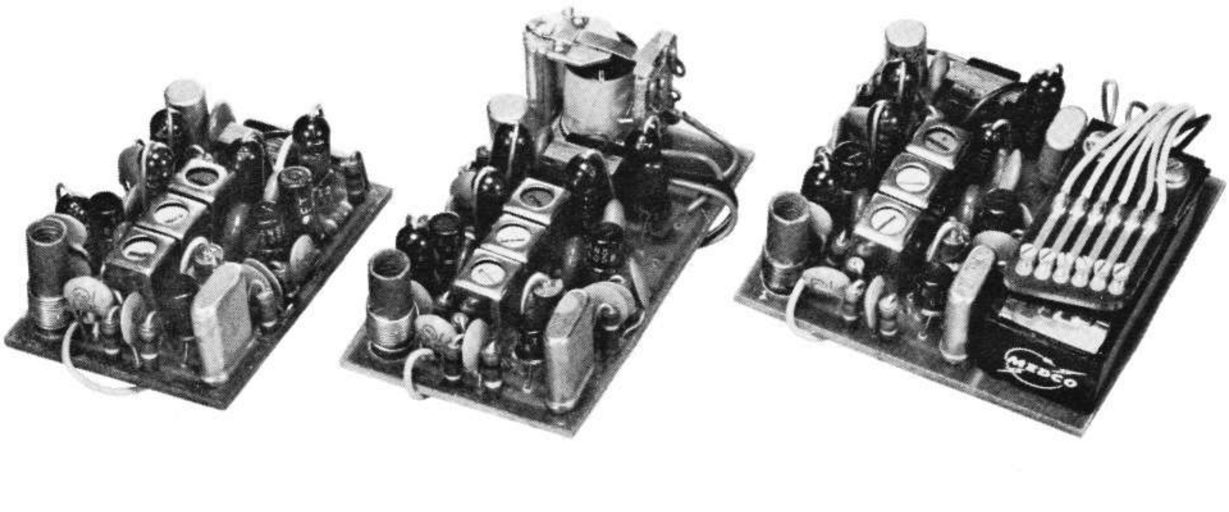
RCM'S CONVERTIBLE SUPERHET



One of the most outstanding and versatile receivers ever designed, RCM's Convertible Superhet is intended for single channel relayless, relay, or 6-channel installations.

By DON MATHES
RCM Technical Editor

The widespread demand for a miniature superheterodyne receiver resulted in a staff assignment to the RCM Technical Department to develop such a unit, having the advantages of small size, ease of construction, and wide operational flexibility. Although several designs incorporating one or more of these features have been developed in the past, this circuit has the added advantages of both simplicity and versatility. It is designed for use as a truly miniature, lightweight relayless receiver for single channel operation in the .01 class, or as a relay receiver for single channel servo or pulse operation with actuators such as the Royal, or Sankyo single channel servo, Accutronics Minipulse, S.E.P. Go-Ac, Tomoser PA-1R, etc. A further design consideration in the development of this unit permits the installation of a standard six channel Medco reed bank for multi superhet operation. The photographs accompanying this article illustrate a few of these various combinations, including a 36″ span, six channel ship utilizing Annco servos.

General Description

Performance measurements indicate that overall performance of the RCM Superhet is comparable to most commercially available transistorized receivers, and in fact, surpasses many of them. Field tests indicate that this unit operates very well with regard to adjacent channel interference and temperature variations.

As shown in the block diagram, the receiver is broken down into four separate sections. The first is the detector, wherein the incoming RF signal is received and converted to a suitable frequency for amplification. The second section is the Intermediate Frequency amplifier which is tuned to the difference between the transmitter and receiver crystals. The next section is the demodulator, or Second Detector, which extracts the audio information as it was initially sent from the transmitter. This information, still at a rather low level, is coupled to the Audio Amplifier, and in turn, drives the appropriate power stages for operation of the various actuators. These stages will now be described in detail in order to give the reader a better understanding of the superheterodyne receiver.

