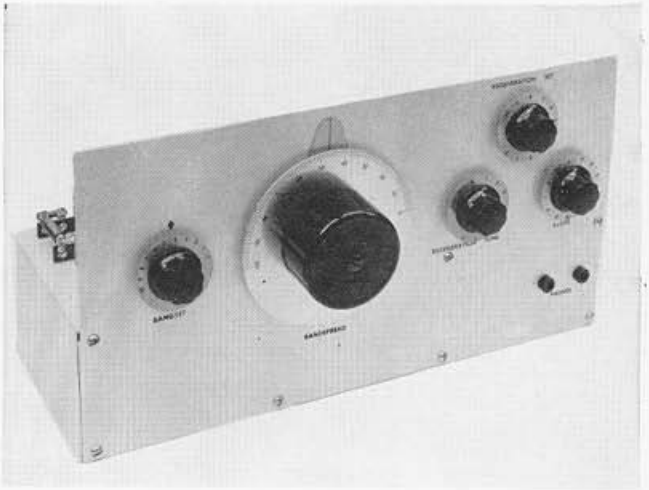

Fig. 1—Three-transistor regenerative receiver covering 1.65 to 30 Mc. Six self-contained 1.5-volt flashlight cells power it, with a current drain of less than 3 ma. The bandspread tuning dial is a Jackson Brothers type 4489.

A Three-Transistor Receiver

The FET as a Regenerative Detector

BY WALTER F. LANGE,* W1YDS

EVEN in this age of crowded bands and sophisticated communications systems, there is room for the lowly regenerative receiver. The unit shown in Figs. 1 through 6 is a simple receiver that should be easy for most anyone to build, regardless of his experience. Plug-in coils are employed, eliminating the complexities of wiring a band switch. No test equipment is required, as nothing needs to be aligned; once the unit is constructed, it should work without any difficulty.

Self-contained flashlight cells are used, making the receiver immune to power blackouts. Since the supply voltage is only 9 volts, there is no shock hazard for the beginner to worry about. Being battery operated and entirely transistorized, the receiver has no power transformers or filaments to heat up and cause drift.

The receiver is more useful than a superhet for checking intruders that are supposedly in the ham bands, as the three-transistor unit has no converter stages to generate spurious signals that may give a false indication of the frequency of an incoming signal. Coverage of 160 meters is provided, a feature left out of many higher-priced commercial receivers. Sensitivity of the receiver is such that a.m., c.w. and s.s.b. signals of 0.1 μv. or greater are audible in the headset. All-in-all, the receiver does a surprisingly good job for the small amount of circuitry involved. It doesn't have the selectivity or signal handling capability of a good superhet, but after all, you usually get what you pay for.

Referring to Fig. 2, the components between points A and B form a filter to attenuate broadcast-band signals. This filter greatly reduces the chances of front end overload by nearby broadcast stations. In locations where there are no powerful broadcast signals, the filter may be left out. Points A and B should then be connected together.

A field-effect transistor (FET), which has high input impedance, is used as the regenerative detector, Q_1. With suitable circuit modifications a conventional n-p-n transistor will work, but its low input impedance will load down the tuned circuit, resulting in some loss of selectivity, and the detector will tend to overload easier. The FET detector uses the Colpitts circuit, doing away with the need for winding a tickler coil or tapping the main inductor. The detector is tuned by bandspread capacitor C_5 and band-set capacitor C_6. One amateur band occurs in the frequency range of each plug-in coil. In each case capacitor C_4, in series with the bandspread capacitor, has been chosen so that the amateur band in question occupies the entire tuning range of the bandspread capacitor.

Regeneration is controlled by varying the source bias of Q_1. Although only one regeneration control is normally found in regenerative receivers, two controls are provided here to make

Although the superhet is by far the most popular receiver in use today, the regenerative receiver still has a place in the ham shack. Its simplicity makes it an ideal beginner's project as well as an easy-to-make standby unit for the advanced amateur.

