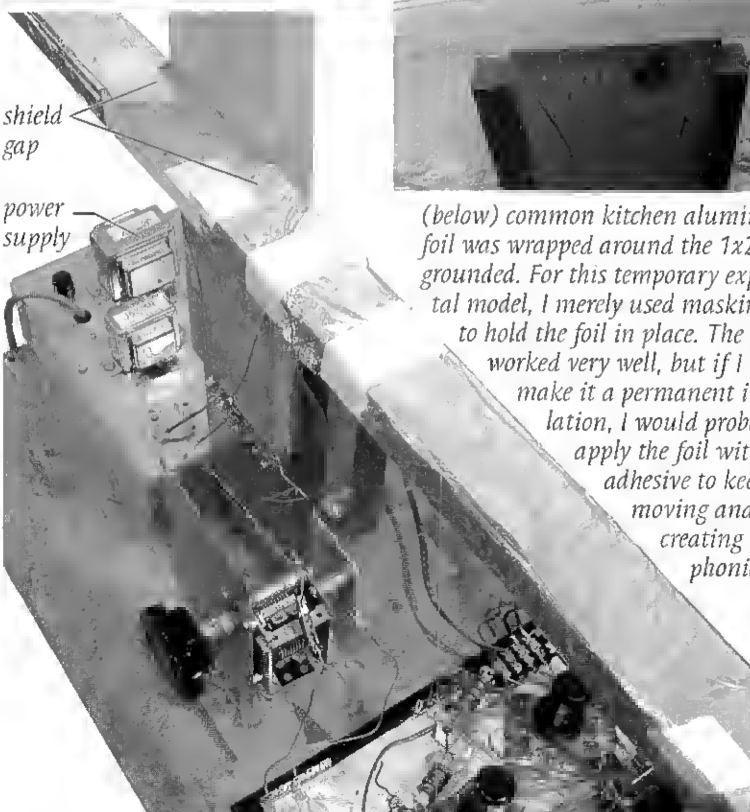
Here, I took 1x2 dimension lumber and ran it through the table saw with a rip fence to create a channel about 3/8" deep. It was easy to do. If you don't have a table saw, look around a home improvement store. There you'll find all kinds of wood and plastic trim that can do the job. Just about any non-metallic channel that keeps the wires away from the shielding should work. The stuff is low in cost, so experiment!

