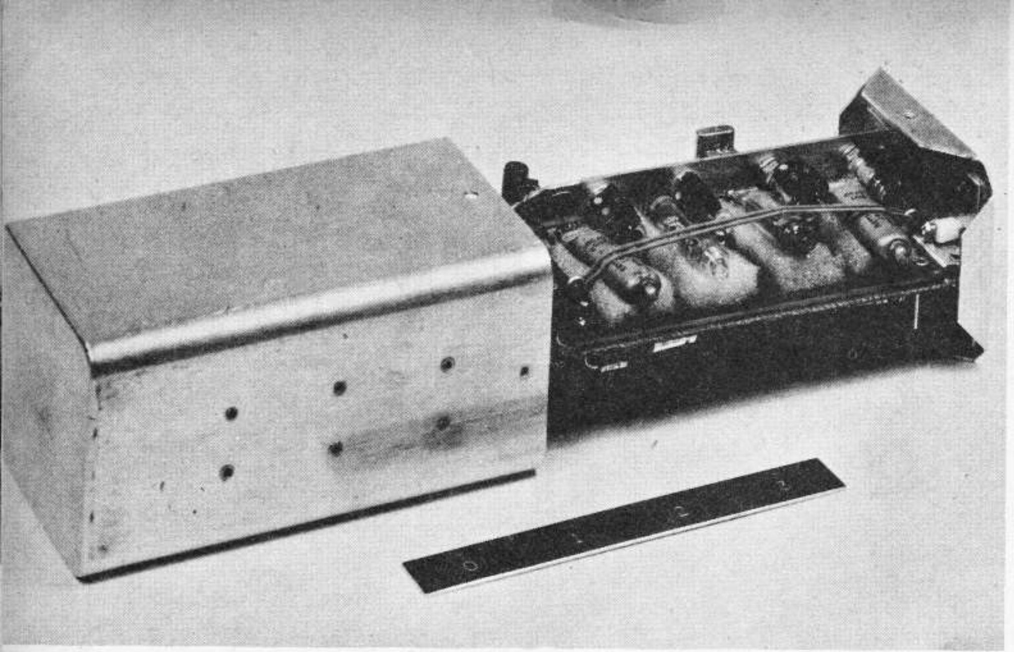
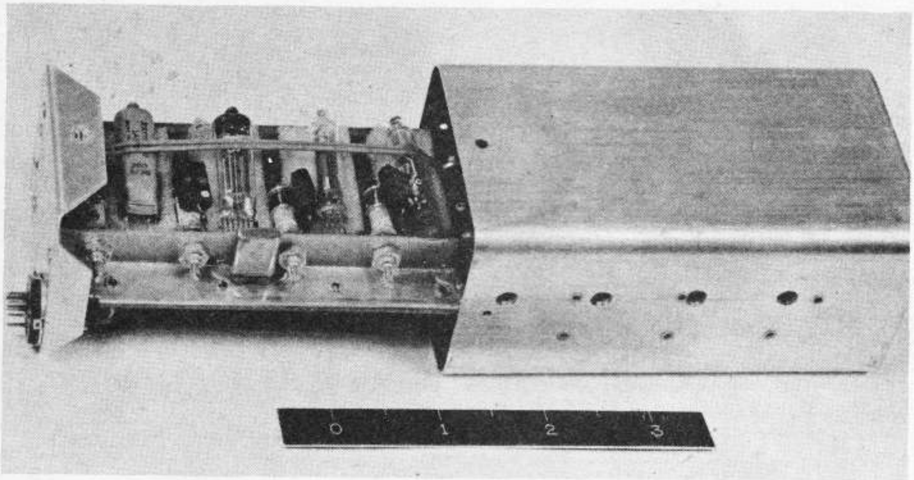