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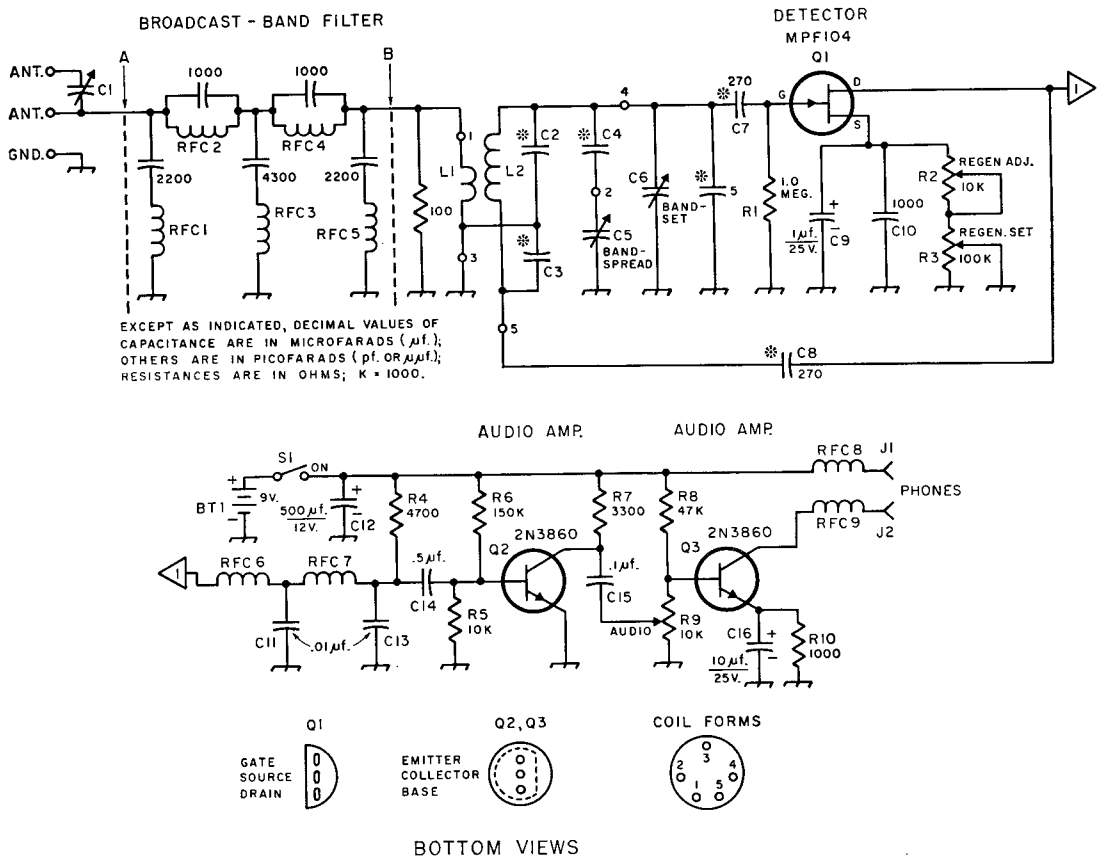

Fig. 2—Circuit diagram of three-transistor regenerative receiver. Fixed resistors are ½-watt composition. Capacitors marked with polarity are electrolytic; those marked with an asterisk are dipped silver mica; other fixed capacitors are disk ceramic. Components not listed below are numbered for reference.

BT_1—Six 1.5-volt flashlight cells (size D) in series.
C_1—9-180-pf. mica compression trimmer.
C_2, C_3, C_4—See Table I.
C_5—50-pf. variable (Millen 19050).
C_6—140-pf. variable (Millen 19140).
J_1, J_2—Insulated tip jacks.
L_1, L_2—See Table I.
Q_1—Field-effect transistor (Motorola MPF104).
Q_2, Q_3—N-p-n transistor (General Electric 2N3860, 2N2925, 2N3391A, 2N3403, or 2N3405).
R_2—10,000-ohm control, linear taper.
R_3—100,000-ohm control, linear taper.
R_9—10,000-ohm control, audio taper, with S_1 attached.
RFC_1, RFC_5—10 µh. (Millen 34300-10[1]).
RFC_2, RFC_4—33 µh. (Millen J300-33).
RFC_3—5 µh. (Millen 34300-5).
RFC_6, RFC_7—2.5 mh. (Millen 34300-2500).
RFC_8, RFC_9—68 µh. (Millen 34300-68).
S_1—S.p.s.t.

[1] James Millen Co. will sell direct if you cannot get the components from a distributor. Write to James Millen Co., Malden, Mass., Attn: Wade Cayewood.

adjustment easier. R_3 is for coarse adjustment and R_2, one-tenth the value of R_3, is for fine control. An electrolytic capacitor, C_9, bypasses both controls for audio; without it, the detector would be rather insensitive. RFC_6, C_{11}, RFC_7 and C_{13}, form an r.f. filter in the drain circuit of Q_1 to keep r.f. from reaching the base of the first audio amplifier, Q_2. A 4700-ohm resistor, R_4, is used as the detector load, rather than an expensive inductor or transformer. Volume control R_9 varies the amount of signal reaching the base of audio output stage Q_3. Q_3 should have a high-impedance headset (2000 ohms or more) as its collector load. The headset leads are kept from acting as antennas (creating hand-capacity effects on the higher bands) by being isolated from the power supply and Q_3 with r.f. chokes.