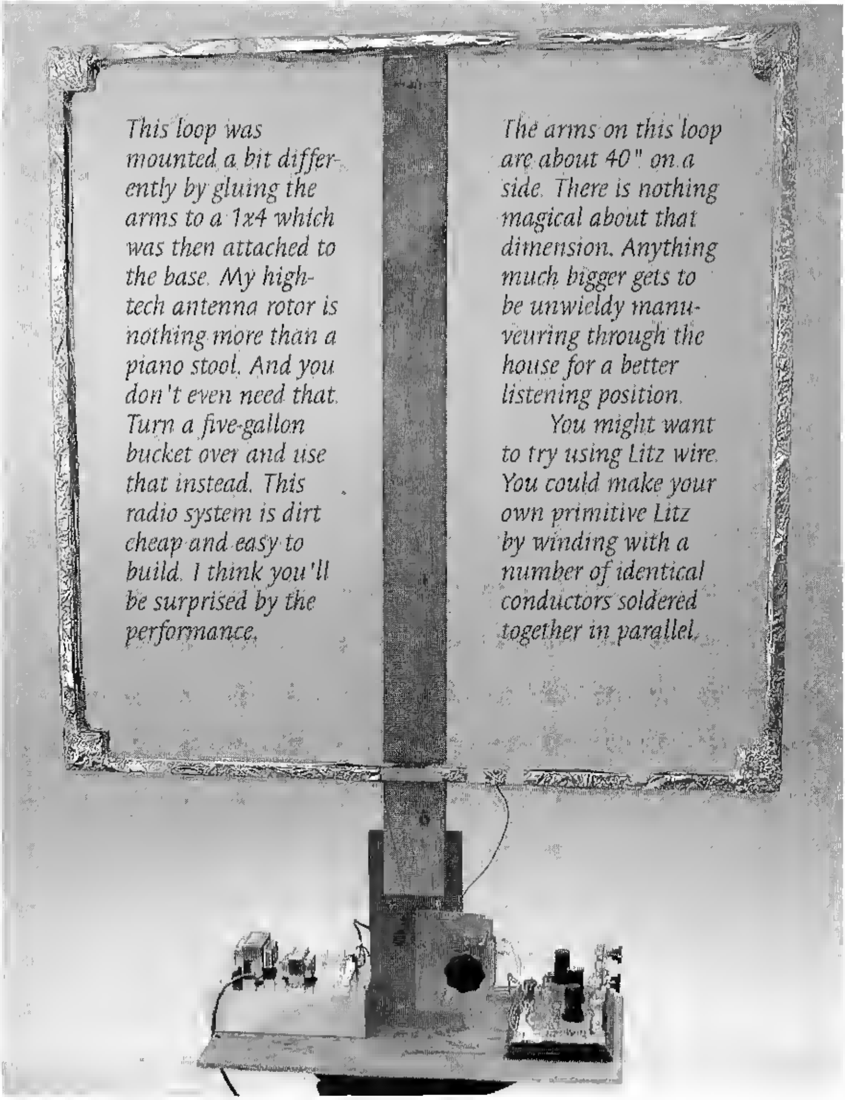


(left) corners were mitered at a 45° angle and glued together to form a weak joint. A block was glued in to strengthen it. The wires in this experimental antenna are only tightly wound. In a permanent antenna you might want to embed the wires in a bead of caulk or wood glue so that they can't move and create unwanted sound ("microphonics") in the earphones.

(below) two small holes are drilled through to the channel so that the antenna leads can be brought out to the receiver circuitry (or RF amp).

(below) common kitchen aluminum foil was wrapped around the 1x2 and grounded. For this temporary experimental model, I merely used masking tape to hold the foil in place. The antenna worked very well, but if I were to make it a permanent installation, I would probably apply the foil with spray adhesive to keep it from moving and thereby creating microphonics.



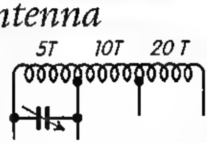


This loop was mounted a bit differently by gluing the arms to a 1x4 which was then attached to the base. My high-tech antenna rotor is nothing more than a piano stool. And you don't even need that. Turn a five-gallon bucket over and use that instead. This radio system is dirt cheap and easy to build. I think you'll be surprised by the performance.

The arms on this loop are about 40" on a side. There is nothing magical about that dimension. Anything much bigger gets to be unwieldy manuveuring through the house for a better listening position.

You might want to try using Litz wire. You could make your own primitive Litz by winding with a number of identical conductors soldered together in parallel.

A Multi-Coil Loop Antenna



The final loop I built consisted of 35 turns tapped at 20 and 30. By changing connections I could have an antenna having between 5 and 35 turns. Using 35 turns and a 1500 pfd capacitor I could tune as low as 53 khz, and was able to hear the WWVB carrier from Colorado at 60khz. With 10 and 20 connected in for a total of 30, I could tune from about 98 to 126 khz. Twenty alone gave me 145 to 184 khz, while ten alone tuned from 184 to 199 khz. If I were to use this on the 160-190 khz license-free experimenter's band, I probably would have wound 15 turns and left it at that.

Transmitters

The IMPOVERISHED RADIO EXPERIMENTER is primarily dedicated to building receivers. If you have a Radio Amateur's license (and if you don't, why not?), a transmitter with a simple receiver could make for some interesting CW work like the ol' boys did back in the twenties and early thirties. But I don't think amateur transmitters really fit here for one powerful reason: the pages of QST over the decades has been filled with scores of construction articles on transmitters. Transmitters are easy to build and get running, while receivers have always scared hams away from construction. Too complicated. Too involved. And this series of booklets has been dedicated to dispelling that self-defeating attitude. Usable receivers CAN be built and used on the air. The simple superhet described in VOLUME 5 would make a great station receiver for 80 and 40 with converters for other bands.