The Detector stage is rather unconventional in this case, inasmuch as an autodyne converter is employed in order to reduce both physical size and overall complexity. The autodyne converter can best be described as a combination local oscillator, mixer, and IF amplifier. This operation gives a conversion gain somewhat lower than would be obtained with the same transistor as a separately excited converter. In our application, this is more than offset by the savings in components and complexity. Perhaps one of the greatest difficulties encountered with autodyne converters is a tendency to stop oscillating under very high signal strength conditions. This circuit has been designed to decrease this difficulty. As an example, the transmitter and receiver antennas may be as little as one foot apart with no problems of this nature. It is seen, however, that AGC is not applied to the converter, and that the operating point of the transistor is stabilized by an emitter bias resistor. In addition, relatively low base bias impedances and short time constants decrease the problem to an acceptable minimum.

The transmitted radio frequency signal is detected through tuned circuit L1 and amplified between base and ground of the converter. The Intermediate Frequency output is taken at the collector. Feedback for the local oscillator portion of the converter occurs from the collector to base through the crystal. The transistor is biased in a relatively low current region, thus evidencing quite non-linear characteristics. The latter enables the incoming signal to mix with the oscillator signal present, creating signals of the following four frequencies: (a) the local oscillator signal (b) the received incoming signal (c) the sum of a and b (d) the difference between a and b.

The I F transformers are tuned here to the difference between the local oscillator and the incoming signal frequencies. This frequency is called the Intermediate Frequency, or IF, and is 455 Kc. This frequency will be maintained, since both transmitter and receiver oscillators are crystal controlled, It is worthwhile to note here that crystals in the transmitter and receiver are separated in frequency by 455 Kc. For example, a transmitter with a frequency of 26.995 will match properly a receiver whose crystal is marked 26.540.

Since the emitter is grounded and the incoming signal injected into the base, the mixer section operates in the grounded emitter configuration. Having extracted a 455 Kc signal at the collector of the converter, it is applied to a tap on the IF transformer to provide proper matching for the stage. The performance of the stage is relatively independent of variations between the transistors specified.

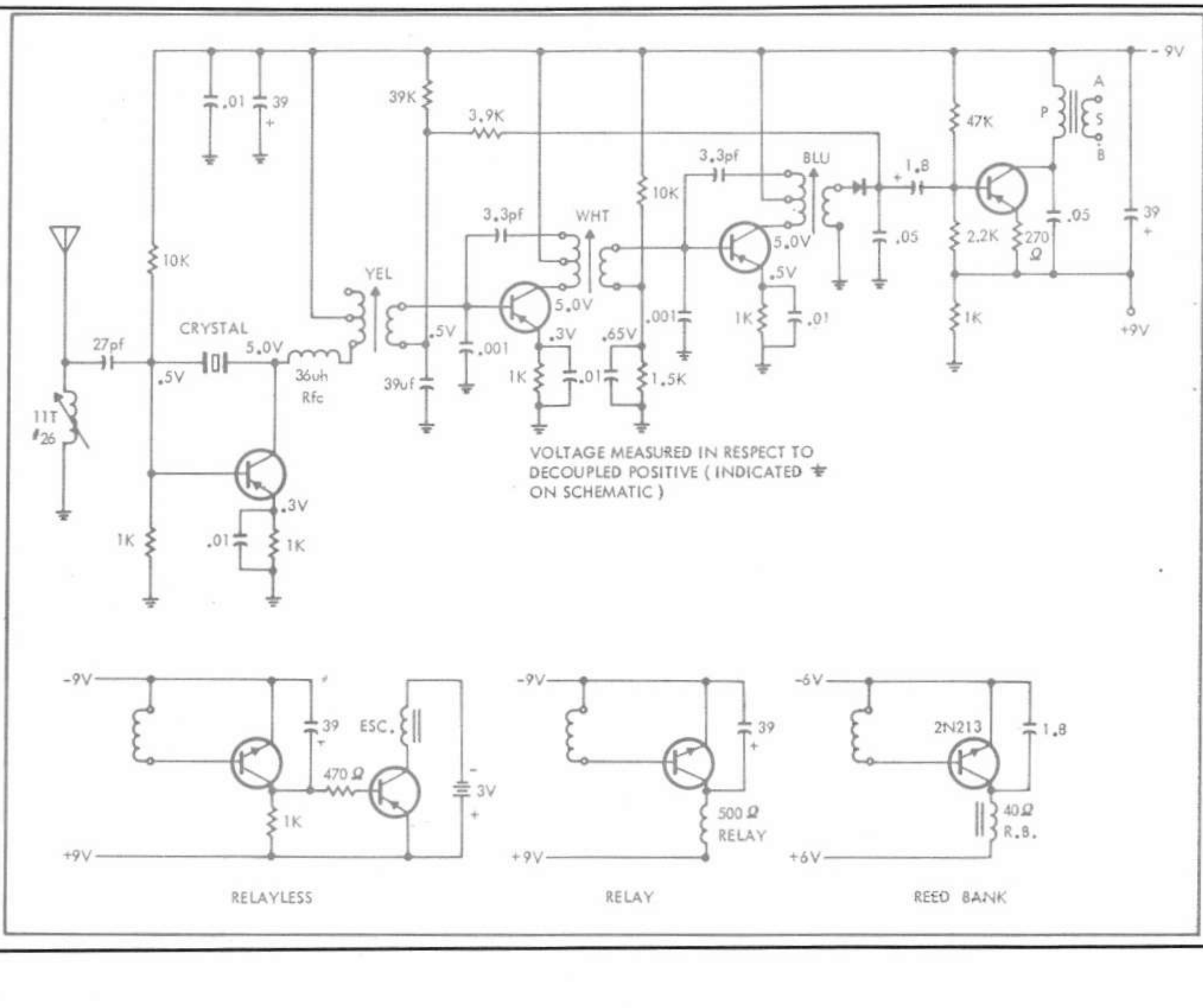
The IF amplifier consists of two grounded emitter stages. These are relatively simple Class A amplifiers. Neutralization was found to be necessary on both in order to avoid common mode regeneration, thereby insuring repeatability and consistent performance.

