SECTION 2

TRANSISTOR RADIOS

solar-powered radio

Just think of it! As long as the sun shines — even a very cloudy day will do — this radio operates from a solar power supply. When there is no sunlight, an auxiliary mercury cell can be switched into operation.

Anyone can build this solar-powered radio. The solar energy converter is a modified self-generating selenium photocell. Generally, solar radios and transmitters have been laboratory-built devices, very expensive and next to impossible for the hobbyist to reproduce. This solar radio, however, uses only standard components and can be built for around $15.

A high-gain transistor (Fig. 201) provides plenty of amplification; a loopstick gives souped-up sensitivity and selectivity. Actually the circuit is a crystal set followed by a stage of transistor amplification, but the sensitivity and selectivity are very much better than usually associated with this type of radio.

A fabulously high Q (about 350) is the hallmark of the "energized" loopstick. Detector loading of the tuned circuit can quickly degrade this figure. Nevertheless, by using loose coupling between coil and detector, we retain a single tuned circuit with exceptionally sharp selectivity.

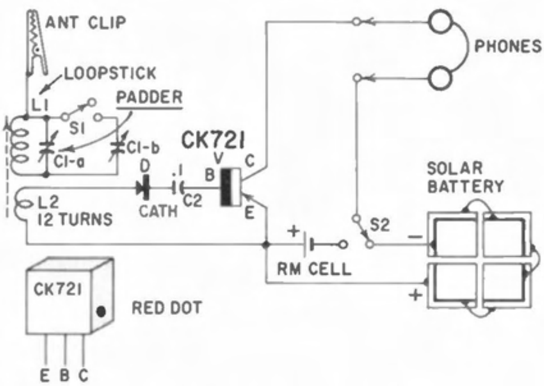
One end of L1 connects directly to the antenna. The opposite end seems to float without any electrical connection to the remainder of the circuit. Coupling does exist though in the form of stray capacitance between L1 and L2. There is also mutual coupling between the two coils, aided by the loopstick core.

A padder type variable capacitor with an attached knob is used for station tuning but does not have sufficient range to cover the lower end of the broadcast band. Thus, an extra capacitance is used to permit low-end tuning. (The diagram shows a variable unit, but a 200-$\mu\mu$f fixed capacitor may be used.) This capacitor parallels the tuned circuit through S1 and effectively splits the broadcast band in two.

L2 is a winding added to the loopstick. Nominally, this coil should be 12 turns wound at one end of L1 as shown in Fig. 202. Increasing the number of turns gives increased sensitivity or loudness, accompanied by some loss in selectivity, and, of course, decreasing the turns of L2 gives better selectivity at the expense of signal volume. The size of the wire used to wind L2 is not critical, but space the turns slightly apart.

The detector is a germanium diode. Any of the many available types are satisfactory. (Surplus silicon "radar" crystals, however, are *not* suitable). Typical crystals that can be used are the Raytheon CK705, Sylvania or Radio Receptor 1N34 and the G-E 1N69.

Crystal-detector receivers operate the diode in the low millivolt



parts list for solar-powered radio

Capacitors: C1-a,C1-b—padder (each section 200 $\mu\mu$f or more). C1-b can be a fixed unit. C2—.1 μf, 200-volt miniature.

Transistor: V—CK721.
Diode: D—CK705 (or 1N34, 1N69).

Coils: L1—5-inch loopstick (Superex-Allied Radio 51CO38); L2—see text.

Batteries: B-15 photocell; RM cell—1.345-volt mercury cell.

Switches: S1,S2—spdt.

Miscellaneous: antenna clip; transistor socket; non-metallic case; knob for padder capacitor; ¼-inch dia. brass shaft; phenolic base; 2,000-ohm earphones; hardware.

Fig. 201. *The solar-powered radio has a crystal detector and a single transistor audio amplifier stage. For sunless days, use the mercury cell.*

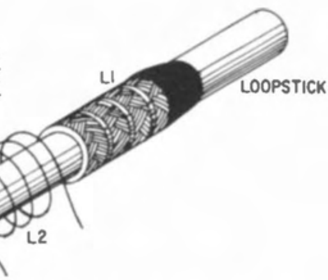
region. In this low-level signal range no diode is a really good rectifier. Detection takes place because the diode is a nonlinear resistance element passing more current in one direction than the other. This is termed "square-law detection," the name being derived from the diode characteristics at low signal levels.

Crystal detectors, with no exceptions, operate on this principle.

And despite what you may have heard, they are not distortion-free. All produce some second-harmonic distortion.

Audio output from the detector is coupled to the transistor by

Fig. 202. *L1 forms part of the tuning circuit. Experiment with the number of turns for L2 and its spacing from L1 for best results in your area.*



a 0.1-µf capacitor. This can be one of the miniature 200- or 120-volt units commonly found in personal radios. Since the capacitor can discharge back through the nonlinear diode resistance, there is no need for a diode load resistor between the diode and capacitor – they are connected directly together.

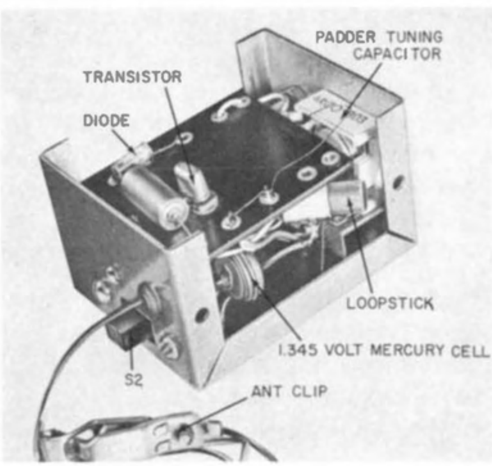


Fig. 203. *The solar-powered radio is a compact little unit.*

The transistor should be a high-gain type, the CK721 for example. Using the CK722 results in a considerable lowering of performance. With a CK721 and 2,000-ohm earphones, the power gain of the transistor stage should be at least 160. A hermetically sealed type of high-gain transistor was used in the original receiver and is visible in the photograph, Fig. 203. Except for the metal case, it is almost identical to the CK721.

Solar power supply

A type B-15 self-generating photocell forms the basis for the solar power supply. The B-15 cell is unmounted. A rectangular silver band around the perimeter of the cell is the negative or front electrode. The solid silver backing is the positive terminal.

For our purpose, the cell must be cut into four equal-area sections. A small hacksaw is suitable for the cutting operation. To avoid overheating the edges, cut slowly. If the cell is clamped in a vise, use cardboard buffers to avoid mutilation of the cell's surface.

Check each of the four photocells by connecting a milliammeter — 0–1 ma will do — across its terminals. The four cells should all give approximately the same output. For checking, each cell can be held near a 100-watt light bulb. If any cell gives appreciably lower output, the edge formed by the cut may be partially shorted. This can be corrected by scraping the edge with a screwdriver or knife blade until the cell delivers normal current.

Pieces of small, flexible, stranded wire connect the cells in series. The wiring arrangement is given in Fig. 204. Tin the wires first and then solder *quickly* to the appropriate silver band or back; otherwise, the silver may melt away from the solder connection. When the cells are soldered together, check them again by connecting a voltmeter across the two output wires. In sunlight, the meter reading should be in excess of 1.5 volts. After the final check, place the cells face down on a square piece of clear plastic and bind them to the plastic with cloth adhesive tape. The modified cell is then ready for installation in the receiver.

Construction and operation

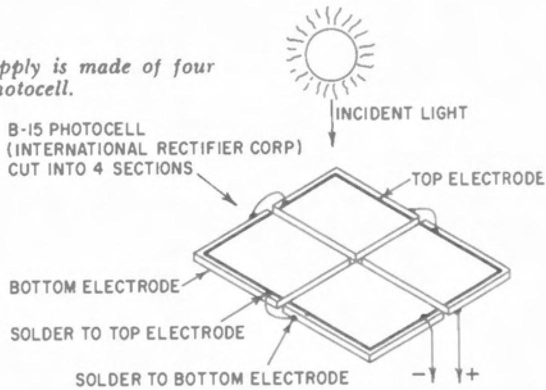
The original receiver was mounted in a small aluminum case but the closed aluminum box reduced the Q of the loopstick. A non-metallic case is recommended.

To attach a tuning knob to the padder, take a piece of 1/4-inch brass shaft and drill a hole in its center very slightly smaller than the padder shaft. Then heat the 1/4-inch shaft until the hole enlarges enough to be pushed onto the padder. When the shaft cools, it will be solidly mounted to the tuning capacitor.

The remaining mechanical details are simple and the parts may be placed wherever most convenient. An easy way to mount the mercury cells is simply to solder the metal extension tab (negative terminal) to the S2 terminal. To avoid damage, soldering to any part of the mercury cell must be done quickly and the cell should be checked afterward with a voltmeter.

For an operational check, clip the antenna lead to something metallic. A screen door, clothesline or short length of wire, say

Fig. 204. *The solar power supply is made of four sections of a photocell.*



15 feet long, should do. By tuning the receiver, stations should be heard with the power switch in the mercury cell position. Hold the receiver facing through an open window and flip the switch

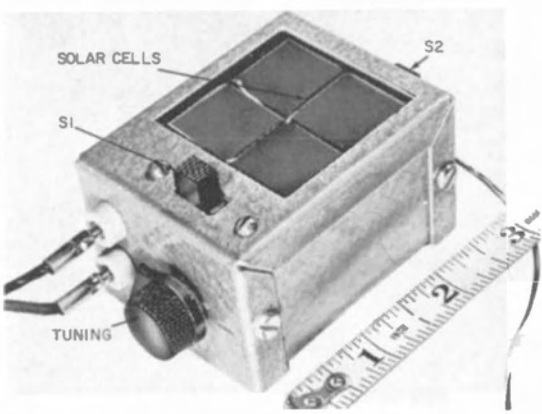


Fig. 205. *The solar-powered radio with the solar cells in position.*

to the solar cell position. The station should come in just as loudly as with the RM cell. Direct sunlight can have an intensity of 10,000 foot-candles; yet the radio operates satisfactorily with only 100 foot-candles. (The complete receiver, with solar cells in position, appears in Fig. 205.)