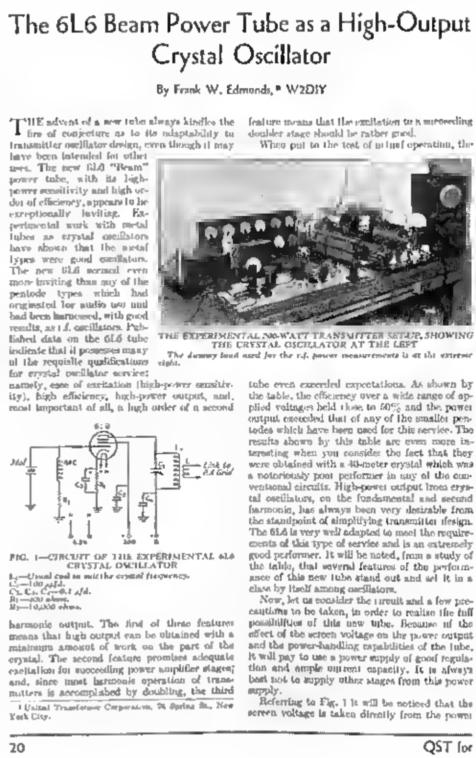
Transmitters can be built from just about any tube with easily found components. The power supply is more complicated than a single tube transmitter, but if you build the supply described in this volume, you'll have a high voltage supply of higher performance than the ol' boys had – at least for lower power.

With QST back issues available on CDROM from the League, you should have no trouble finding something to your liking. One series of transmitter articles that comes to mind starts in June 1936 with Frank Edmonds's article on using the new 6L6 as a high power (at least in QRP terms) single tube crystal controlled transmitter.

The circuit couldn't be much simpler. And it could put enough power on the antenna to "work the world."

In the February 1938 issue of QST Fred Sutter showed hams for the first time his little transmitter, now quite famous among builders, as the "QSL Forty". A single 6L6 driven to forty watts provided hours of radio fun for him in a time when amateurs always dreamed of "bigger and better".

Then in April 1939, Sutter came back with his "Economy Forty" subtitled as "An Inexpensive Three-Band C.W. Transceiver". Here, he used a 6L6G with a built in power supply using an 83 rectifier and simple RC filtering.



The 6L6 Beam Power Tube as a High-Output Crystal Oscillator

By Frank W. Edmonds,* W2DIY

THE advent of a new tube always kindles the fire of conjecture as to its adaptability to transmitter oscillator design, even though it may have been intended for other uses. The new 6L6 "Beam" power tube, with its high-power sensitivity and high order of efficiency, appears to be exceptionally inviting. Experimental work with metal tubes as crystal oscillators have shown that the metal types were good oscillators. The new 6L6 seemed even more inviting than any of the pentode types which had originated for audio use and had been harnessed, with good results, as r.f. oscillators. Published data on the 6L6 tube indicate that it possesses many of the requisite qualifications for crystal oscillator service; namely, ease of excitation (high-power sensitivity), high efficiency, high-power output, and, most important of all, a high order of a second harmonic output. The first of these features means that high output can be obtained with a minimum amount of work on the part of the crystal. The second feature promises adequate excitation for succeeding power amplifier stages; and, since most harmonic operation of transmitters is accomplished by doubling, the third feature means that the excitation to a succeeding doubler stage should be rather good.

THE EXPERIMENTAL 300-WATT TRANSMITTER SET-UP, SHOWING THE CRYSTAL OSCILLATOR AT THE LEFT

The dummy load used for the r.f. power measurements is at the extreme right.