Construction

The receiver layout is uncritical and you can vary it considerably to suit your own requirements. However, don't alter the detector circuit too much, if you expect it to have the same band coverage as listed in Table I. If you are a new-

Table I

Coil and Capacitor Data

Capacitors are dipped silver mica (values are in picofarads) mounted in the coil form close to the base of the form. Coils are close-wound with enameled or Nylclad copper wire on 1-inch diameter 5-pin coil forms (Millen 45005). For winding details see Fig. 3.

Coil	Range Mc.	C_2	C_3	C_4	L_1 turns	L_2 turns	Wire Size	Dimensions, inches A	B	C
I	1.63–2.55	68	1800	short	4½	44¼	No. 26	⅜	½	1 5/16
II	2.45–5.6	—	1300	68	3½	35¼	No. 24	5/16	9/16	1⅜
III	4.90–10	—	680	22	2½	18¼	No. 20	11/32	19/32	1¼
IV	9.70–18	—	220	12	2½	9¼	No. 20	11/32	19/32	15/16
V	16–25.7	—	100	12	2½	6¼	No. 20	11/32	19/32	13/16
VI	20–30	—	68	18	2½	5¼	No. 20	11/32	19/32	23/32

comer to amateur radio, construct the receiver as shown in the photographs and become familiar with its operation. Once you have gained some experience, you will be in a better position to make changes, if you want to.

The receiver is built on a 13 × 5 × 3-inch aluminum chassis with a 13 × 7-inch aluminum plate serving as the front panel. If you don't have the tools to cut a piece of sheet aluminum to the specified size, a commercial bottom plate will serve nicely.

Referring to Fig. 4, center C_6's tuning shaft 2 inches from the right edge of the panel, and center C_5's tuning shaft 5½ inches from the same edge. Bolt the capacitors to both the panel and the chassis, being careful not to damage the plates at the front of the capacitors with mounting screws that may be too long. Attach two 1-inch ceramic pillars (Millen 31001) to a 5-contact tube socket (Amphenol 78RS5) and position this assembly half way between C_5 and C_6 so that pin 3 of the socket is closest to the front panel. Before bolting the pillars to the chassis, put a soldering lug (to be connected to pin 3) under the ceramic insulator nearest the front panel, and slide a flat washer under the other insulator. Space terminal strips TB_1 through TB_4 2½ inches apart, with the first mounting hole 1 inch from the left edge of the chassis and ½ inch from the rear. Fasten these terminal strips and the battery holders to the chassis with the same screws.

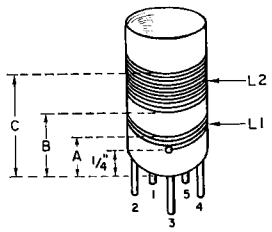

Fig. 3—Sketch of typical plug-in coil used in the regenerative receiver. L_1 and L_2 are wound in the same direction. The hole for each wire is drilled directly above the pin to which the wire is to be soldered. The bottom of L_1 goes to pin 3, the top of L_1 goes to pin 1, the bottom of L_2 goes to pin 5, and the top of L_2 goes to pin 4. For specific information on each coil see Table I.

Install C_5's dial mechanism on the front panel using two ¾-inch 6-32 threaded spacers. Attach C_6's dial so that it indicates 0 at maximum capacitance and 10 at minimum capacitance. All the dials except the one for C_5 are from Millen's 10005 series.

By close inspection of the photographs and the schematic diagram, it should be easy to wire the chassis. The circuit runs from left to right in the schematic and from approximately right to left in the rear view of the chassis. Using Fig. 6 as a guide, connect transistor sockets to the appropriate terminal strips. Solder the center lead of each socket directly to the terminal lug shown and use short lengths of wire between the remaining leads and lugs. Use a heat sink, such as an alligator clip, when soldering the last end of each wire to be secured, otherwise the lead may come undone from the first connection. Make all the remaining connections as short and direct as shown in the photographs.

Referring to Fig. 3 and Table I, begin constructing the coils by drilling four holes in each 5-prong form with a No. 50 drill. Each hole should be drilled above the prong to which the end of the coil will be terminated. Wind L_1 first and then L_2. Scrape the ends of the coils with a knife or razor blade, so that good electrical contact can be made to the prongs. It will be easier to get tight windings if the wire spools are held in a vise while the coils are being wound. Wind the coils at a distance from the vise, keeping the wire taut. After L_1 and L_2 have been put on the form, install C_2 (if applicable), C_4 or a short, and C_3 in that order. Push the capacitors down to the base of the coil form, keeping the connecting leads as short as possible. Carefully solder the coil prongs. Wipe away any rosin from the prongs with a cloth dipped in alcohol. To protect the coils, it may be desirable to spray them with clear lacquer or coat them with coil dope.