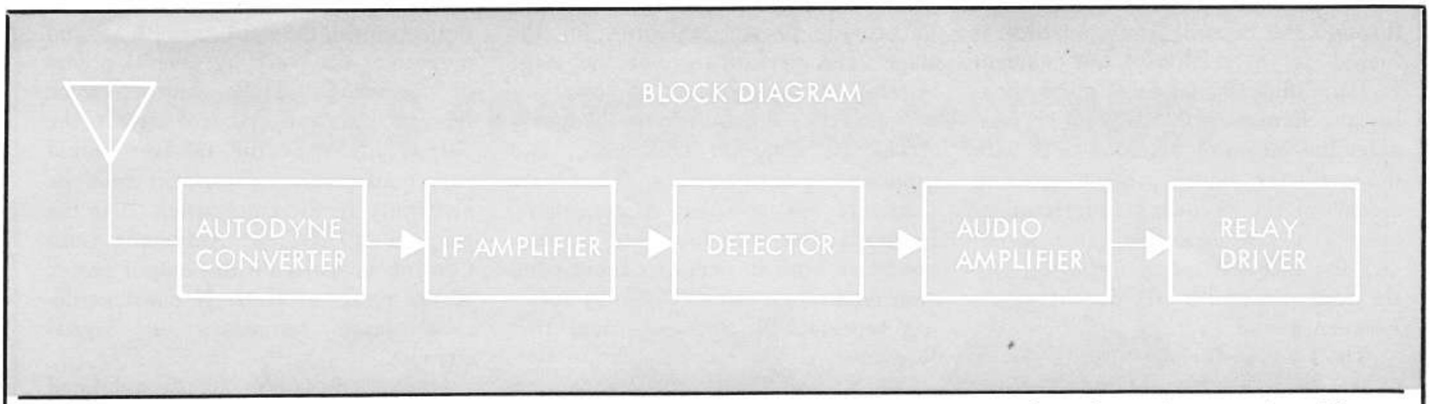
The Second Detector stage consists of a slightly forward biased diode which operates out of the square law detection portion of the IE characteristics. AGC potential is proportional to the signal level, and is applied through an AGC filter network to the base of the first IF transistor, so as to decrease collector current of the first IF stage at increasing signal levels.