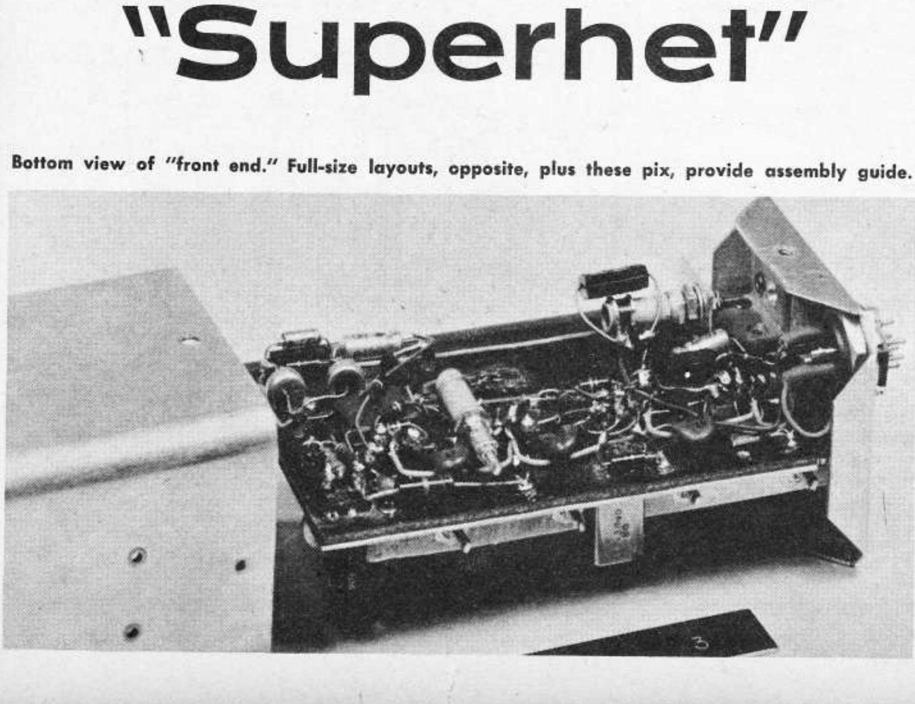
Unit slides into Ace aluminum case which, incidentally, takes care of the shielding. Note rule.



Viewed from opposite side, tube arrangement, crystal, trimmers. Arrangement is very important.

A Proved "Superhet"

Bottom view of "front end." Full-size layouts, opposite, plus these pix, provide assembly guide.



Precisely designed job is a "front end," usable with reeds, WAG TPPW, etc. Dependable selectivity kills those interference germs! Beginners—nix.

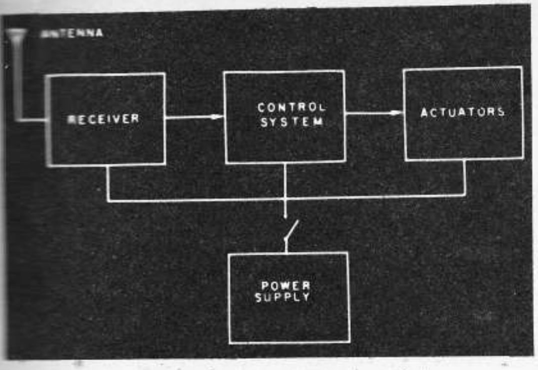
by DICK JANSSON

► The recent FCC regulations governing frequency allocations usable by R/C modelers have created quite a flurry of activity in the equipment designer's workshops. This author, being a die-hard equipment perfectionist, decided to join the pack to see if these frequencies could really be used.

To describe the approach to a model R/C control, a simple block diagram, Figure (1), is used. This diagram applies not only to the R/C gear being used now but also to equipment employing this superhet receiver. Most present day equipment, using super regenerative detectors, combine the Receiver and Control System functions into one box since the receiver portion is usually only one tube and a fairly simple device. Superhet receivers are not as simple nor as inexpensive and the two functions are placed into two boxes. Under an arrangement such as this the modeler allows the versatility of using the receiver portion for different models and even different types of control systems, such as WAG TPPW, reeds, etc. It is this receiver "front end" that will be described here. A future article will describe the extremely simple process of using the front end with your already existing control equipment.