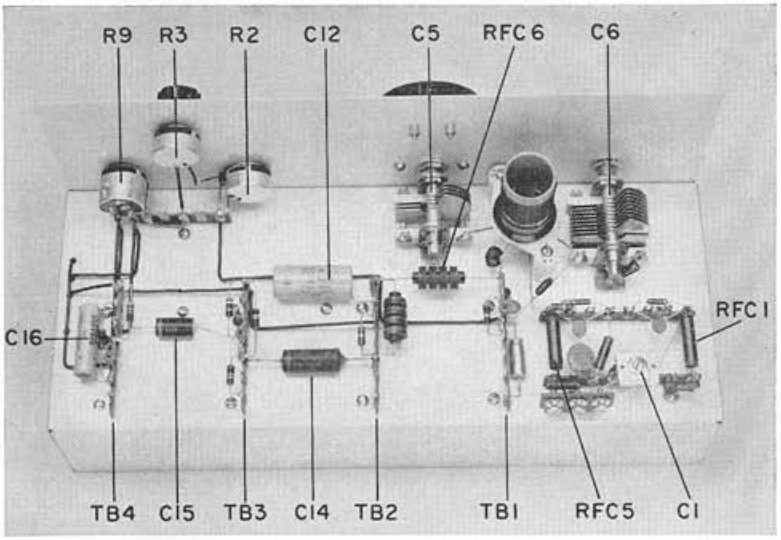

Fig. 4—Top view of the regenerative receiver. The two eight-lug terminal strips at the lower right support the components of a broadcast-band filter. Antenna and ground input terminals are located beside the filter at the edge of the chassis; the connector is a cut down screw-type terminal strip soldered to a standard lug-type tie-point. Of the four parallel terminal strips next to the filter, TB_1 and TB_2 support the regenerative detector, Q_1, TB_3 supports the first audio stage, Q_2, and TB_4 supports the output stage, Q_3.

Before turning the set on, check the wiring carefully with the schematic diagram and the photographs. Be especially careful that the batteries and transistors are installed correctly; note that the negative side of the supply is connected to the chassis.

Use

The audio output stage works best with high-impedance headphones (connected to J_1 and J_2) although lower-impedance phones will work, at reduced output. To check out the receiver, connect an antenna to either antenna terminal and run a ground lead to the set. Plug coil II in the receiver and set the 0 to 10 band-set capacitor dial at 7.5. With C_6 at this setting, the bandspread capacitor should tune from approximately 3.5 to 4 Mc. Turn the audio gain control full on. With the fine regeneration control, R_2, at about midrange, advance the coarse regeneration control, R_3, until the receiver starts to oscillate. The point at which the detector begins to oscillate is easy to recognize, as a thumping sound is heard and the background noise increases. Then by tuning the bandspread capacitor it should be possible to hear signals.

It will be necessary to vary the regeneration controls for optimum reception of different signal types (a.m., c.w. and s.s.b.), strengths and frequencies. For a.m. reception, advance the regeneration controls to the point just before where the detector oscillates. This is the most sensitive operating point for a.m. signals, and the selectivity of the circuit is better than at lower settings of the regeneration controls. Very strong signals, which may cause "blocking," may be reduced by backing off either R_2 or R_3 or both or by reducing the antenna coupling by connecting the antenna to the receiver through C_1 and opening up the plates of the capacitor as much as required.

The most sensitive setting of the detector for code reception is with the regeneration controls advanced just beyond the point of oscillation. However, very strong signals may overload the detector and become impossible to tune in at low beat notes. This can be overcome by further advancing the regeneration controls or by reducing the antenna coupling as described above. Note that if the regeneration is pushed too far, a point may be reached where an audio squeal will be heard. For satisfactory operation of the receiver, be sure the regeneration controls are set below this point.

S.s.b. is tuned in with the regeneration controls set at the same point as for c.w. The bandspread capacitor should be tuned very slowly through

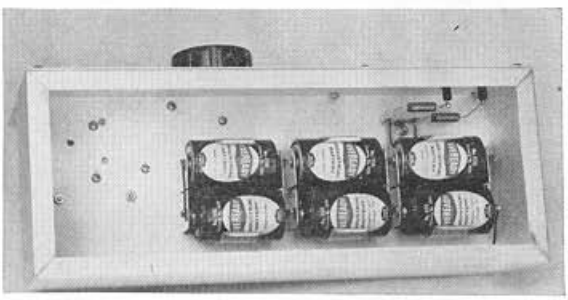

Fig. 5—Interior view of the chassis. Three double battery holders (Keystone type 176) support the receiver power supply. The two r.f. chokes at the upper right are RFC_8 and RFC_9.