The operating point of the first IF stage is chosen to obtain almost optimum gain at a point where it takes little power to get maximum AGC action.

At this point a brief description is in order as to what is meant by AVC or AGC. Since there is a great deal of variation in range between transmitter and receiver, as applied to radio control, the field strength around a receiver can vary by several orders of magnitude. Thus, without some form of automatic control circuit, the output power of the receiver would vary considerably, dependent upon its proximity to the transmitter. It is the purpose of AGC, or Automatic Gain Control, to maintain the output power of the receiver relatively constant despite large variations in signal strength.

Having detected, or demodulated the transmitted intelligence at the detector, the audio derived is coupled to a conventional audio amplifier. This is also a Class A stage with transformer coupling at its output to provide a proper impedance matching. The primary of the transformer is broadly resonated with a capacitor for optimum performance at the desired audio frequency — in this case, approximately 600 cycles. The secondary is coupled to still another grounded emitter stage, which by this time, has amplified the transmitted signal to a point suitable for driving a relay or reed bank. The relay, or reed bank, is used as the collector load, and suitable capacitors are chosen for each to provide the proper filtering.





One more stage is added for those who wish to drive a standard escapement directly. This is nothing more than a switching transistor which is turned on or off, as desired, by the preceding stage. Any conventional escapement, operating from 3 volts, can be used here, such as the Babcock Mark II, Bonner VariComp, or CitizenShip compound. In the relay and relayless versions, a single 9 volt transistor battery is used for the receiver power. The reason for this is that power supply coupling effects when using motorized actuators are detrimental to optimum receiver performance. On the reed version of the RCM superhet, however, it was found that it could be successfully operated with no difficulty from the standard servo supply — in this case, six volts.

The specifications for the RCM Convertible Superhet are:

(1) Nominal Sensitivity — 10 microvolts for full control.

(2) Selectivity — 6 KC at 6 db.

(3) Supply Voltage — 6 to 9 volts.

(4) Weight — Relayless, 1⅛ ounces; Relay, 1¼ ounces; 6 Channel, 1¾ ounces.

Construction

No difficulties should be encountered in the construction of the RCM Superhet if you have had previous experience in scratch or kit building. Read the instructions through twice, proceed carefully, and use good construction and soldering techniques throughout. The following tools will be needed for assembly: (a) 25-40 watt soldering iron with pencil tip (b) one pair of flush cutting side-cutters (c) one pair of long-nosed pliers (d) one pair of wire strippers.

If you are scratch building this unit, be sure to obtain all components of the proper value. The easiest way to produce the printed circuit board is with the aid of a standard photographic process printed circuit kit, available at most electronic supply houses, some hobby shops, or from World Engines. Follow the instructions exactly and you will encounter no difficulty with this stage of construction.

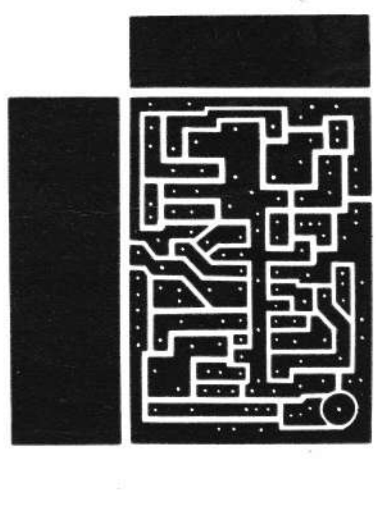
If you are assembling the receiver from the kit that has been made available, check all components against the parts list to be sure that none are missing. Lay all parts out in front of you and identify them. Begin construction by mounting coil L1 into the large hole in the printed circuit board. Note that this hole has purposely been left undersized so that the coil form may be forced into it, thereby making a good mechanical connection. Eleven turns of #26 wire is wound around the coil form. Begin by inserting one end into the board, then proceed to wind until you have completed eleven turns, then terminate the other end. The coil is now coated with model cement, such as Aero Gloss or Ambroid, and should be set aside to dry for a few minutes before further work is attempted.