The volume and selectivity obtainable from such a simple circuit is amazing. Strong stations are loud enough to be heard with the phones pushed back from the ears. Selectivity is good enough to separate three stations located at 1550, 1450 and 1230 kc and it "takes some going" to do this with only one tuned circuit. Full credit for this achievement goes jointly to the super loopstick and the high-gain transistor.

shirt-pocket radio

WITH the help of transistors, experimenters and hobbyists can construct their personal all-transistor radio – one that can fit into a *shirt pocket.*

This receiver requires only 4.5 volts, supplied by 3 penlight cells. These should last more than 600 hours of normal use, so the

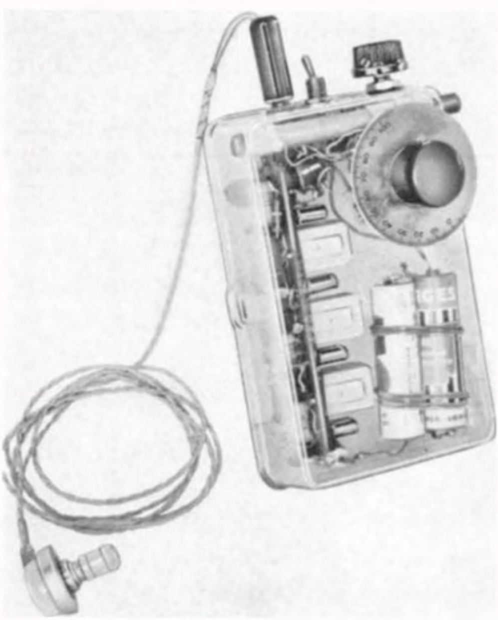


Fig. 206. *The shirt-pocket radio, completed and ready to go with you.*

operating cost is about 1 cent for 24 hours. Fidelity is very good because of the reduced sideband cutting of a transistor amplifier. The entire set is housed in a transparent plastic box (see Figs. 206 and 207) with a hinged cover. This is a $4\frac{1}{2} \times 2\frac{3}{4} \times 1\frac{1}{8}$-inch box and can be bought at many hardware and department stores for about 20 cents. The set weighs less than 7 ounces. It delivers a strong signal to its earpiece. Actually, the receiver will operate well with as little as 2 volts at less than 1 ma. Perhaps this is a good chore for a group of sun batteries!

Tested in many localities and under different conditions, the set seems to work anywhere. Carrying it in a shirt pocket, you can walk along the street, in a steel building . . . even in a cellar, yet pick up stations loud and clear. Unlike some other "self-contained"

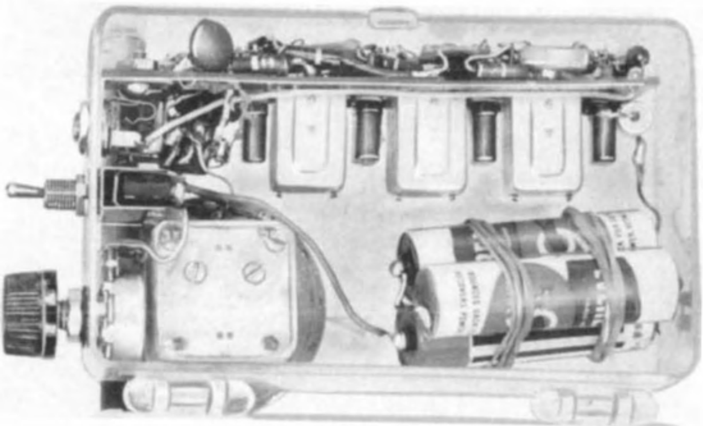


Fig. 207. *The shirt-pocket radio inside its plastic case.*

sets which may also work well but require a 10- or 20-foot antenna, this radio depends entirely on its own.

Two important problems had to be worked out — the converter stage and the if amplifier. In each case the result was completely successful, providing a very efficient and sensitive radio. Full earpiece volume is obtained without a separate audio stage.

Six separate units make up this receiver: the antenna loop, battery control, variable capacitor, converter–if amplifier, battery and switch.

Constructing the receiver

The first component to be mounted in the box is the loop antenna. It is Lafayette part MS-272, slightly modified. Remove 25 turns from the larger winding of the loop, that is, starting with the white lead. Then tape or cement the ends so that there will be no further unwinding.

Saw off part of the form which is nearly 3½ inches long — the plastic box is only 2¾ inches wide. Saw the form (preferably a little from each end) until its total length is about 3 inches. This will leave some of the form extending from each side of the box for support. A hacksaw will do the job nicely.

The words "horizontal," "top," "side," etc., refer to directions with the box standing on ends as when placed within a shirt pocket.

Holes for the loop should be only slightly larger than 1/4 inch in diameter. Drill them with a 1/4-inch drill, then file a little. These holes should be as near the *top* and *front* of the box as possible. (The front is the side opposite the hinged cover and is farthest from the person wearing it in his shirt pocket.) To insert the loop, open the box cover and push one end of the core into one of the holes until the other end can pass through the hole in the opposite side.

Next mount the battery control. This is Lafayette part VC-32, a 1,000-ohm potentiometer. It requires a 1/4-inch hole through the top of the box and as far to the left as possible. This unit has a diameter of 3/4 inch so there is plenty of space for it and the loop, also. Before mounting this control cut off part of its long shaft (to less than 5/16 inch) and solder leads to its terminals – soldering is more difficult later.

The variable capacitor is mounted just below the battery control and also to the left as far as possible. This capacitor is Lafayette part MS-270, one of the most unusual items made available to experimenters in recent years. Only 11/16 inches square and 5/8 inch deep behind the panel, it is a complete two-gang capacitor with a cut-plate type oscillator section and built-in trimmers. The two columns in the center of the table show the capacitance of the tuning sections as the shaft is rotated through 180 degrees from its maximum-capacitance (plates fully meshed) position. The column at the extreme right shows corresponding frequencies tuned in when using an antenna coil with an inductance of 327 μh and an oscillator coil of 221 μh.

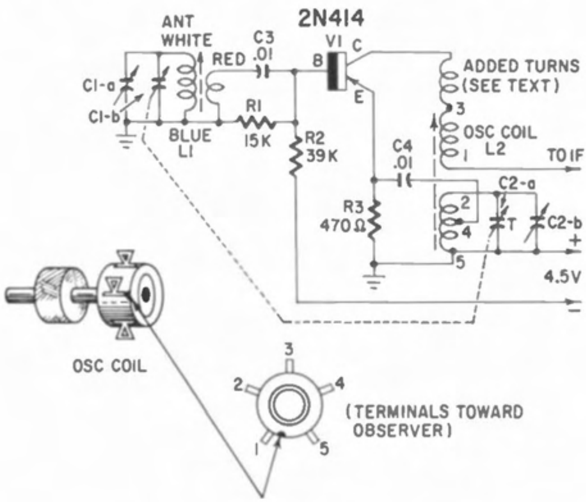
dial (%)	ant (μμf)	osc (μμf)	freq (kc)
0	211.0	101.0	535.00
10	189.4	94.8	562.35
20	168.9	88.2	594.03
30	148.0	81.1	631.70
40	126.9	73.3	678.15
50	105.4	64.6	737.71
60	83.8	54.9	816.66
70	61.8	43.7	930.76
80	41.6	31.8	1093.59
90	23.9	19.7	1336.73
97	13.0	11.0	1605.00

You can use a dial calibrated like the one in the photograph

(Fig. 206) or you can make your own and calibrate it in terms of frequency or use station call signs. (Before mounting the capacitor, you may wish to cut the shaft to 3/8 inch or less.) The unit is mounted on the *front* of the box by two tiny screws supplied with it. Now, solder the white and blue antenna leads across corresponding terminals of the dual capacitor. (See Fig. 208.)

Converter and if

The converter – if amplifier is the heart of the receiver. The converter stage is shown in Fig. 208 and the if amplifier in Fig. 209.



parts list for shirt-pocket radio

Resistors: R1,R5—15,000 ohms; R2,R13—39,000 ohms; R3—470 ohms; R4,R7,R8,R11, R12,R14,R15—1,000 ohms; R6,R10—2,200 ohms; R9—10,000 ohms; R16—1,000-ohm potentiometer (switch on potentiometer optional). All fixed resistors ½ watt.

Capacitors: C1-a,C1-b,C2-a,C2-b—two-gang tuning capacitor, rf tuning range approximately 10–208 μμf, oscillator tuning section approximately 10–100 μμf; C3,C4,C5,C6,C7, C8,C9,C10,C13,C14,C15—.01 μf; C11,C16—16-μf,16-volt electrolytics; C12—56 μμf.

Transistors: V1,V2,V3,V4—2N414.

Coils: L1—loop antenna (Lafayette MS-272); L2—oscillator (Lafayette MS-265).

Transformers: T1,T2,T3—if units (Lafayette MS-268).

Miscellaneous: battery holder (optional); 1.5-volt penlight cells (3 required); tuning dial; earphone; switch (see text); miniature closed—or open-circuit jack (Telex); plastic case, approximately 4½x2¾x1⅛ inches; hardware.

Fig. 208. *The rf section uses a loop antenna. Additional turns are put in series with the oscillator coil. These turns are adjacent to the oscillator coil.*

Actually, these circuits (except loop and battery control) are mounted together on a strip of Bakelite or other strong plastic.

The converter uses a 2N414 transistor for maximum gain. The oscillator transformer is Lafayette part MS-265 and requires a slight modification. The terminal arrangement of this transformer is shown in Fig. 208.

As used in the converter, the collector winding needs 14 additional turns. These are easily added. Use No. 30 enameled wire or smaller. Holding the transformer with the terminals *toward* you, solder one end of the fine wire to terminal 3. Now wind 14 turns *counterclockwise* on the form (not over the existing coil). Use Polystyrene cement to hold the winding in place. The free end of the winding connects to the V1 collector. No other connection is to be added to terminal 3.

The oscillator transformer, all transistors and if transformers are mounted on a piece of thin Bakelite or hard plastic measuring 1/16 inch thick, 4⅛ inches long, 15/16 inch wide. Such a strip is

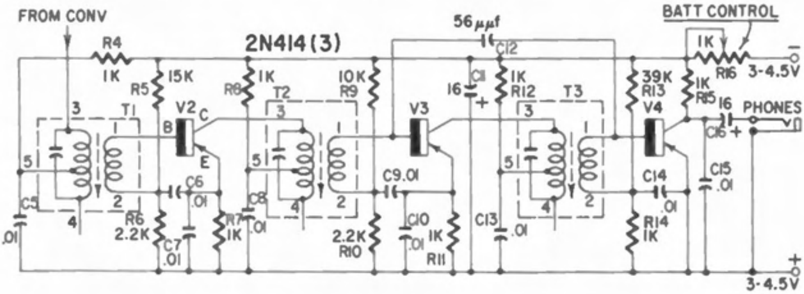


Fig. 209. *The if and audio sections of the shirt-pocket radio.*

easy to machine and there is no difficulty in drilling, filing or sawing.

If you compare Fig. 209 with other diagrams you have seen, you may conclude that the transformer connections are not correct. Manufacturers' data specify that terminal 5 is the collector output and terminal 2 is the base input. Here both windings have been *reversed* and for an excellent reason. If you try to wire the circuit according to such instructions, you will run into difficulties and will need long leads between transformers and transistors. If you follow Fig. 209, your work will be greatly simplified. This is an important feature where components are so close together and so tiny! The reversed windings produce no noticeable loss.

The if transformers are mounted in square holes. First, cut a hole about 7/16 inch in the sheet of Bakelite. Then file the sides a little at a time until the opening is large enough for the transformer to drop into place and fit snugly. The adjustment screw is accessible from the bottom. Holes for the five-pin transistor sockets are best made by drilling two or three small holes and then enlarging and joining them with a file, until the socket fits through. The oscillator transformer requires a 1/4-inch mounting hole. It is held in place (with terminals upward) by its own leads passing through the Bakelite strip.