Perhaps a brief description of the operation of a superhet receiver is in order. V_1, Figure (2), operates as a radio frequency (R.F.) amplifier. It amplifies the radio signal that is picked up by the antenna and also isolates the remainder of the receiver from unwanted signals. Tube V_2 is a dual purpose element. The second half is an oscillator to generate a small amount of radio power at the crystal frequency. This power is fed into the first half of V_2 along with the received signal from V_1. Here the two signals are mixed together with the output being a different frequency, around 4.5 Mc., called the intermediate frequency (I.F.).

V_3, the I.F. amplifier, is the real heart of this receiver (or any superhet) as it provides a power boost to the I.F. Also the job of "seeing" only a narrow band of desirable radio energy (selectivity) is taken care of in the I.F. amplifier. Superhet selectivity is the prime compelling reason to go to all of this bother. Our new frequencies are only 50KC apart and the conventional super regenerative receiver will receive signals, 250KC on either side of the



desirable signal, i.e. it will pick-up all of our new frequencies at once. The selectivity of this superhet is only 10KC and will easily distinguish between any two adjacent R/C signals.

V_4 is known as a detector. It takes the amplified I.F. signal and eliminates the radio energy leaving only the audio output (modulated) signal. Transistor V_5 is used as an intermediary between V_4 and the audio output and automatic volume control (AVC) functions. The AVC is needed to prevent "over loading" of the receiver when it is close to the transmitter and also maintain a nearly constant level audio output signal. Super regenerative receivers have a natural AVC characteristic, a desirable feature for many technical reasons.

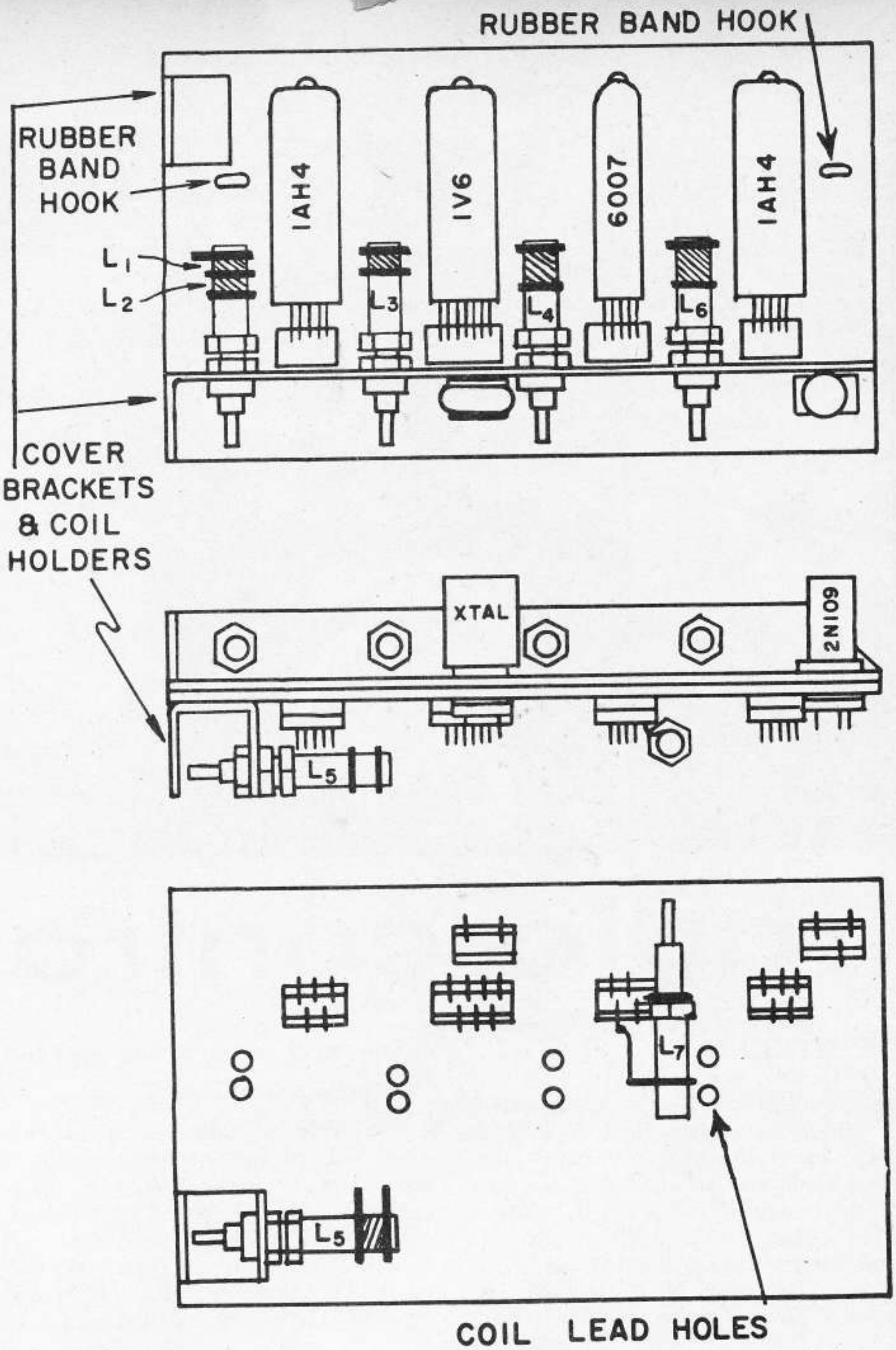
Now there will be many eyebrows lifted quite high to see a vacuum tube receiver in this day of transistors. A number of reasons exist for this, the biggest of which is a technical difference of opinion with many of the superhet receivers published or marketed today.