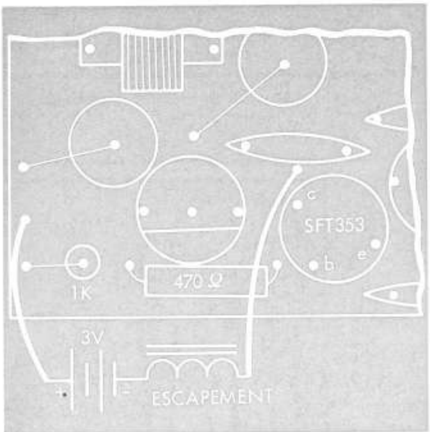
After the cement has dried sufficiently, carefully scrape the enameled ends of the wire as they come through the board so that a good electrical connection can be made. The three IF transformers are now installed, carefully noting the colors of the transformers and their position on the board. Note that the mounting lugs on the transformers share a common hole. The lugs of the transformer are bent over slightly to provide a good mechanical mounting until the soldering operation.

Next to be installed are all resistors. Note that several of these lay flat on the board.

All disc ceramic capacitors are inserted in place, and finally, all electrolytic capacitors. Note polarity of these capacitors. It may be well to

(Continued on Page 20)





stop at this point and clip the leads on the printed circuit side of the board before it becomes too congested. Note that the lands are quite close together — be careful not to bridge any leads over onto an adjacent land.

The RF choke, transistors, diode, and crystal may now be installed, carefully noting the basing of the transistors and polarity of the diode. The small 10K to 1K transformer is inserted in place at this point. Be sure to install the latter with the "S" on the transformer on the outermost edge of the board.

Install the wires on the receiver, and with reference to the pictorial diagram, the relay or reed bank, if your choice is other than the relayless version. The relayless receiver will have one additional transistor mounted on the board, whereas the relay and reed bank configurations omit this transistor.

All components may be carefully soldered to the board. After completing this operation, all flux should be thoroughly removed with an acid brush and lacquer thinner. Inspect all parts and printed circuit to make absolutely sure there are no parts or leads touching each other. Inspect the bottom of the board for accidental solder bridges. Install an antenna wire approximately 24"—30" long and you are ready for checkout.

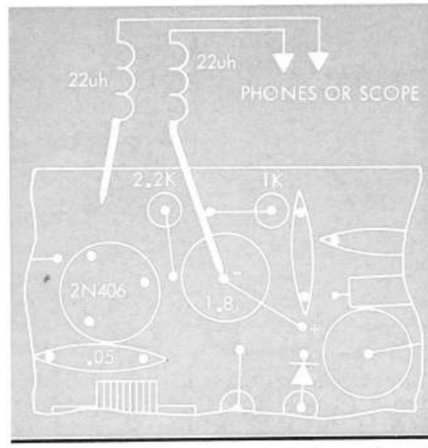
Alignment

Alignment of the RCM Superhet is begun by first hooking up to the appropriate power supply, carefully noting polarity. Although an oscilloscope is extremely helpful in the alignment of any superheterodyne receiver, a pair of earphones can be used in lieu of the scope. These should be high impedance (2000 ohms or more). In either case, the scope leads, or headphone leads, should be isolated from the receiver with two IF chokes of approximately 20 microhenries inductance. Clip the scope, or phones, onto the test point on the receiver. Turn on a transmitter, making sure that the transmitter and receiver crystals are separated by 455 Kc. The transmitter should modulate 100% at approximately 600 cycles for operation of this receiver.

Depress the tone button on the transmitter and the demodulated audio tone should be heard on the phones, or alternately, seen on the scope. This will be at quite a low level — make sure that the tuning slug in the antenna coil is located approximately half way in the form. When the tone is heard, adjust the IF transformers until they are the loudest. Move the transmitter further away from the receiver and repeat these adjustments until the maximum range is obtained. With the antenna removed from the transmitter for these tests, a range of approximately 10-15 feet will normally operate the relay or escapement, and is more than adequate sensitivity.

When all three IF transformers have been adjusted for maximum signal strength, the core in the tuning coil may be turned in to increase the sensitivity even more. This coil slug should always be kept in the uppermost portion of the form.