Mounting dimensions

Here are some dimensions for mounting the parts: The oscillator transformer hole is located 3/4 inch from one end of the Bakelite strip. The if transformers are spaced 7/8 inch apart (center-to-center), the last one being 3/4 inch from the other end of the

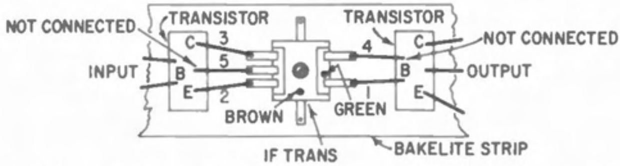


Fig. 210. *Bottom view of if transformer showing connection details.*

Bakelite strip. A small portion of the strip must be cut away where it interferes with the antenna loop.

Fig. 210 shows typical connections to an if stage. It is a bottom view of the Bakelite strip with the converter stage (not shown) at the left. Each if transformer is mounted with its brown dot on the bottom. This places three of its terminals on the left, two on the right. Each transistor socket is mounted with its collector terminal at the top. Remember: Fig. 210 is a *bottom* view. Note the coding dots.

The transformer terminal numbers are marked in the diagram. Terminal 3 connects *directly* to the collector of the previous transistor. This is made possible by carefully bending the terminals of the transformer and transistor until they meet! Likewise, terminal 1 is soldered directly to the base of the following transistor. Terminal 4 is not connected electrically but is soldered to a dummy terminal of the following transistor for support and to keep it from moving. In the same way, terminal 5 is soldered to a dummy terminal of the preceding transistor. Terminals 5 and 2 are connected to other components as indicated in Fig. 209.

To make this convenient wiring (or rather, lack of wiring) possible, the transistor sockets must be mounted just as shown in Fig. 210. If the socket is turned around, wiring becomes more difficult.

Neutralization

Neutralization is generally required in a transistor if amplifier because transistors are triodes with no shielding between input and output. Without neutralization the amplifier may oscillate and generate whistles as each station is tuned in. A 56-μμf capacitor was found necessary between the bases of V3 and V4. Strangely enough, none was found necessary between V2 and V3.

One other component is needed on the amplifier assembly. It is a miniature earpiece jack, such as made by Telex. Either a *closed-* or *open-*circuit jack may be used. This jack should come out of the box at the *top* for easy plug-in. A small aluminum angle bracket can be made up for this. It may be ½ inch on each side and ½ inch wide. A ¼-inch hole at one end takes the jack. Two small screws mount the other end (of the bracket) onto the Bakelite sheet.

Testing

Before mounting the amplifier you may wish to test it. With the power on you should hear a buzz when the amplifier is brought near a fluorescent lamp. This shows that the if amplifier is working. The oscillator may be checked by listening to its signal in a nearby receiver. Connect a capacitor temporarily, across the coil for tuning. You should be able to cover from approximately 1 to 2 mc; that is, 455 kc higher than the broadcast band limits.

To mount the amplifier, remove the screw from the earpiece jack and insert the jack into a hole drilled for it in the box top. Tightening the screw on the jack is sufficient to hold the entire amplifier unit in place. If desired, the unit may also be supported near the bottom of the box.

The power supply for this receiver is composed of three penlight cells held together by a rubber band. Connections are soldered directly to the cells as required.

The battery switch problem is more difficult than might be supposed. The only satisfactory solution is a tiny toggle switch made by Milliswitch of Los Angeles, a very expensive item costing nearly $4. Unfortunately, there is no miniature earpiece jack that can close a battery circuit when the earpiece is plugged in. This would solve the problem nicely. Other substitutes might be a miniature four-position switch (sold by Lafayette) or a potentiometer with switch instead of the battery control used here.

Alignment

After all parts are mounted and connected in the plastic box, align the receiver. If you have no signal generator, try using the fluorescent buzz mentioned before. This buzz will grow in strength as you approach correct alignment. Also, you may use a loud station to help your alignment. Alignment with a signal generator is much better, of course, and in some cases will make the difference between excellent and erratic operation.

Adjust the oscillator core for maximum pickup at low broadcast frequencies. Tune the antenna trimmer of the dual capacitor for maximum pickup at high frequencies.

The battery control has only slight control over gain. Actually, it is useful for reducing drain from the battery and also acts as a filter in conjunction with the 16-µf capacitor. As batteries grow old, it may be necessary to turn this control up to compensate for added resistance in the battery. With full resistance in the circuit, the battery drain should be about 2.5 ma. This control also prevents overloading on the more powerful local stations.

Don't hesitate to build this transistor radio. You will find plenty of use for it since you can keep in touch with the ball games, news flashes, your favorite concerts, etc. When carried in a shirt pocket, everything remains hidden except for the hearing-aid earpiece. The sound fidelity is far better than provided by most tube radios and the tuning is much less critical. Yet there remains sufficient selectivity to separate even the closest locals. As for volume, the stronger stations may be heard as much as a foot or two from the earpiece!

adding a speaker

If you constructed the shirt-pocket radio (or similar transistor tuner) you can make a simple modification and adapt it for speaker operation. With few additional parts, the signal is boosted and

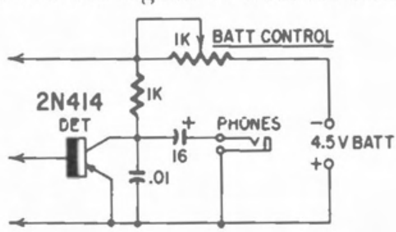


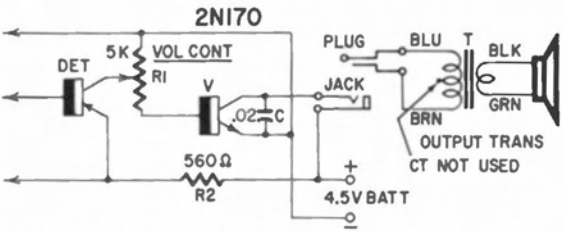
Fig. 211. *Circuit of the class-B detector used in the shirt-pocket radio.*

made audible several feet from a speaker in a quiet location. The output stage is coupled directly to the transistor detector, thus simplifying construction. The amplifier is similar to that used in G-E receiver models 675-676.

Fig. 211 shows the class-B detector used in the shirt-pocket radio. When modified for an additional audio stage, the circuit looks like Fig. 212. Note that an n-p-n transistor audio stage must be used when the detector transistor is p-n-p. The direction of current through the p-n-p collector is correct for biasing the n-p-n base.

In Fig. 212, variable resistor R1 acts as the detector load as well as a volume control. It replaces the 1,000-ohm fixed resistor, originally part of the shirt-pocket radio. It may be a dime-size potentiometer (for example, Lafayette VC-33) and it occupies the hole originally drilled for the battery control which is no longer used. A 560-ohm resistor is added for isolation and filtering.

A tiny speaker assembly can be made up with an Argonne



parts list for single-ended speaker stage

Resistors: R1—5,000-ohm midget potentiometer (Lafayette VC-33 or equivalent); R2—560 ohms, ½ watt.

Capacitor: C—.02 µf.

Transistor: V—2N170.

Miscellaneous: T—output transformer, primary impedance 500 ohms, secondary impedance 3.2 ohms (Argonne AR-119); speaker (Argonne SK-61); perforated plastic board; subminiature plug and jack (Telex); Batt—4.5 volts; battery holder; transistor socket; knob for R1; mounting board; hardware.

Fig. 212. *This modification adds a single-ended speaker stage to the shirt-pocket radio.*

SK-61 speaker and Argonne AR-119 transformer. This speaker is only 1½ inches square and 1⅞ inches deep. The transformer has a 500-ohm primary (the center tap is not used) and a 3.2-ohm secondary. This speaker fits into the hinged plastic box in which the transformer is sold. Slight filing down of the speaker sides may be needed for a neat fit.

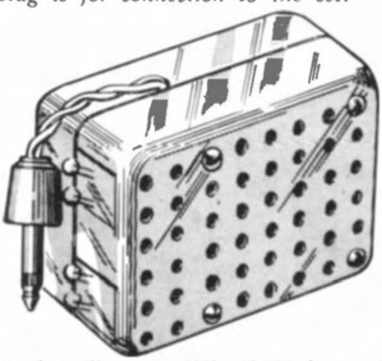
To increase the baffling action and to strengthen the assembly, use a piece of perforated plastic board (Lafayette Radio part MS-304) between speaker and plastic box. (See Fig. 213.) The perforated board permits sound to pass out of the speaker. Of course corresponding holes must be drilled through the front of the plastic box. Only 6 rows of holes are needed through the box, because the speaker is 1½ inches square. One of the speaker screws holds the transformer inside the box. Leads from the transformer primary should end in a Telex or similar subminiature plug for insertion into the jack on the set. The completed amplifier is shown in Fig. 214.

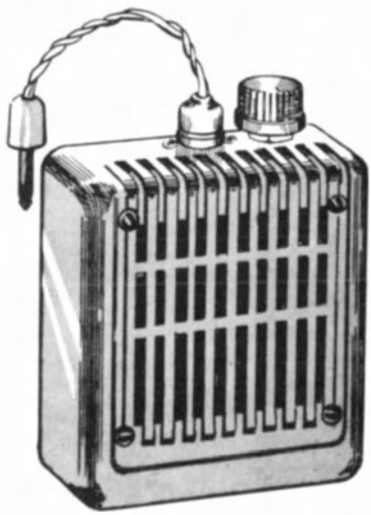
With this amplifier, most stations come in too loudly on an earpiece and the volume will have to be lowered. With a speaker, the signals are audible up to 5 or 6 feet away. The last stage requires about 0.5 to 5 ma, depending on signal strength.

If you want a full-power signal from your pocket radio, add the direct-coupled stage but use a class-B amplifier before the speaker.

Fig. 213. *(below) Insert a piece of perforated plastic board between the speaker and the box.*

Fig. 214. *(right) The completed amplifier is a compact unit. The plug is for connection to the set.*





The class-B stage (Fig. 215) is small enough to be placed within the speaker case along with its battery supply. The output will be sufficient to be loud and clear many feet from the speaker, yet power consumption is low.

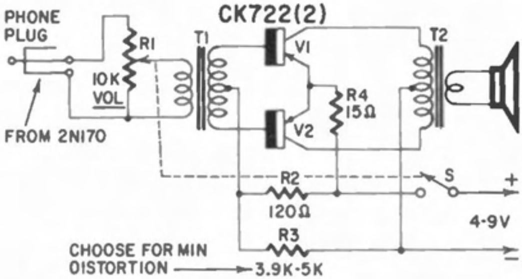
The class-B circuit can be operated from any voltage from 4 to 9. All parts are mounted on a piece of perforated board measuring about 2½ x ⅞ inches. When completed, the board may be wedged at one side of the speaker.

The speaker and Sound Box are designed for each other. The speaker is a 2½-inch unit (Lafayette SK 65). The sound box or speaker case is already fitted with a beautifully styled grill, and a two-pin socket at the top. Incidentally, this case machines very well. It can be drilled or filed without fear of the cracking or chipping that we except from most plastic materials.

The battery used in this particular device is an RCA VS 308 which gives 4 volts. The voltage can be boosted up to about 9 with a proportional increase in output power.