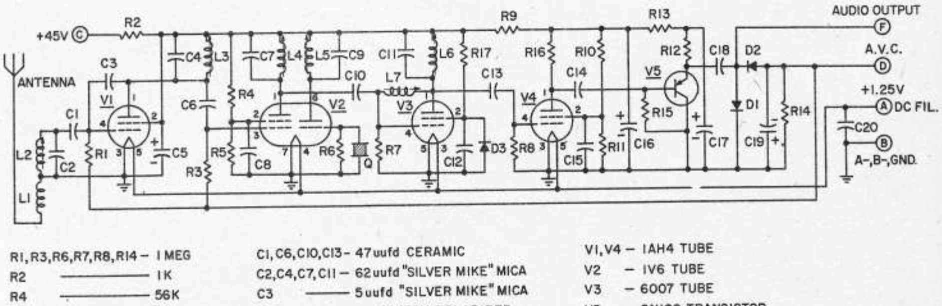
To explain, a mixer stage like V_2 actually will convert two antenna signals into the I.F. signal. One is the "sum" of the oscillator and I.F. frequencies (22.5 Mc. plus 4.5Mc. equals 27.0 Mc.) while the other is the "difference" of the oscillator and I.F. frequencies (22.5 Mc less 4.5 Mc. equals 18.0 Mc.). In this receiver the "difference" signal is called an "image". The 18.0 Mc. image is 9 Mc. away from the desired 27.0 Mc. R/C signal in which case the R.F. amplifier (V_1) can easily admit *only* the 27.0 Mc. signal.

My contention is with the frequently used ½ Mc. I.F. frequencies where an image would only be 26.0 Mc., not 18.0 Mc. No simple R.F. amplifier can adequately distinguish between 27.0 Mc. and 26.0 Mc. I fear that there are going to be "interference" troubles for R/C modelers with superhets of this type.

To build a transistor ½ Mc. I.F. amplifier is fairly easy but for the 4.5 Mc. I.F. it was found easier to use known vacuum tube techniques.

With the advent of this design several factors became evident. The superhet, unless (*Continued on page* 52)