6L6 Xtal RFC Link to P.A. Grid 6.3V 300 B

FIG. 1—CIRCUIT OF THE EXPERIMENTAL 6L6 CRYSTAL OSCILLATOR

L1—Usual coil to suit the crystal frequency.
C1—100 μμfd.
C2, C3, C4—0.1 μfd.
R1—400 ohms.
R2—10,000 ohms.

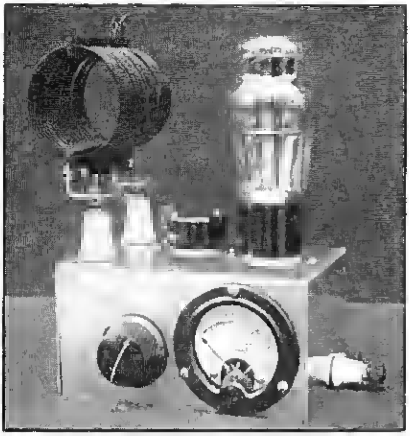
When put to the test of actual operation, the tube even exceeded expectations. As shown by the table, the efficiency over a wide range of applied voltages held close to 50% and the power output exceeded that of any of the smaller pentodes which have been used for this service. The results shown by this table are even more interesting when you consider the fact that they were obtained with a 40-meter crystal which was a notoriously poor performer in any of the conventional circuits. High-power output from crystal oscillators, on the fundamental and second harmonic, has always been very desirable from the standpoint of simplifying transmitter design. The 6L6 is very well adapted to meet the requirements of this type of service and is an extremely good performer. It will be noted, from a study of the table, that several features of the performance of this new tube stand out and set it in a class by itself among oscillators.

Now, let us consider the circuit and a few precautions to be taken, in order to realize the full possibilities of this new tube. Because of the effect of the screen voltage on the power output and the power-handling capabilities of the tube, it will pay to use a power supply of good regulation and ample current capacity. It is always best not to supply other stages from this power supply.

Referring to Fig. 1 it will be noticed that the screen voltage is taken directly from the power

* United Transformer Corporation, 72 Spring St., New York City.

20 QST for



In September 1939 Sutter provided construction details on his "Runt Sixty" and his "QSL Sixty." It sounds kind of daring to push a glass 6L6 to sixty watts of plate input power, but it can be done with CW since the duty cycle is low.

December 1939 revealed Sutter's "Portable Five", a transmitter built around a 25L6 with a 25Z6 rectifier in a power supply using no power transformer (potentially dangerous if you're not careful.)

The last article in the series (at least the ones I know about) appeared in April 1941. Using a 6L6, again, Sutter pushed it to only 25 watts. Maybe he melted a few plates at higher power.

All of these transmitters are simple and easily built. Complete construction details, even chassis layouts, are shown in the magazine pages. All of these transmitters used a balanced output because back then, hams didn't use coax. If I were to build the QSL 40, I would put a pie network filter on the output so that I could load it into a length of coax feeding just about any piece of wire I could get up in the sky. Pie-network design is easy. Just find the plate resistance in the tube manual so that you know what the plate voltage to

"QSL 40" from QST, Feb '38

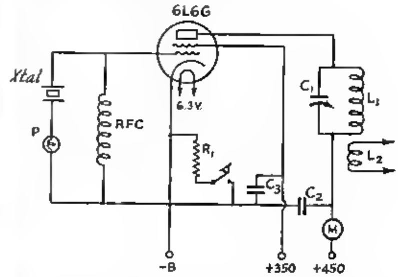


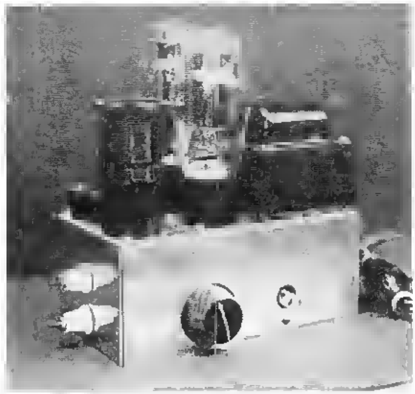
plate current ratio will be and use the charts in any old edition of the Radio Amateur's Handbook from about 1965 on back to come up with the values for the coil and two capacitors you'll need. Your transmitter will load up. No SWR meter needed. No antenna tuner. Well, unless you're trying load up a bedspring or something...