If any trouble is encountered, the voltages at all test points are indicated on the schematic — these should be within approximately 10-15% of the voltage measured at the receiver. As the receiver is broken down, stage by stage, and isolated by transformers, any problems should be easily isolated. If, after careful testing and analysis, you still cannot obtain proper operation, drop a letter to the Technical Editor, R/C Modeler Magazine, P.O. Box 487, Sierra Madre, California.



PARTS LIST

270 Ohm 1/4 watt 10%
2.2K 1/4 watt 10%
(4) 1K 1/4 watt 10%
1.5K 1/4 watt 10%
3.9K 1/4 watt 10%
47K 1/4 watt 10%
(2) 10K 1/4 watt 10%

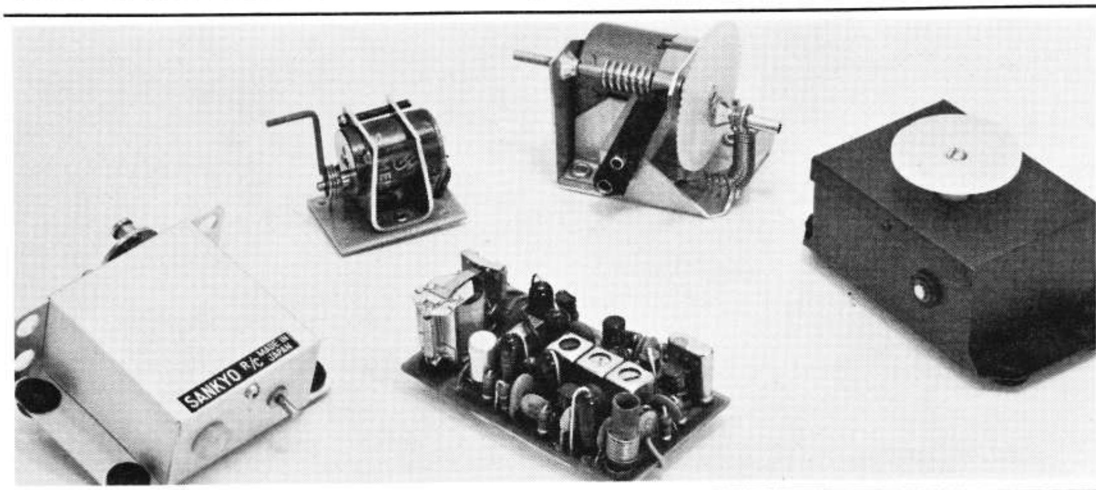
(2) .05 mfd.
(4) .01 mfd.
.001 mfd.
.39 mfd.
(2) 39 uf
(2) 3.3 pf
1.8 mfd.
.001 mfd.
27 pf

T1 Mitsumi A7S-A IF Trans.
T2 Mitsumi A7S-B IF Trans.
T3 Mitsumi A7S-C IF Trans.