R1,R3,R6,R7,R8,R14 — 1 MEG	C1,C6,C10,C13 — 47uufd CERAMIC	V1,V4 — 1AH4 TUBE
R2 — 1K	C2,C4,C7,C11 — 62uufd "SILVER MIKE" MICA	V2 — 1V6 TUBE
R4 — 56K	C3 — 5uufd "SILVER MIKE" MICA	V3 — 6007 TUBE
R5,R10,R11,R13 — 100K	C5,C16 — 10 ufd/50V POLARIZED	V5 — 2N109 TRANSISTOR
R9 — 2.2K	C8,C14,C20 — 0.005 ufd/75V CERAMIC	D1, D2 — FEDERAL 1215 DIODE
R12 — 47K	C9 — 82 uufd "SILVER MIKE" MICA	D3 — 1N207 ZENER DIODE
R15 — 3.3 MEG	C12,C15,C18 — 0.1 ufd/75V CERAMIC	Q — 22.2 Mc TO 22.5 Mc CRYSTAL FUNDAMENTAL VALPEY CRYSTAL CO. VM-6 CASE
R16 — 220K	C17,C19 — 1.0 ufd/35V POLARIZED	
R17 — 27K		

NOTE: ALL RESISTORS ARE ¼ WATT

L1 — 5t #30 Awg.
L2,L3 — 8t, #30 Awg.
L4,L6 — 60t, #42 Awg.
L5 — 10t, #30 Awg.

L1 & L2 WOUND ON SAME FORM
L1 THRU L7 WOUND ON 3/16 DIA. CERAMIC COIL FORMS, C.T.C.
LST-L WITH WHITE DOT TUNING SLUGS

L7 — COILHEAD SOLDERED TO PLATE V3, END CLIP TO GRID V3. ADJUST COUPLING FOR MAXIMUM SENSITIVITY WITHOUT REGENERATION

Referred to in text are, top, L, Fig. 1; above, Fig. 3; and, below, Fig. 2. Selectivity is 10 kc.

must be the same as for the elevator control unit. That is, the stem of the control unit must line up with the back part of the eyelet (when viewed from wing tip). Do not use the same eyelet for both lines.

Check flying lines before each flight to be sure that there are no kinks where they pass through the wing tip eyelet. If you attempt to fly with kinks at this point both elevator and engine controls will be erratic. Give it a fair chance and you'll be well rewarded for your efforts.

A Proved "Superhet"

(*Continued from page* 25)

purchased assembled is not for the novice to build. It is not a cheap receiver to construct; none in this class are. I estimate a parts cost of \$30 to \$40, all depending on one's ability to scrounge parts.

This receiver is brand new and its flight experience is not great. It has, however, been thoroughly tested and checked for range sensitivity, selectivity, ease of tuning, and compatability with various control systems.

Having given these few warnings with a hope that they haven't discouraged too many modelers, a discussion of this particular circuit design will help the builder.

Most superhets utilize shielded I.F. cans with two tuneable coils as transformers. Experiments, unfortunately, confirmed all the theory books; that is, a double tuned transformer gives very good side signal rejection but is poor in really getting a sharply tuned signal frequency. I got 30 Kc. to 70 Kc. bandwidths with modified commercial transformers. Since our new frequencies are separated by 50 KC. the commercial transformer idea was discarded.

Digging through the "radio Amateur's Handbook" on this subject I came across the idea of the regenerative amplifier; high gain and exceptionally large increase in tuned circuit "Q" or sharpness. By proper placement this receiver utilizes unshielded coils.

Coil L_7 controls the amount of regeneration and is the sensitivity key to the I.F. amplifier. Once set it will stay there and should need only an occasional trimming. L_7 is a form, with no windings, connected between the plate and grid of V_3. If turned in too far, the amplifier will oscillate causing squeals or chirping noticeable in the earphone used for tuning, or if it is turned too far out the set will not be able to do its designed job. The proper setting is just before the set wants to oscillate. A little trial and error will be needed at first but it can be mastered readily. Just two points of note: after each setting of L_7, retune L_4 and L_6; the proper operation should be finally determined while the set is in its case, which also acts as a shield.

With the I.F. amplifier designed, a proper detector (V_4) is needed. Diode detection is by far the most commonly used method and simplest. This was tried and rejected because of low output and a very old-fashioned circuit called the "grid leak" detector was tried. It has very high amplification for one tube and in this case does a stupendous job.