The volume control (with switch) is mounted on top of the speaker case. It is single-hole mounted.

This Sound Box makes a very attractive and useful addition to the shirt-pocket radio. It permits listening in at comfortable sound



parts list for push-pull amplifier

Resistors: R1—10,000 ohm potentiometer; R2—120 ohms; R3—3,900–5,000 ohms (experiment with resistors in this range for minimum distortion); R4—15 ohms (all resistors ½ watt, 10%).

Transistors: V1,V2—CK722.

Transformers: T1—driver transformer, primary impedance 10,000 ohms, secondary impedance 2,000 ohms center-tapped; T2—output transformer, primary impedance 500 ohms center-tapped, secondary impedance 3.2 ohms.

Switch: S—spst (mounted on R1).

Battery: 4 volts (RCA VS 308).

Miscellaneous: 2½-inch speaker and sound box (Lafayette SK 65); phone plug (Telex); phenolic board; battery holder; knob for R1; transistor sockets (2); hardware.

Fig. 215. *Push-pull class-B amplifier that can be added to the shirt-pocket radio. Experiment with different values of R3 for minimum distortion.*

levels and can be attached to the radio with a flexible cable. Some constructors prefer to use the same power source for both the radio and the class-B amplifier. This is easily arranged since they both require approximately the same voltage. Alternatively, both units may be built into the same box, and energized from the same battery. This will give you a high-performance device with all desirable features: two stages of high-gain if, power detector, class-B audio and low drain from an inexpensive battery.

regenerative receiver

Two distinctive features make this transistor detector really new. First, without sacrificing any audio gain, all long time constants have been completely eliminated from the detector. This, for all practical purposes, does away with audio bypass capacitors and the familiar regenerator squeal, growl or motorboat sounds. Second, but also of first-order importance, we have used the surface-barrier transistor which performs circles around conventional diffused-, alloy- or grown-junction transistors.

The SB (surface-barrier) transistor is a hot-performing detector at radio frequencies. It is worth while to the reader to know why this is true. So let us start with some explanatory background. The cutoff frequency of a transistor is the frequency at which the transistor gain is 3 db below its low-frequency value. This cutoff frequency is measured *with the transistor in the grounded-base connection.* You should also know that beta is the transistor's ground-emitter current gain.

Current gain

The grounded-base transistor connection does not give current gain. However, the grounded-emitter connection provides plenty of current gain at low frequencies. This is because the base circuit must be supplied with only enough current to make up for the small difference between emitter and collector currents. Current gains of a hundred or more are common in the grounded-emitter connection.

But, this current gain can be realized only when the emitter and collector currents are in phase. As the frequency is increased, the emitter and collector currents get further and further out of phase. This phase difference causes the emitter current to have a much different value from the collector current at any given instant. This results in a lowered current gain at high frequencies. And the higher the beta gain of the transistor, the more this effect is magnified at high frequencies.

The high-frequency gain of a grounded-emitter stage begins to roll off at a frequency equal to the quotient of the transistor cutoff frequency divided by the beta gain.

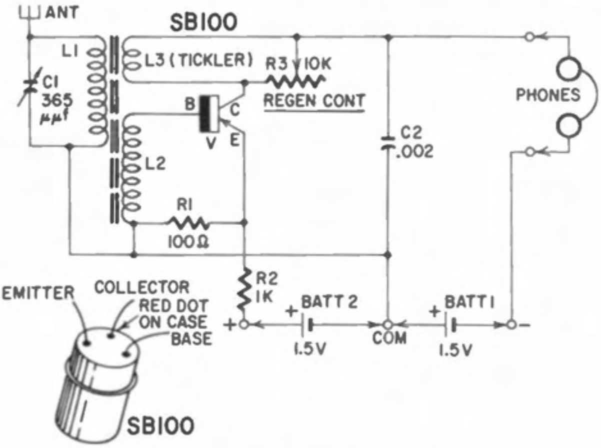
Suppose we have a transistor with a beta of 40 and a 10-mc cutoff. With these conditions, the performance of a grounded-emitter stage will begin to drop at 250 kc (10 mc divided by 40), well below the broadcast band. Usually, high-frequency transistors also have very high betas. This makes conditions, usually, somewhat more unfavorable than those just presented.

For the reasons just presented, low-frequency transistors (the 2N107 or CK722, for example) are most useful in the broadcast band as grounded-base-connected amplifiers or detectors. High-frequency units like the 2N136, however, are suitable in the grounded-emitter connection.

Surface-barrier transistor

In contrast to junction types, with their degraded high-frequency performance, the surface-barrier transistor just begins to show its clear-cut superiority at radio frequencies. It is designed to give optimum performance at high frequencies.

Typically, an SB transistor may have a *cutoff frequency at 50 mc and a beta of 10!* This means performance is excellent through the broadcast band and far into the shortwave bands. The SB transistor gives this type of performance with only a volt of col-



parts list for regenerative receiver

Resistors: R1—100 ohms, ½ watt; R2—1,000 ohms, ½ watt; R3—10,000-ohm potentiometer.

Capacitors: C1—variable capacitor, 365 μμf; C2—.002 μf; ceramic or paper.

Transistor: V—Philco SB100.

Coils: L1—ferrite-rod antenna; L2,L3—special windings (see text.)

Miscellaneous: Batt 1, Batt 2—1.5-volt dry cells; pegboard; Fahnestock clips, wire, knobs, solder, screws, terminal strip.

Fig. 216. *The surface-barrier transistor performs well at broadcast frequencies in this regenerative circuit. R3 controls the amount of feedback, hence the volume indirectly.*

lector supply and a power consumption only one-tenth that of a junction transistor.

SB detector circuit

Fig. 216 shows the regenerator circuit employing the SB100 surface-barrier transistor. Notice the emitter is biased from the drop across a 100-ohm resistor (R1). This value of resistance is low enough to obviate the need for a bypass capacitor. Because the bypass capacitors are eliminated, the usual audio howls are gone. Admittedly, there is a bypass capacitor (C2) across the headphones, but this has little effect at audio frequencies.

The usual emitter or base bypass capacitor has been dispensed with at the expense of some power loss in the 1,000- and 100-ohm resistors (R2 and R1). Even then the resulting power consumption is still far less than for a junction-transistor stage.

An interesting facet of this circuit points up the marvelous characteristics of the SB transistor. Once the detector has gone into oscillation, the emitter bias can be reduced to zero and the circuit will continue to oscillate strongly! As many experimenters will know, this just can't be done ordinarily. It is indicative of the circuit's high gain and merit.

This was the reason we had to control regeneration with a shunt resistor (R3) across the tickler coil. If a bias type regeneration control had been used, it would have lost control immediately with the beginning of oscillation. The only way to stop oscillation under these conditions would be to turn off the battery supply.

Construction

The original circuit was built on a pegboard (Fig. 217) allowing the circuit to be quickly modified without the confusion that usually rules the breadboard layout. This arrangement is very convenient. Otherwise hard-to-mount components are easily attached to the board with wire harness running over the components and through the pegboard holes. As the photo in Fig. 217 shows, the tuning capacitor, antenna and dry cells were all attached that way. Almost any component can be jockeyed around on the board's surface until its mounting holes coincide with those punched in the board.

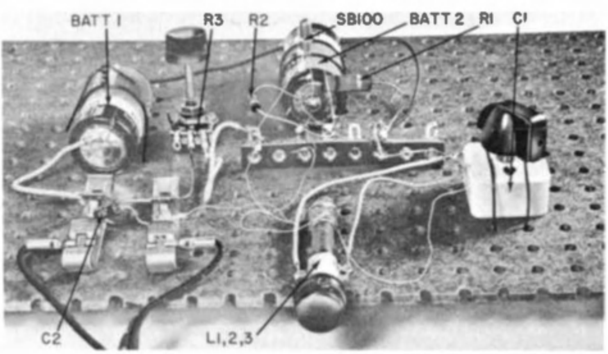


Fig. 217. *A pegboard can be used as the chassis for the regenerative receiver.*

As a design rule of thumb, any regenerator tuned circuit should have the highest possible Q. This is the reason a ferrite-rod antenna, or loopstick, is used. It must have two additional windings — one for the transistor base circuit and the other to provide feedback from the collector. Winding L2 is seven turns and L3 two turns of flexible wire wound over the main winding. The wire size is not too important. It is advisable, though, to wind tickler L3 on a small paper sleeve so it can be slid on or off the ferrite rod. This provides a rough regeneration control that can be adjusted to account for changes in antenna length and loading.

Some of the newer ferrite-rod antennas are tapped for transistor use. The Lafayette MS-299 is the latest example. If this type is used, simply connect the transistor base to the tap and add only the tickler coil L3.

Connect the emitter and collector cells, observing the proper polarities, which are exactly the same as for a junction p-n-p transistor. The emitter is biased with a positive current and the collector operated with a negative voltage.

Operation

Now, connect a short antenna — say 10 feet — to the detector and rotate the regeneration control back and forth. The detector should go into oscillation with a plopping sound or a click. If it does not oscillate, reverse the leads to the tickler coil.

Adjust the tickler position so the detector goes in and out of oscillation near mid-position of the control. With these adjustments made, stations should be picked up easily. Local stations will be loud and clear with plenty of volume. Some can even be picked up without an antenna. Distant stations can be received in the daytime but the audio level will be too low to hear comfortably. Two stages of additional transistor audio amplification can be added if desired for distant reception.

The tuning capacitor

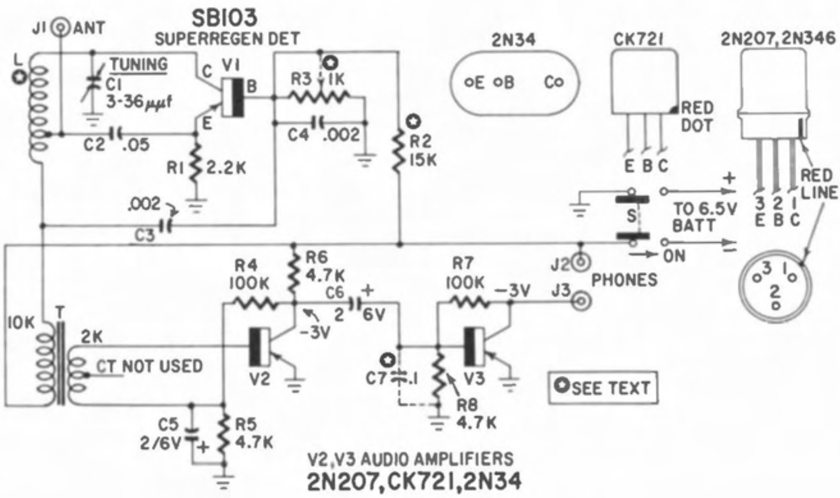
The new solid-dielectric type of tuning capacitor was used on this model. It does not produce the annoying swish during rotation that earlier models had exhibited. As shown in Fig. 217, the tuning screw on the antenna coil has a knob attached and is used for fine tuning. Knobs are now available that exactly fit the diameter of this tuning screw.