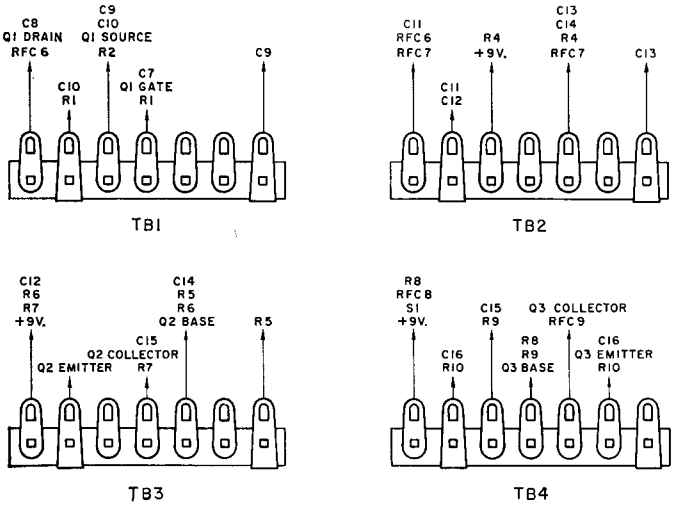

Fig. 6—Connections to the four terminal strips, TB_1 through TB_4. The left edge of each terminal strip is closest to the front panel.

the signal until the voice becomes intelligible. Overloading is conquered in the same manner as for code reception.

Best use of the two regeneration controls will be obtained by following this procedure: Set the band-set capacitor, C_6, for the desired band coverage. Turn C_5 and R_2 to midrange. Set R_3 at the point where the detector just starts to oscillate. Tune C_5 and adjust R_2 as required. In some cases the fine regeneration control may run out of range; it will then be necessary to readjust R_3 to bring it back in the ballpark.

Two undesirable effects may be noticed with this receiver, especially at the higher frequencies. If an inadequate ground system is used, the receiver will exhibit hand-capacitance effects. Also, as with any regenerative set, an antenna blowing in the wind can cause the frequency to change. If the latter difficulty becomes serious, an indoor antenna might be called for. Lighter antenna coupling and coaxial feed will also reduce the effects of antenna movement on the detector.

The bandspread system used in this receiver was set up with the amateur bands in mind. Other bands are spread out to a lesser or greater degree. Table II shows the approximate settings of the band-set capacitor, C_6, for spreading each high-frequency ham band over the tuning range of the bandspread tuning capacitor, C_5. How accurate each setting is, of course, depends on how closely the coils are duplicated.

Possible Modifications

In order to keep costs down, no cabinet was used to house the receiver. The set should perform well in most locations without one. However, in some spots, a.c. pickup may be a problem. By using a metal cabinet, there won't be any need to worry about hum, and the set will look more attractive. A cabinet having a hinged cover is the most desirable, as it will facilitate coil changing.

If additional coverage is desired, more coils can be constructed. In order to cover the broadcast band, three plug-in coils will likely be required because of the small size of C_6. In addition, it will be necessary to disconnect the b.c. filter to prevent severe attenuation of the broadcast signals. It may be possible to tune the 6-meter band if an appropriate coil is constructed; however, performance will probably not be too satisfactory at v.h.f.

In order to achieve optimum Q with easy-to-make closewound coils, three sizes of wire had to be used. However, if you don't mind the slightly more difficult job of space winding the coils, you can save yourself the cost of two spools of wire. Using the same dimensions and turns count given in Table I, wind coils II through VI with No. 26 wire, being careful to equally space the turns.

Table II

Coil	*Band*	*C_6 Setting*
I	160	4.5
II	80	7.5
III	40	7.5
IV	20	8.0
V	15	8.0
VI	10	9.5

If you are a Novice and want more bandspread for the Novice frequencies, use a smaller value of capacitance at C_4 than that listed in Table 1. Try a 10-pf. capacitor in coil II and 8-pf. capacitors (3- and 5-pf. units in parallel) in coils III and V. If this change is made, the setting of the band-set capacitor for the amateur band in question will be different than that listed in Table II.

Since the current drain of the receiver is less than 3 ma., just about any size of 9-volt battery can be used to power the set. However, the author prefers a bank of ordinary flashlight cells, as they are available at more stores than any other type, and will last a long, long time in this receiver. QST

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