In selecting a tube for the mixer-oscillator one arrives at the compromise stage; the 1V6 was selected for V_2 because of its separate two-tube construction. A mixer stage is quite straightforward. Oscillator circuits brought on other compromises with the oscillator in the range of 22.0 Mc. to 22.5 Mc. Wanting to be "crystal controlled" for stability in the reception and having simple oscillator (one with a fundamental crystal) appeared to be like having one's cake and eating it too. The Valpey Crystal Company (1214 Highland Street, Holliston, Mass.) helped me out by grinding the crystal I desired and also put it into a very small case (their VM-6 case). It has proven to be a real gem and they are obtainable for just $7.50. Only one crystal is needed for all frequencies as the set is readily tuneable to receive all the 27 Mc. R/C channels.

The final circuit to be discussed is the AVC. Most AVC's are obtained from rectified I.F. power, but the grid leak detector prevents this so I had to use some of the detected audio voltage. Without AVC the audio output varies from 0.2 volt to 30 volts, a rough proposition for the following control circuits to digest. With AVC the output varies from 0.2 volt to 0.8 volt, an acceptable variation.

Many ideas were considered for packaging a radio of this nature. Of prime importance are functions of shielding and circuit cross coupling. The shielding was taken care of by using a case (available from Ace R/C) which is of thin but sturdy aluminum measuring 2⅜ x 1⅞ x 4 inches. A piece of 1/16 inch thick epoxy-fiberglass phenolic board makes an excellent construction base. Figure (3) shows this board with the major components attached as a guide to the builder. Not shown are small components, the case cover (normally riveted to the board), or any terminals that may be needed. Aluminum was used to make slide tracks attached to the inside of the case. They are spaced the thickness of the board and allow the whole unit to slide easily into the case.

The physical arrangement of components in any radio can be quite critical. Most radios are laid out in logical order, like schematics are often drawn on paper. In this case it is important to have the tube-coil placement as shown in the illustrations; a necessary consolation to using unshielded coils. To facilitate this placement a piece of aluminum four inches long and bent as an angle was riveted to the board to support the coil forms.

Tuning of a radio of this type is, at first, a little more involved than the one adjustment superregen receiver. Once tuned it has the stability to remain that way for a long time. Firstly determine that the oscillator is operating. This can be done several ways, the simplest of which is to monitor the B plus current to the oscillator coil. A drop in current will be noted while tuning L_5 indicating an oscillating condition. If no drop is noticeable, the stage may already be in operation. This can be checked by removing the crystal from its socket and comparing the higher current to that obtained with the circuit completed.

For the remainder of the tuning process a high impedance AC voltmeter (100 kohm or better) should be connected between the audio output and ground. The meter should also have an earphone output connection since the ear is more sensitive than even the low range (0-1 volt) of a meter. A description of a field portable meter for this purpose will be described in the following article. Also handy is a modulated transmitter, crystal controlled of course, of the proper frequency. With the voltmeter connected, the radio power on and the transmitter on with full antenna at close range, you will barely hear the tone. Adjust L_2, L_3, L_4, and L_5 to increase the loudness. As the audio voltage rises above 0.5 volt, the transmitter antenna should be lowered and moved away. Be alert for the signs of I.F. regeneration as described before. Once the I.F. is oscillating it will show an audio voltage reading when the transmitter is turned off. Adjust L_7 for proper operation and retune. When a good tuning is obtained the oscillator coil L_5 should be trimmed for a maximum reading of output. A completely shielded transmitter with no antenna should give about 0.2 volt audio at about seven-foot distance in the basement shop.

Like any amateur receiver with a long-wire antenna system, this radio likes lots of antenna. In a large multi airplane the antenna should run out to the fin, back to a wingtip and across the entire wing span. Everytime a different antenna is connected coil L_2 should re betuned. Under these conditions I measure about 0.5 volt audio at 1/3rd mile range with the ship three or four feet off of the ground. This is the ultimate test, a really good range check. Every R/C modeler should make tests with a new receiver or installation to gain confidence with the operation of the equipment. It is only with this confidence should a model be released from the shackles of the ground and committed to the unknown qualities of pilot error in flight.

One final note is on installation. In spite of the lack of relays within this device it is good to pad the receiver mounting with a quarter inch of sponge material. The receiver is rugged but it still needs the shock protection for landing nose first into the ground.

(To be concluded next month.)