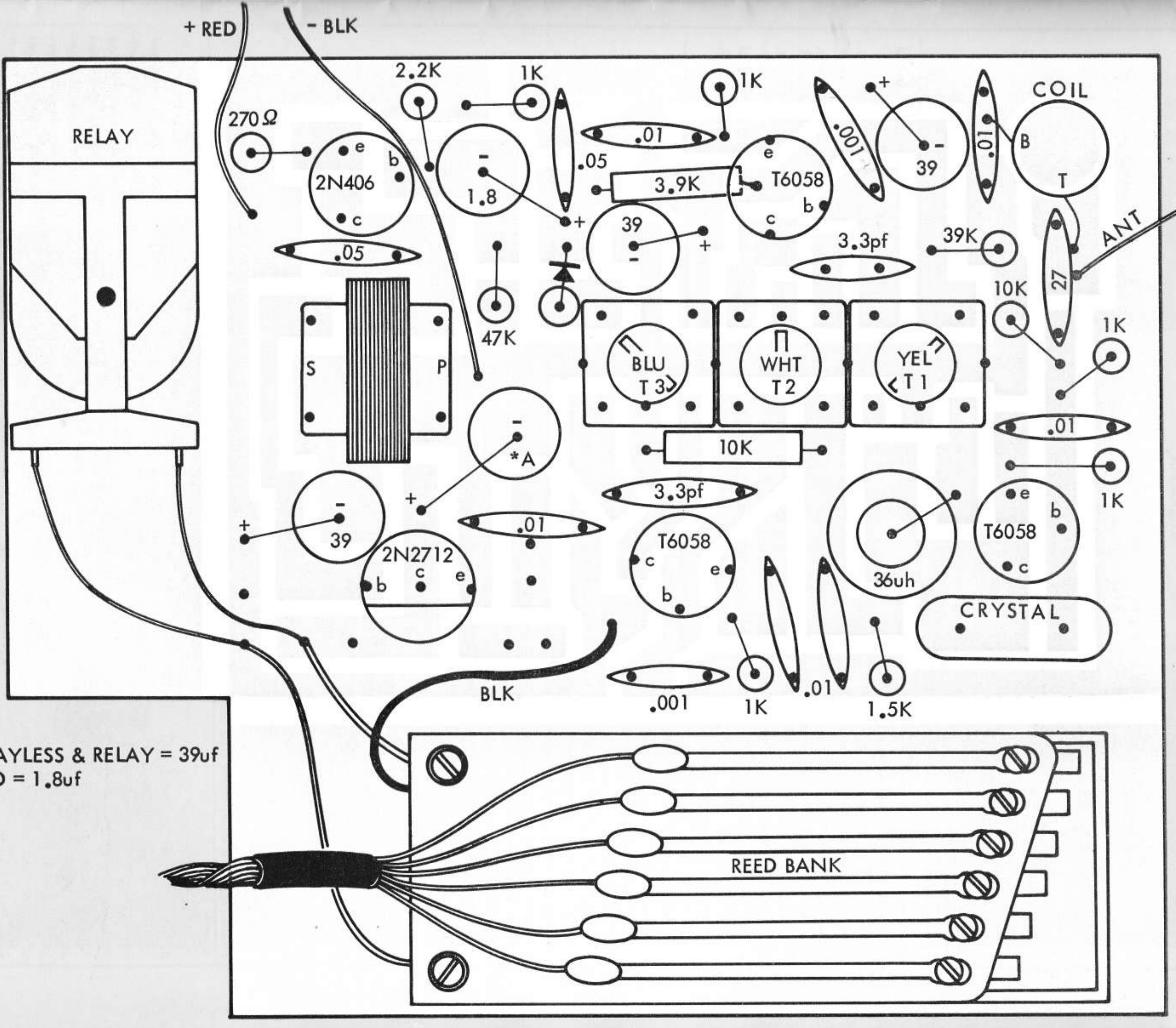
(1) 2N2712 G.E.
(3) T6058 Philco
(1) 2N406 RCA

10K—1K Zebra transformer
1N34 diode
36 uh RFC choke
crystal (Wright)
3/16" dia. CTC coil form

1K 1/4 watt 10% (relayless only)
470 ohm 1/4 watt 10% (relayless only)
39 mfd (relay or relayless)
SFT 353 transistor (relayless only)
500 ohm Deans relay (relay only)
1.8 mfd (6-channel only)
2N214 Sylvania transistor (6-channel only)
40 ohm Medco reed bank (6-channel only)