What tubes can you use? Practically anything. A common ol' 6AU6 pentode has a maximum plate dissipation of 3 watts. That means it can handle three watts of waste heat. If you figure your transmitter will be about 60% efficient, you can safely put in over seven watts with four watts going to the antenna and three watts going into heating the plate. But you probably don't want to use a 6AU6 because it has an astronomically high plate resistance, a megohm, that would probably be difficult to match. Don't know. Haven't tried it.

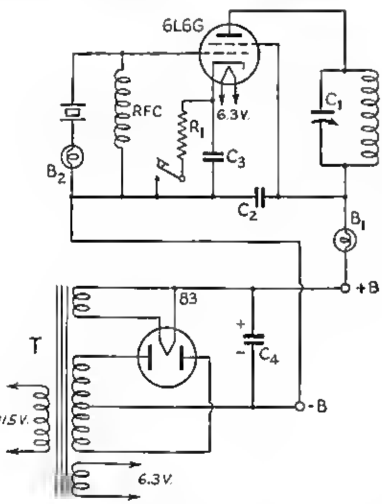
A 6L6 a beam power pentode has

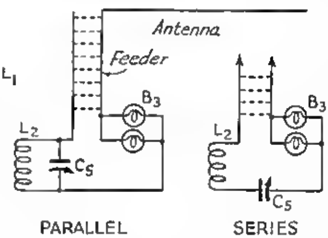
The "Portable Five" from QST, Dec '39

a plate resistance of between 2500 and 5000 ohms and is better suited to a pie-network circuit. But you could use a 6C4 triode with a plate resistance of about 6500 ohms and 3.5 watts dissipation. You could put about 8.5 watts into the plate, with about 5 watts going to the antenna and 3.5 watts heating the plates. You would need 235 volts at 36 ma to get a voltage-to-current-ratio of 6500 ohms. At 36 ma you're pushing the tube too hard really. Its max current rating is about 25 ma. You might want to only push it to 4 watts plate input power, letting about 2.5 watts into the antenna. The tube is safe, and 2.5 watts will do some pretty amazing things, as QRPers know.



"QSL 25" from QST, April 1941





"QSL 25" from QST, April 1941

Building a tube transmitter is really easier than a receiver, and the pages of QST in the 30's, 40's and 50's are loaded with both simple and complex transmitters.

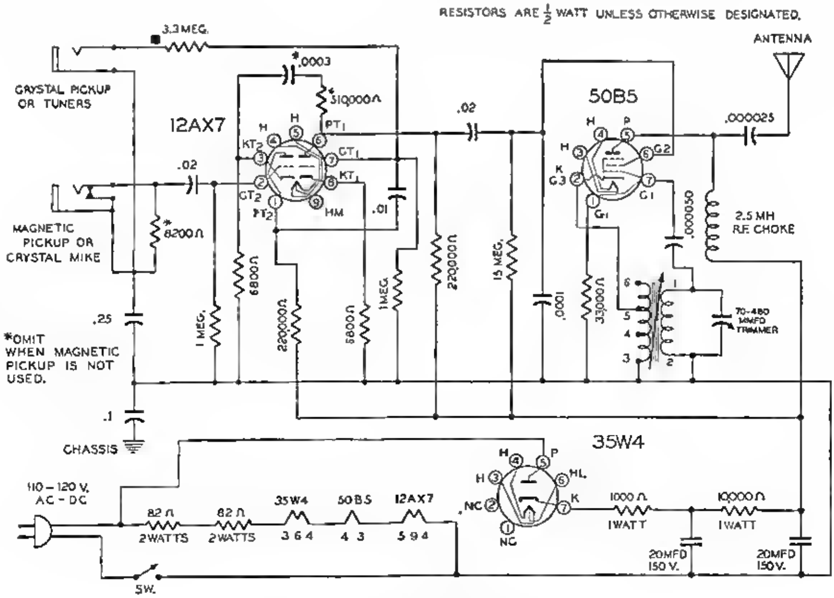
In early 1950s the coming of television attracted people to electronics and to amateur radio. Many people got their licenses for the first time. As a result construction articles for beginners were plentiful in issues of QST of that era. Try these...