If you are interested in transistor regenerators, try this circuit. We believe it will outperform anything you've seen yet.

pocket police receiver

THE idea of owning a police radio receiver is always intriguing. Interest spans all age groups from children to grandparents. There is a thrilling vicarious experience; listening to emergency broadcasts is exciting to all but the victims.

Added to this, we have an extra-special police receiver. It is hand- or pocket-size and completely transistorized. Its operating frequency range is about 30 to 45 mc.



parts list for pocket police receiver

Resistors: R1—2,200 ohms; R2—15,000 ohms (see text); R3—1,000 ohms (see text); R4,R7—100,000 ohms; R5,R6,R8—4,700 ohms (all resistors ½-watt 10%.)

Capacitors: C1—3-36-μμf trimmer (Bud MT—833 or equivalent) C2—.05 μf ceramic, subminiature type; C3,C4—.002 μf, disc ceramic; C5,C6—2 μf, 6 volts, miniature electrolytic; C7—0.1 μf ceramic (see text.)

Transistors: V1—SB103 (Philco); V2, V3—2N34 (CK721 or 2N207 may be substituted.)

Jacks: J1, J2, J3—pin jacks.

Miscellaneous: L—7 turns, tap at 2¼ turns (Barker & Williamson type 3003 Miniductor); S—dpst slide switch; T—driver transformer, primary impedance 10,000 ohms; secondary impedance 2,000 ohms center tapped (Argonne AR—109 or equivalent); battery—6.5 volts (Mallory TR—165R or equivalent); terminal board; case; miscellaneous hardware.

Fig. 218. *This superregenerative receiver has a high-frequency detector and two stages of audio amplification. The circuit is designed to eliminate practically all controls.*

The small size makes it ideal for auxiliary police, Civil Defense workers, merchant police, ambulance crews and the like. Also, it is just the thing for those who like to know what is going on.

The circuit (Fig. 218) is simple and there are few parts. One of the transistors is a surface-barrier type. It is used just like a p-n-p fused-junction type. However, SB units can operate at very high frequencies.

The SB transistor is used as a high-frequency superregenerative detector. The other two transistors are audio amplifiers.

The receiver, as illustrated, is a fixed-frequency type. Tuning can be changed only by adjusting C1 through a hole in the case, and even the amount of *superregeneration is set at a fixed value.* These are desirable features, since they eliminate controls.

Receiver sensitivity

To appraise its performance, here is a report on the receiver in use. However, bear in mind that signal strengths vary tremendously in this type of service.

From experience, the audio output is strong and clear 5 miles from a central police transmitter. Reception is usually good, even without an antenna. Reception of patrol cars or utility truck transmissions is another matter. Unless the vehicle is very close, audio is weak and garbled.

This circuit has been used with a third audio stage and a small speaker. Still, earphone operation seems preferable for one-man listening. If a third stage is added for speaker operation, considerable audio decoupling is necessary to eliminate motorboating.

Detector circuit

The superregenerative detector is the receiver's nerve center. Superregeneration develops tremendous amplification in a single stage.

Inherently, the superregenerative detector is not very selective. Also, it has a natural automatic volume control action.

With rare exceptions, the stations in the 30-60 mc band are narrow-band frequency-modulated. The pocket police receiver picks up these stations by slope detection.

Because the detector is broadly tuned and the frequency swing is very small, audio output from the detector is low. This makes the two medium-gain audio stages necessary.

The superregenerative detector's selectivity can be sharpened somewhat by setting the value of superregeneration carefully. In fact, it *must* be set for greatest selectivity for really good performance. This procedure requires a signal generator and is explained later.

The maximum frequency at which the detector will superregenerate depends upon the Q of the coil, transistor characteristics, the value of C2, the position of the coil tap and transistor bias.

To operate the receiver at 40 mc or higher, you may have to juggle or vary all of these values for maximum superregeneration.

High-frequency performance is particularly dependent upon coil L. For this reason, we will give it special mention. First, the coil must be kept away from the sides of the case, transformers and other metal parts. If at all possible, use a larger metal case, a plastic case or no case at all. Test the circuit before placing it in a case.

The receiver (Fig. 219) operated up to 45 mc before placed in its case. In the case, it works to about 39 mc using a selected, hot-performing 2N346/SB103 transistor. Other units may not perform as well.

A lot of experiments were carried out with some of the completely shielded miniature iron-core coil forms now available. These would do away with effects caused by nearby components. But, because their performance was lower initially, they made no improvement.

The Miniductor type coil (Barker & Williamson No. 3003) gave the best results. Coil L consists of 7 turns tapped at 2¼ turns. This coil is ½ inch in diameter, with a pitch of 16 turns per inch.

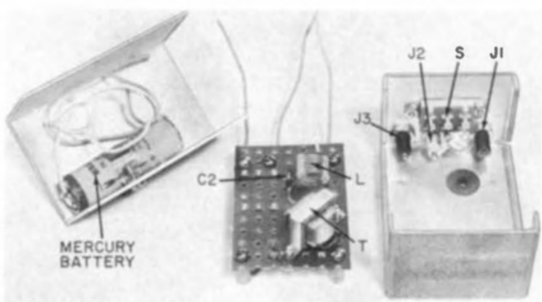


Fig. 219. *A metal case will lower the limit of the receiver's high-frequency operation.*

Resistors R2 and R3 control superregeneration. With fixed frequency operation, fixed values of resistance can be used. For each individual receiver and frequency, however, these values will have to be changed for best performance. Either decrease R3 or R2. (Decreasing R2 has an opposite effect from decreasing R3.)

To make superregeneration variable, substitute a 1,000-ohm potentiometer for R3 and connect the center terminal of the control as indicated by the dotted lines in the schematic. Also, decrease R2 to 10,000 ohms.

Capacitor C2 should be a subminiature ceramic. The rather large value for C2 is necessary for superregenerative action.

Another essential is transformer coupling. The transformer characteristics have an effect on the detector's quench action. The Argonne AR-109 or something very similar should be used.

Only surface-barrier transistors will work properly in the detector circuit. The 2N346/SB103 is satisfactory (so is the 2N128).

Audio amplification

The two audio transistors have medium beta (current-gain) figures -- about 40 to 45. Any other p-n-p transistor with about the same gain is suitable.

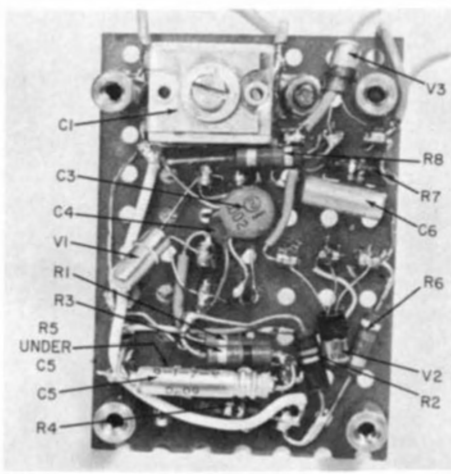


Fig. 220. *This underside view of the pegboard shows the placement of the parts.*

Direct-current feedback stabilization is used. While this is not as good as having emitter stabilization, it is sufficient and saves the space occupied by two emitter bypass capacitors.

The feedback does not compensate for individual transistor variations, but it does hold temperature changes of the collector current to a reasonable amount. The circuit works like this: If collector current tends to increase because of temperature effects, collector voltage decreases because of the drop across the collector load resistor. This, in turn, tends to decrease the base bias current and reduces the total change considerably. This bias method is infinitely better than just a single resistor from the base to the supply voltage.

Collector voltage of transistors V2 and V3 should read -3 volts (± 0.5 volt) using a 20,000-ohms-per-volt meter. If higher, *decrease* the value of R4 or R7, as the case may be, to *decrease* the collector voltage and vice versa.

If a 2,000-ohm earphone is used, R7 may have to be reduced to about 47,000 ohms.

You may find that listening is more comfortable when the optional capacitor C7 is added. Capacitor C7 suppresses the ultra-

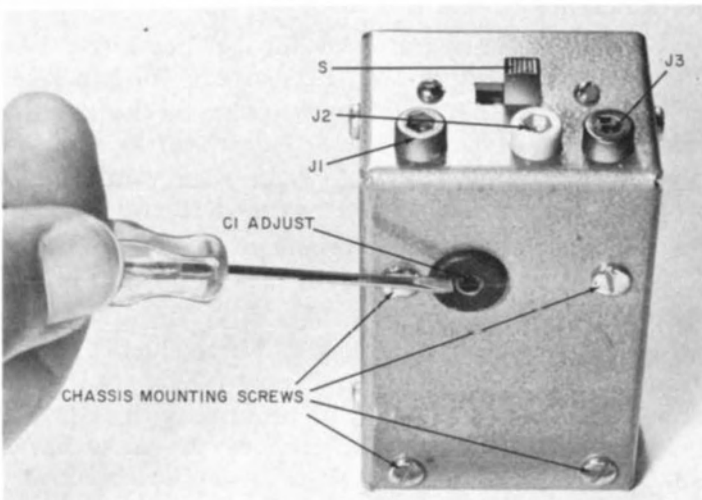


Fig. 221. *The tuning capacitor, C1, is reached through a hole in the case.*

sonic quench frequency before it reaches the earphones or overloads V3.

A small terminal card (Fig. 220) simplifies construction. The components are wired to the card. Then the card (pegboard or terminal board) is bolted into the case with four brass standoff spacers.

The mercury cell is clamped to the case cover with a piece of strapping material. Of course, a capacitor clip or battery holder could also be used.

The antenna can be a heavy piece of Copperweld wire, about 12 inches long, that plugs into the antenna jack. Increasing the antenna length does not seem to improve reception very much. Too much antenna length will load the oscillator and reduce the maximum working frequency.

Final check

For reception or narrow-band FM, detector superregeneration must be set for maximum selectivity. To do this, a signal generator is necessary. Assuming the set is working, a hiss or frying sound is heard when the detector is superregenerating. With the antenna connected, tune the receiver to the carrier frequency. (See Fig. 221.) This is found by setting the generator at the carrier with tone modulation. Now, rock the tuning capacitor C1 back and forth and adjust the value of R3 until the sharpest selectivity is obtained.

Turn off the generator and listen for a police carrier. The instant the carrier is heard, *turn C1 very slightly* for best reception. This is necessary to account for inaccuracies in the signal generator's calibration and *because the detector must be tuned to one side of the carrier for slope detection.* In other words, best audio *will not* be obtained with the detector tuned exactly to the carrier.

If the detector does not superregenerate, check the connections to the surface barrier transistor. It is easy to confuse the emitter with the base lead.

Next, check the transistor voltages. There should be about 6 volts from ground to collector and, very roughly 0.1 volt from emitter to base. The base should be negative with respect to the emitter. Also, check to see that none of the parts have been omitted.