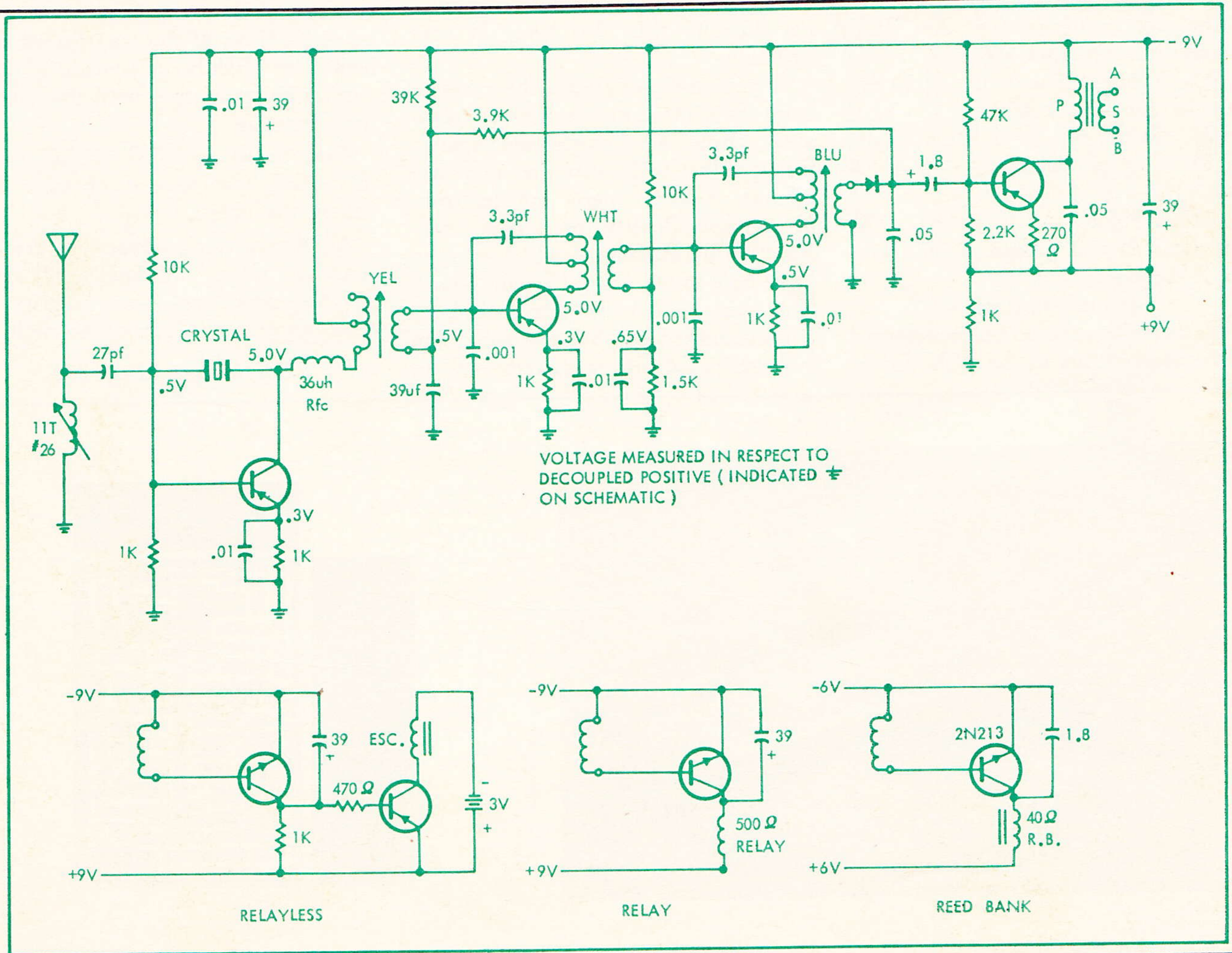


Relay single channel version of RCM's convertible Superhet along with several motorized actuators. L to R: Sankyo compound servo; Tomoser proportional rudder actuator; new S.E.P. Go-Ac for Galloping Ghost; Royal compound servo.



*A
RELAYLESS & RELAY = 39uf
REED = 1.8uf

A COMPLETE KIT FOR THE RCM CONVERTIBLE SUPERHET IS AVAILABLE — SEE PAGE 50



-9V
+9V
.01
39
+
39K
3.9K
10K
3.3pf
WHT
BLU
3.3pf
1.8
47K
A
P
S
B
10K
5.0V
.05
.05
39
2.2K
270 Ω
.5V
YEL
5.0V
.3V
.65V
.001
1K
.01
1K
CRYSTAL
27pf
5.0V
.5V
.5V
.001
39uf
1K
.01
1.5K
36uh
Rfc
11T
#26
.3V
.01
1K
1K
VOLTAGE MEASURED IN RESPECT TO DECOUPLED POSITIVE (INDICATED ON SCHEMATIC)
-9V
39
+
ESC.
470 Ω
3V
1K
+9V
RELAYLESS
-9V
39
+
500 Ω
RELAY
+9V
RELAY
-6V
2N213
1.8
40 Ω
R.B.
+6V
REED BANK