May & June 1951 - **The Novice One-Tuber** - Don Mix
about 14 watts, power supply, antenna details – good!
July 1951 - **How to Lay Out a Transmitter** - Byron Goodman
basic construction how-to - 6AG7 driving a 6L6
Dec 1951 - **How to Build a Radio Transmitter** - Byron Goodman
Feb 1952 - **How to Wire a Transmitter** - Byron Goodman
Jan 1953 - **A Novice 35-Watter** - Lew McCoy
6AG7 driving a 6L6 with 80 rectifier
August 1953 - **Four Band Miniature 'Phone-C.W. Rig** - W.W. Deane
simple, little AM rig
Nov 1953 - **Novice 80- and 40-Meter One-Tube Rig** - Lew McCoy
a single 6AG7 - same project found in later Handbooks

Broadcast Band Transmitter

Transmitting code on amateur bands is easy. Putting voices and music on the AM band with a low power transmitter is a bit more complicated, but not much. An examination of an old Allied Knight-Kit transmitter from decades ago can teach us a few things.

easy to find, but you'd need 467 ohms 10-1/2 watts in series with the filament to connect it directly to 115 volts. You can make up a dropping resistor by putting three 1500 ohm 5 watt resistors in parallel to get a 500 ohm 15 watt resistor which would do the job. But other tubes will work, too.



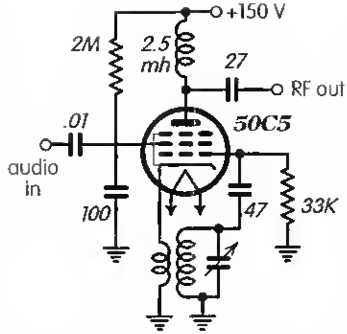
SCHEMATIC DIAGRAM

Here we see a three-tube circuit. A 35W4 rectifies 115 VAC into DC for the plates. A 12AX7 serves as a high gain audio amplifier which in turn modulates the 50B5 transmitter tube. The tube filament voltages, 35, 12 and 50 add up to 97 volts and together with a pair of 82Ω resistors in series can be connected directly to the 115 VAC input. No power transformer is required.

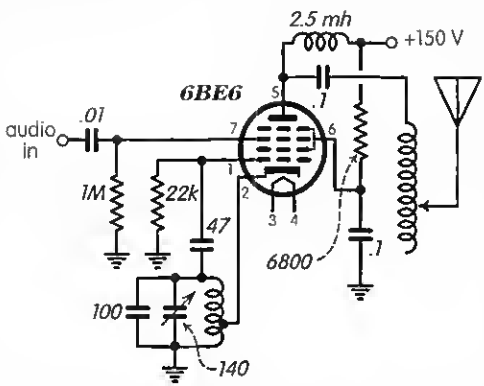
The 50B5 is a power beam tube designed for "All American Five" radios. It's equivalent to the 50C5 miniature except for different basing. The 50C5 is

The 50B5 uses the control grid and cathode to create a feedback oscillator. The coil and capacitor are chosen to resonate in the AM broadcast band. A tank circuit that works well in a crystal set would probably work here, too. As many turns of tickler is wound over the coil with insulated wire to get oscillation. The exact number is not critical so long as it oscillates. The coil used in this little transmitter was probably the small compact universal-wound oscillator coil found in the All-American Five.

The 12AX7 boosts the input



from a microphone or phonograph pickup to voltage necessary to modulate the oscillator. When a low level magnetic pickup or crystal microphone is used, both sections of the 12AX7 are used. A feed back network of a 510,000Ω resistor and .0003 (300 pfd) capacitor provide equilization to improve frequency response.