When the receiver is first connected to the battery, set R3 at maximum resistance. This protects V1 if the battery is inadvertently connected with wrong polarity.

carrier-power receiver

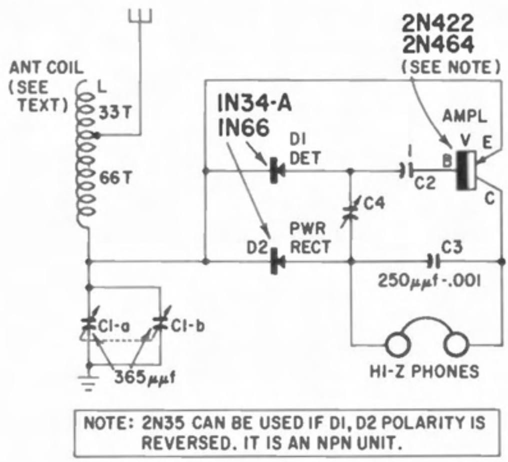
If you live within 10 miles or so of a broadcasting transmitter, the circuit shown in Fig. 222 is a way to get something for nothing. The field created by the nearby transmitter can supply the power you need to operate a 1-transistor receiver.

In this receiver only one antenna is needed and the detector, amplifier and power supply are connected by only one lead to the rf or tuned section. No ground return is used as it is not needed. At first glance the circuit may appear unworkable, but it does work, and very efficiently at that.

Check for power

Before building any free-power receiver you should determine if your location, plus a suitable antenna system, will deliver enough power to operate the amplifier. One important factor that affects the strength of a receiver's signal is the height of the receiving antenna. In practice, antenna height contributes as much as its effective length to signal strength, so place the receiving antenna as high as you can possibly get it.

A good way to determine the amount of available power is



parts list for carrier-power receiver

Capacitors: C1—2 gang variable capacitor, 365 μμf each section. C2—1μf; C3—250 μμf–.001 μf; C4—small tuning capacitor.

Diodes: D1, D2—1N34A, 1N66.

Coil: L—antenna coil, 99 turns No. 22 or 24 dcc on 2-inch diameter form, tapped at 33 turns.

Miscellaneous: M—dc milliammeter (1 ma full scale or more, as required) rfc—2.5 mh (optional, see text); hardware.

Fig. 222. *The power supplied by a strong transmitting carrier will operate this receiver. Select the most powerful station. The length and height of the antenna are important factors.*

empirical – erect the longest and highest single-wire antenna possible in your location and connect it to the simple crystal set shown in Fig. 223. The tuner and the two diodes are connected with clip leads as these components will be used in the receiver. Place a milliammeter between the diodes and, if you get a reading of 500 μa or better, you should have enough power for a batteryless transistor radio. If you get a reading between 1 and 2 ma, you have enough dc to operate an efficient speaker. Of course, a good ground such as a waterpipe will contribute to the power received.

Sometimes multiple ground connections to separate grounds produce even greater current.

In making your tests, be certain you have tuned in your strongest station because this is the frequency you will use later. In short, if you live within reasonable distance of a strong transmitting station, have an antenna at least 100 or 150 feet long and 35 to 45 feet high, you should have no power shortage. Some antenna systems only 75 feet in length at an average height of 35 feet are capable of delivering better than 1 ma when located in a favorable spot.

The receiver circuit

While the few components required are familiar to all radio men and need no description, the unconventional circuit does require some discussion. Its operation is similar to that of the double-diode arrangement in the power-checking circuit of Fig. 223 with detector diode D1 working in conjunction with the

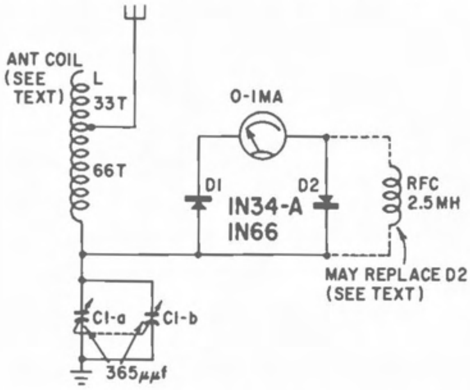


Fig. 223. *This circuit will give you an idea of the relative strengths of carrier power in your vicinity.*

emitter to the base element of the transistor. Diode D2 is set up so the rectified carrier dc is supplied to the collector in the proper direction. While the circuit appears freakish upon casual inspection, its operation is entirely conventional.

It may interest readers to know that in the power-checking circuit, one of the diodes may be replaced with an rf choke with equal efficiency.

Of the many types of diodes, the 1N34A and 1N66 will be found suitable. Various types of junction transistors can be tried and some will perform better than others. Among these will be

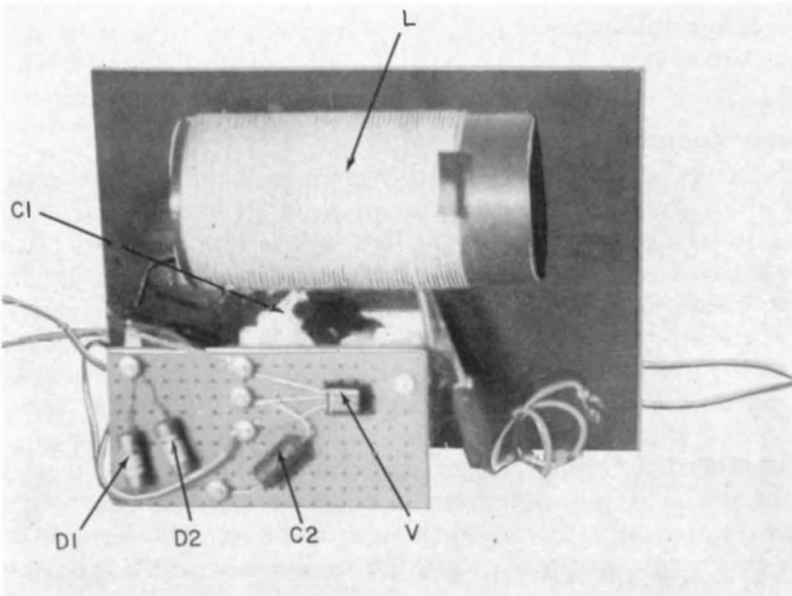


Fig. 224. *This is a rear-view photo of the carrier-power receiver. The coil is tapped at the 33d turn for an antenna connection.*

the 2N422, 2N464, 2N107 and the 2N35. The last is a n-p-n type and, if used, the polarity of both diodes must be reversed. The circuit works just as well with either type of transistor if proper current direction is insured. The value of the base capacitor is not critical and values from 0.1 to 1 μf were suitable. A base-bias resistor did not add to the circuit's efficiency. Try several diodes and transistors, using the ones that perform best in your final circuit. Many inexpensive types are suitable.

Almost any type of coil may be used in the antenna circuit (Fig. 224). A single-layer coil of 99 turns of No. 22 or 24 dcc wire, tapped at the 33d turn allowed for adjusting the total inductance used, so you can adjust for the most favorable ratio of L to C in the series-tuned circuit. For best power response C1 should be the largest value that will let the circuit be resonant at a given frequency in respect to the value of L — more current is passed when the ratio of C to L is large. Naturally, a series-tuned tank is not the most selective type of tuning element, but selectivity is not too important with this receiver. Both the signal frequency and the power or carrier frequency are the same. A station has to be on frequency for the power circuit to function, hence the amplifier works only when there is sufficient power to activate it. Furthermore, it is unlikely that any builder lives at a location where more than two or three local transmitting stations furnish enough power for signal overlapping. So selectivity is sacrificed for simplicity.

Some operating notes

Receiver operation is exactly the same as that of a simple crystal set — the one dial is moved to the point of greatest volume. With certain transistors, a heterodyne-like whistle may be heard just to the higher-frequency side of the station resonant point on the dial. The whistle is caused by feedback, but does not interfere with reception if the dial is turned a slight bit toward the lower-frequency side. By adjusting C4, a small tuning capacitor or medium-sized trimmer, the whistle can be eliminated. The point of clearest reception is easily noted, and once adjusted need not be changed.

Another interesting point noted was that it does not seem to make much, if any, difference how long a conductor is used to connect the tuning circuit to the rest of the set. One experiment was made with the tuner proper left in one room while the rest of

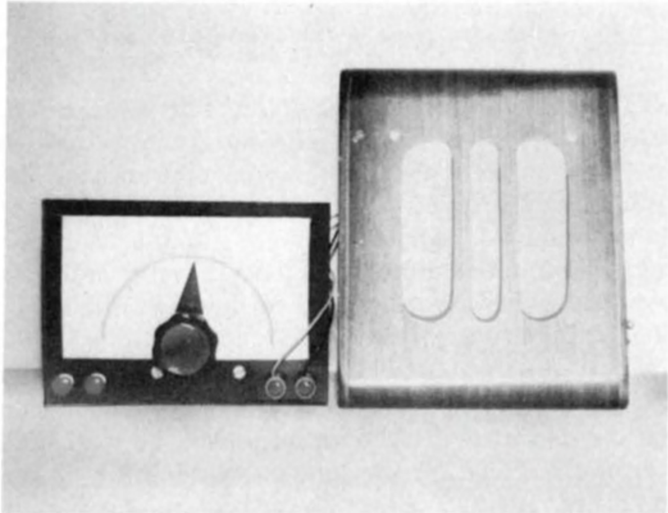


Fig. 225. *If the station carrier is strong enough, the carrier-power receiver will operate a speaker.*

the unit was placed 40 feet away in another part of the house. There was no reduction in volume.

If the receiver is operating correctly, its output is in the order of four to eight times that of a plain crystal set. Exact measurements cannot be given because the volume always depends on the actual power delivered by the antenna. In some places the volume level is surprisingly strong – enough to drive a sensitive PM (Fig. 225) or an old magnetic type speaker, should one be at hand. Signals from a pair of headphones should be audible 10 or 15 feet away. The whistle effect will be absent and the quality ragged if power is borderline. A longer antenna will usually end this problem.

The percentage of modulation of the transmitter can also affect reception on a receiver of this type. If the modulation is less than 100%, the quality of the receiver's output will be far better than otherwise. There must always be more carrier power to the collector than voice signal.

The experimental receiver described here uses the same station to furnish both the signal and power but somewhat more advanced circuitry will lead to a batteryless receiver which uses the carrier frequency of a very strong transmitting station to amplify the signals from a low-level or weaker station on another frequency. The receiver in Fig. 222, though, serves as an interesting introduction to the construction of more complicated receivers using the free-power principle. And we all like to get something for nothing.

transitube pocket radio

THIS radio is designed around a subminiature hearing-aid tube and two transistor amplifier stages. The subminiature tube is a 2E31 used as a regenerative detector. Of course, a 2E35, CK503AX or CK506AX could also be used.