If a crystal pickup or tuner is used, both being high output, then only one section of the 12AX7 is used for amplification.

If you choose to experiment with this circuit, you can substitute two 6AV6's for the 12AX7. A 12AX7, after all, is just a pair of 6AV6's inside a glass envelope with a common filament. Used 12AX7 are hard to find because of the vacuum tube stereo religion. I have quite a number of 12AX7s, including the Mullards which are idolized by that strange crowd, but finding them even used at a flea market is difficult anymore. Fortunately, brand new 6AV6's can be had for a dollar or two.

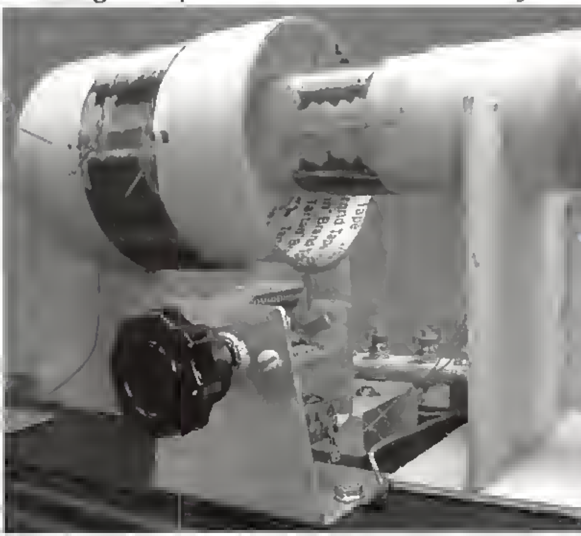
There are other alternatives. Just as a demonstration I lashed together two other modulated oscillator AM transmitters using a 50C5 and 6BE6. The 50C5 circuit is similar to the Knight-Kit, and it works quite nicely. The only drawback is the high voltage filament.

I recommend lashing up a 6BE6 instead. These tubes are common. They're everywhere. Fifty cents will get you a good used one. And they're designed as oscillators. After all, they were intended to be the first mixer in the All-American Five. Sample circuits are found in the last pages of a tube manual. The circuit shown here is a simple Hartley. Wind the tank circuit so that if falls in the AM band, and provide a tap at about 25% up from ground. With 150 volts on the plate and 88 on the screen grid, you can generate about 150 milliwatts of power (which is legally too much) and fill the house with a tone taken from an audio oscillator which I used to modulate the transmitter tube. The coil used to load the antenna was a junk box tapped coil with 280 µh of total inductance, but only about 85 µh was used to load up a length of hook-up wire strung to the basement ceiling. I had little trouble getting these to work. You can build them too. Just be sure not to create interference with your experimentation.

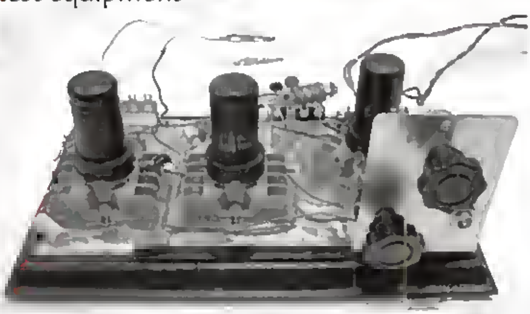
YOU can build old-time radios!

Vacuum tubes are to the electronics industry what steam locomotives are to the railroading industry: hot, inefficient maintenance headaches. But like a steam locomotive, a tube has a simple fascinating charm that no high-tech chip can match.

You must try building a simple radio with tubes! It's easy, and it's cheap. (And don't tell me that doesn't appeal to you...) Do you remember the excitement when you built your first crystal set? This is even better.



Here you get tips, tricks, hints and details on building components and test equipment that will help you to put your radio on the shortwave frequencies you desire and carefully tune in the station you want.



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