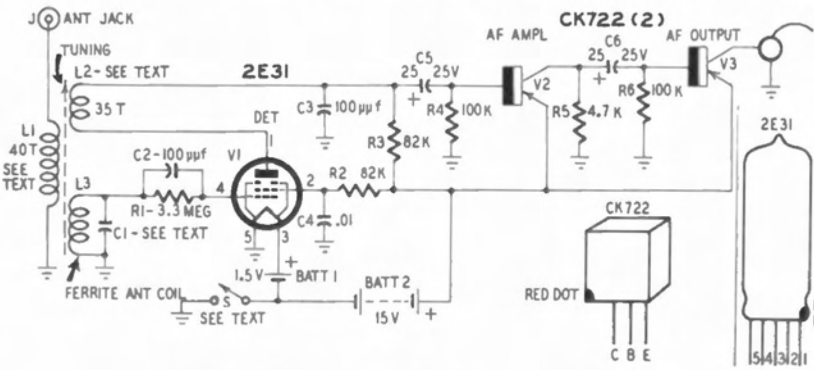
Building the receiver

The ferrite antenna coil (L3) is a high-gain unit with a long core. Two windings are added to the coil. The first (L1) consists of 40 turns of No. 28 enameled wire closewound over the existing coil. See Fig. 226. Secure this winding with cellophane tape. The other winding (L2) is 35 turns of No. 28 wire closewound about ½ inch away from L3.

The whole broadcast band may be covered by placing a 220-µµf capacitor (C1) across L3.

A 25-µf electrolytic (C5) couples the signal from the plate of the detector to the base input of the first transistor amplifier. The transistor stages are conventional R-C-coupled amplifiers with base and collector resistors connected to ground. Their emitters are connected to the positive end of the B-supply. The last stage drives a hearing-aid earpiece.

A miniature 15-volt battery is used for the B-supply and a 1.5-volt penlight cell for the detector's filament. Filament leads must be connected as shown. The on-off switch is home-made. Two small



parts list for transitube pocket radio

Resistors: R1—3.3 megohms; R2,R3—82,000 ohms; R4,R6—100,000 ohms; R5—4,700 ohms (all resistors ½-watt, 10%.)

Capacitors: C1—see text; C2,C3—100 µµf, ceramic; C4—.01 µf, ceramic; C5,C6—25 µf, 25 volts, electrolytic.

Transistors and Tube: V1—2E31; V2,V3—CK722.

Coils: L1—40 turns No. 28 enameled wire closewound, ½-inch from L3; L3—ferrite antenna coil (Superex Ferri-Loopstick; Lafayette MS-11; Allied No. 51 C 036, or equivalent.)

Batteries: Batt 1—1.5 volts, penlight cell; Batt 2—15 volts, hearing-aid type.

Miscellaneous: J—tip jack; S—see text; plywood boards, 6x3½ inches (for case); hearing-aid earpiece; hardware.

Fig. 226. *Tubes and transistors form a good working combination in this three-stage receiver. Regeneration can be controlled by making C3 variable, but this will add another control.*

brads are nailed through the bottom of the set's wooden case, and a soldering lug is bolted to the case. Turning this lug connects the brads, completing the battery circuit.

The case (see Fig. 227) is made from two pieces of ¼-inch and one piece of ½-inch plywood. First, cut the three pieces to size, place a small brad through each corner and sand all sides evenly. Next, the center of the ½-inch board is removed, leaving a ½-inch border. At the top of the case a ¼-inch hole is drilled for the antenna coil's core. Another ¼-inch hole is drilled for the antenna jack. The earpiece leads run through a hole in the opposite end of the case.

There is no special way of mounting the parts, although they must be kept as close together as possible. Be very careful to prevent parts from touching and leads from shorting. Generous use of spaghetti will help. (The finished receiver is shown in Fig. 228.)

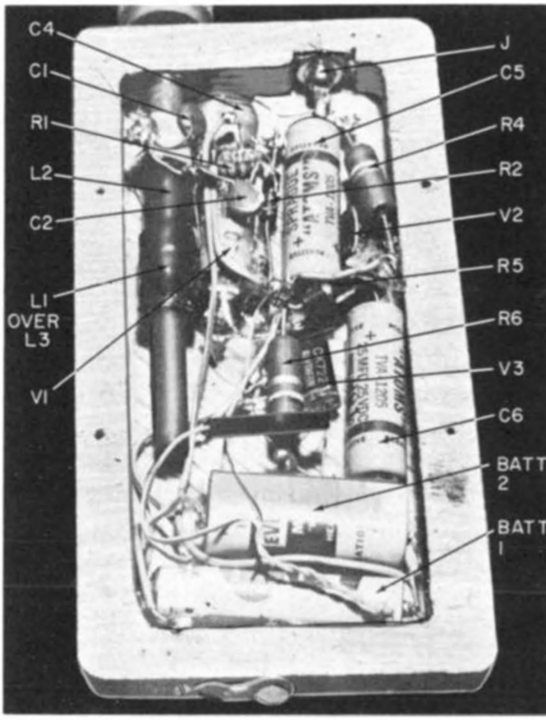


Fig. 227. *A wooden case forms the housing for the transitube pocket radio.*

Using the receiver

Operation is simple. Just turn on the power, plug an outdoor antenna into the antenna jack and you are ready to listen. The antenna coil's core is a combination tuning and volume control. Tuning is critical for distant stations, but for local stations some detuning may be necessary to reduce volume. Outdoors, you can

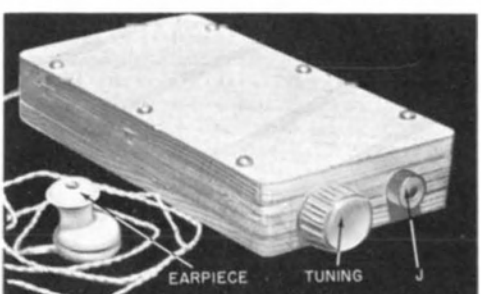


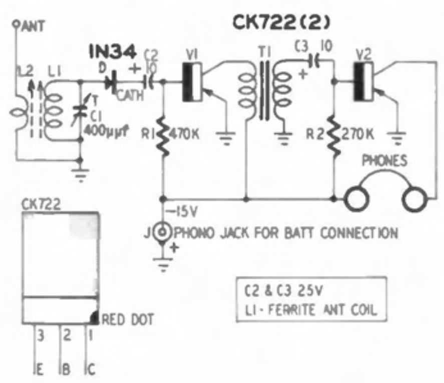
Fig. 228. *The regenerative receiver is a fairly compact, flat unit.*

use a flexible antenna wire run up your coat sleeve to receive local stations.

If the set's gain and sensitivity seem poor, reverse the L1 winding connections. Varying the value of the detector's plate-load resistor (R3) may give sharper tuning.

headphone radio

THIS two-stage transistor radio is a simple one for training the beginner. Designed around a sensitive ferrite coil and two CK722 transistors it fits into a small plastic box. The ferrite coil (L1 in Fig. 229) used in this simple circuit is the adjustable powdered-iron slug type, commonly used for replacing bad or worn-out an-



parts list for headphone radio

Resistors: R1—470,000 ohms; R2—270,000 ohms (both ½ watt.)

Capacitors: C1—400-μμf trimmer; C2 and C3—10-μf, 25-volt electrolytic.

Transistors: V1,V2—CK722.

Diode: D—1N34.

Miscellaneous: J—phono jack; L1—ferrite antenna coil; T1—interstage transformer (Stancor U113 or equivalent); midget battery, 15 volts; alligator clip; phono plug; headphones.

Fig. 229. *This easy-to-build receiver uses a diode detector and two transistors as audio amplifiers. Any large metal area, such as a window screen, can act as the antenna.*

tenna coils in small table radios. Adjusting the slug controls the volume of strong stations and increases the volume of distant ones.

Around the coil wind 25 turns of No. 28 enameled wire (L2). Tape these windings to the coil. One side of L2 is grounded and the other end fastened to a 3-foot length of flexible wire with an alligator clip soldered to it. With this setup you can easily clip to the bed springs, outside antenna or over the insulated telephone cord for an outside antenna connection.

Capacitor C1, a 400-μμf trimmer, is used to tune in the broadcast stations. A 1/4 x 1/2-inch brass rod is soldered to the original adjustment screw so a knob can be used for convenient tuning.

A 1N34 crystal diode detects the incoming signal. From here the rectified signal is fed to the base of V1 through capacitor C2. The

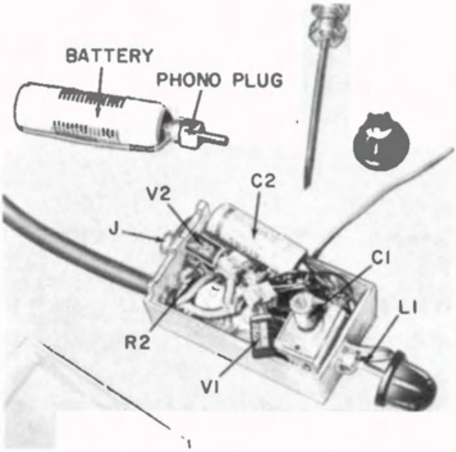


Fig. 230. *The headphone radio is a tiny unit.*

emitter is grounded and the collector coupled to a transistor interstage transformer.

Capacitor C3 couples the signal to the base of V2. The output of this transistor is fed to the headphones. On local stations volume is so great that the phones can be set down and the program easily heard 2 feet away.

There is only one battery, a 15-volt Eveready hearing-aid type. The shell of a male phone plug is soldered to the positive end of the battery. Drill a small hole through the plug's shell. A length of wire is slipped through this hole and soldered to the center prong. The other end of the wire goes to the negative terminal of the battery. With this arrangement the battery plugs into the radio and serves as an on-off switch.

The radio is built to fit a 2 x 2 x 3-inch plastic case (Fig. 230). Although any type of container can be used, plastic is about the easiest material to work with. Place the ferrite coil in one corner of the case. The 1N34 diode is placed next to the coil. Then the interstage transformer is put on the opposite side of the coil with capacitor C3 mounted directly above it. Capacitor C1 is soldered as closely as possible to the terminals of the ferrite coil.

Solder a brass wire to the grounded side of the trimmer to be used as a support for mounting the transistor sockets. Plug in the transistors, making sure that the red dot is on the proper end of the socket. A phono jack is mounted on the case. On the same end drill a hole for the headphone cord. It should be a tight fit so the small unit will not slide off the cable.

The radio is easy to operate. Be sure to check the wiring before trying it out. Place the earphones over your head and plug in the battery. Hook the alligator clip to an outdoor antenna and tune in the station you want. Adjusting the ferrite coil's slug will vary the volume of the receiver.

transistors for 10 meters

AFTER being confined to the laboratory, audio and broadcast radio, for the first few years of its life, the transistor is finding its way into the hamshack. Because it is a fairly new device to the ham, many have hesitated to make full use of transistors in their gear.

This section describes a 10-meter receiver that uses low-cost readily available transistors. The set's performance is not equal to

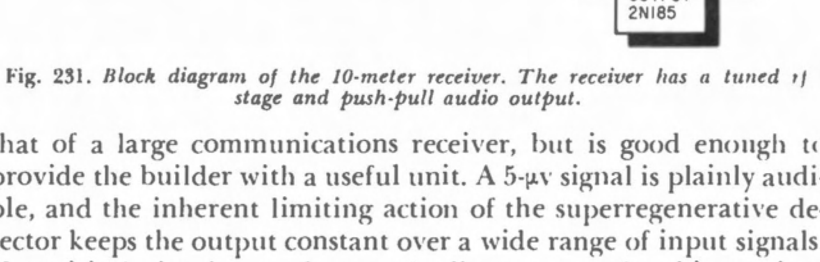
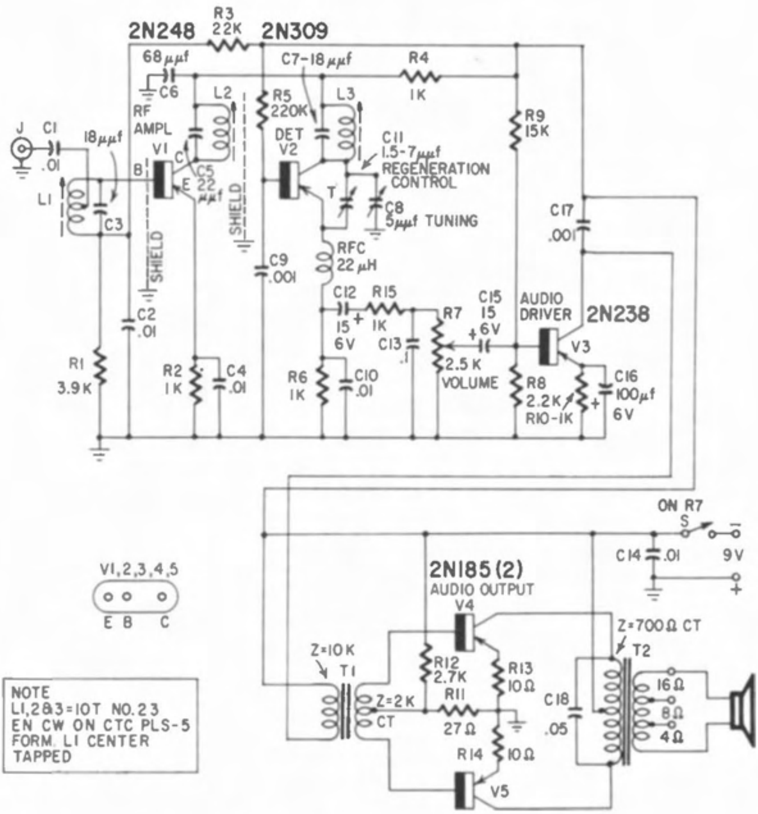


Fig. 231. *Block diagram of the 10-meter receiver. The receiver has a tuned rf stage and push-pull audio output.*

that of a large communications receiver, but is good enough to provide the builder with a useful unit. A 5-µv signal is plainly audible, and the inherent limiting action of the superregenerative detector keeps the output constant over a wide range of input signals. Noncritical circuitry and ease of adjustment make this receiver ideal for the ham just getting started with transistors.

Receiver circuit

A block diagram of the receiver is shown in Fig. 231. Func-



parts list — transistors for 10 meters

Resistors: R1—3,900 ohms; R2,R4,R6,R10, R15—1,000 ohms; R3—22,000 ohms; R5—220,000 ohms; R7—2,500 ohm potentiometer, audio taper, with spst switch; R8—2,200 ohms; R9—15,000 ohms; R11—27 ohms; R12—2,700 ohms; R13,R14—10 ohms (all fixed resistors ½-watt, 10%.)

Capacitors: C1,C2,C4,C10,C14—.01 μf, ceramic; C3,C7—18 μμf, mica or ceramic; C5—22 μμf, mica or ceramic; C6—68 μμf, mica or ceramic; C8—5 μμf, variable; C9,C17—.001 μf, ceramic; C11—1.5-7 μμf trimmer; C12, C15—15 μf, 6 volts, electrolytic; C13—0.1 μf paper; C16—100 μf, 6 volts, electrolytic; C18—.05 μf ceramic.

Transistors: V1—2N248; V2—2N309; V3—2N238; V4,V5—2N185 (all Texas Instruments.)

Coils: L1—10 turns No. 23 enameled wire, close-wound, tapped at 5 turns, on Cambridge Thermionic PLS-5 form with green slug; L2,L3—10 turns No. 23 enameled wire, close-wound on Cambridge Thermionic PLS-5 form with green slug.

Transformers: T1—driver transformer: primary, 10,000 ohms impedance; secondary, 2,000 ohms, center tapped; T2—output transformer: primary, 700 ohms impedance, center tapped; secondary 4, 8 or 16 ohms (Gramer-Halldorson GH6 or equivalent.)

Miscellaneous: J—coaxial connector; speaker; metal shields (2); transistor sockets (5); 9-volt battery (Burgess 2N6 or equivalent); hardware.

Fig. 232. *Circuit diagram of the 10-meter receiver. A shield, connected to the common ground bus, prevents coupling between L2 and L3. Capacitor C13 has a fairly low reactance to the quench frequency, bypassing most of it around the volume control. Capacitor C17, shunted across the primary of the interstage transformer, T1, acts as an additional quench filter.*

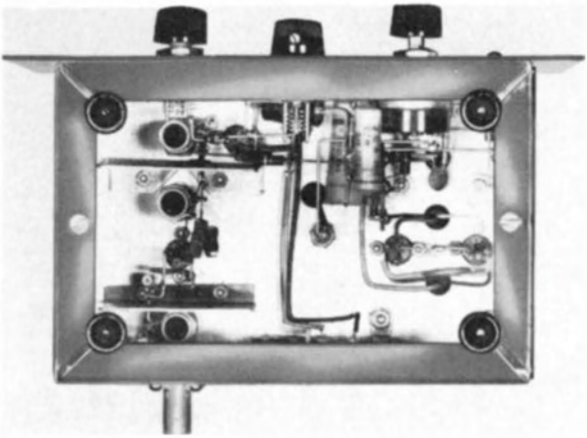
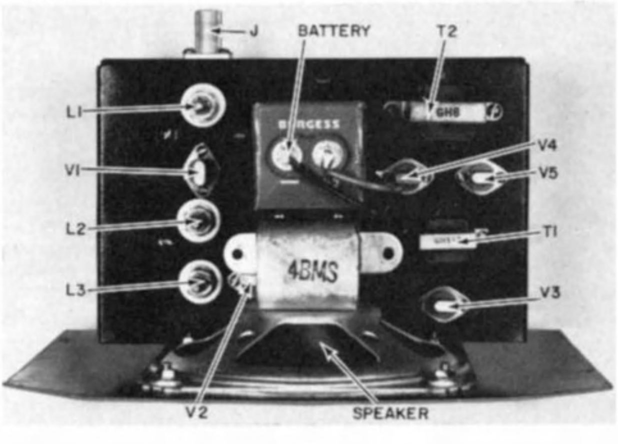


Fig. 233. *Placement of most of the components can be seen in this under-chassis view.*

tionally, it is no different than a comparable vacuum-tube set. The receiver consists of an rf amplier, superregenerative detector, audio driver and push-pull audio output stages.

Fig. 232 shows the receiver's circuit. The rf stage uses a 2N248 in a common-emitter amplifier circuit. The input from the antenna is connected to a tap on the coil (L1) in the base circuit. The coil's tuning is very broad because of the base circuit's input resistance. Resistors R1 and R3 set the base-bias voltage. R2 maintains the desired emitter current. The collector tuned circuit consists of L2 and C5.

Fig. 234. *The positioning of the coils, transistors and speaker is shown in this photo.*



Coils L2 and L3 are not inductively coupled. The shield shown in the schematic helps insure this. Capacitor C6 acts as a coupling between the two coils. As its value goes up, the coupling decreases.

The superregenerative detector uses an easily adjusted circuit that is very tolerant of transistors. A 2N309 is used here. Though intended for 455-kc if amplifier circuits, it works well as an oscillator in the 10-meter range. A 2N248 may also be used here if desired, but is more expensive. The circuit is basically a grounded-base oscillator with an R-C timing network (R5 and C9) provid-

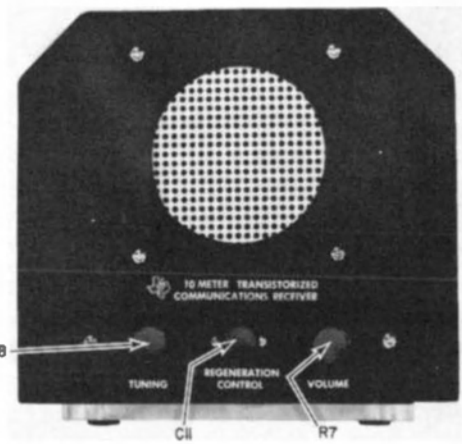


Fig. 235. *This is a front view of the 10-meter receiver and shows the position of the controls.*

ing the quench frequency for superregenerative operation. The capacitor from collector to emitter, C11, controls the feedback. It is adjusted to insure oscillation over the entire band. Audio output from this stage is taken across the emitter resistor R6. (Most of these components are shown in the under-chassis view in Fig. 233.)

The audio signal contains a large amount of the quench frequency, which would tend to overload the following audio stages. A simple filter consisting of R15 and C13 removes most of the quench voltage and allows the desired audio to pass on to the volume control.

The audio driver stage uses a 2N238. Biasing network R8, R9 and R10 operates in the same manner as its counterpart in the rf stage. A transformer couples this stage to the push-pull output. Capacitor C17 helps to attenuate any quench-frequency signal which was not eliminated at the stage's input.

The output stage is operated class B to provide plenty of power when needed, while keeping the average battery drain low. Any size speaker may be used. The maximum audio output is 250 milliwatts, more than adequate for good room volume. A small speaker may be used, but will not be as efficient as somewhat larger ones. (The speaker is shown in the top view of Fig. 234.)

The TUNING, REGENERATION and VOLUME controls are mounted on the front panel. The REGENERATION control could be made a small trimmer capacitor since it is seldom touched in normal operation.

Final steps

Adjusting of the receiver is simple. With power on, a hiss should be heard from the speaker. If not, vary the REGENERATION control until you hear the hiss indicating the detector is operating. Apply a 28-mc signal from either a grid-dip meter or other signal source to the antenna input. With C8 set for maximum capacitance, adjust the slug in L3 until the signal is heard. While tuning C8 through its entire range, the hiss should continue, indicating detector operation over the whole band. The positioning of the controls on the front panel of the receiver is shown in Fig. 235.

Apply a 29-mc signal and tune it in. Adjust the slugs in L1 and L2 for maximum signal. This completes the alignment, making the receiver ready to use. A couple of details might be mentioned at this point. Varying the regeneration control will change the detector's frequency, but once this control is set it need not be changed. The tuning of L1, as mentioned previously, is very broad.

The set's performance is quite startling, considering its size and power consumption. Several types of antennas have been used, ranging from a mobile whip to a pair of TV rabbit ears. Good signals have been heard with all of them. The input is designed for a 50-ohm unbalanced line and the receiver works best with a good antenna.[1]

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[1] When conditions are right, there is no limit to the distance possible on the 10-meter band. Listening tests show that this little set can really reach out. Within a short time after turning it on, phone hams had been picked up coast to coast and from South America.

Selectivity is less favorable. A single strong station can completely blot out several weak ones on other frequencies. Also, the regeneration control affects frequency, so it should not be touched after being set to optimum.

During the tests, a noiselike kind of distortion made it impossible to understand *strong* stations. It was cured by placing a large electrolytic (250 μf at 25 volts) across the battery.