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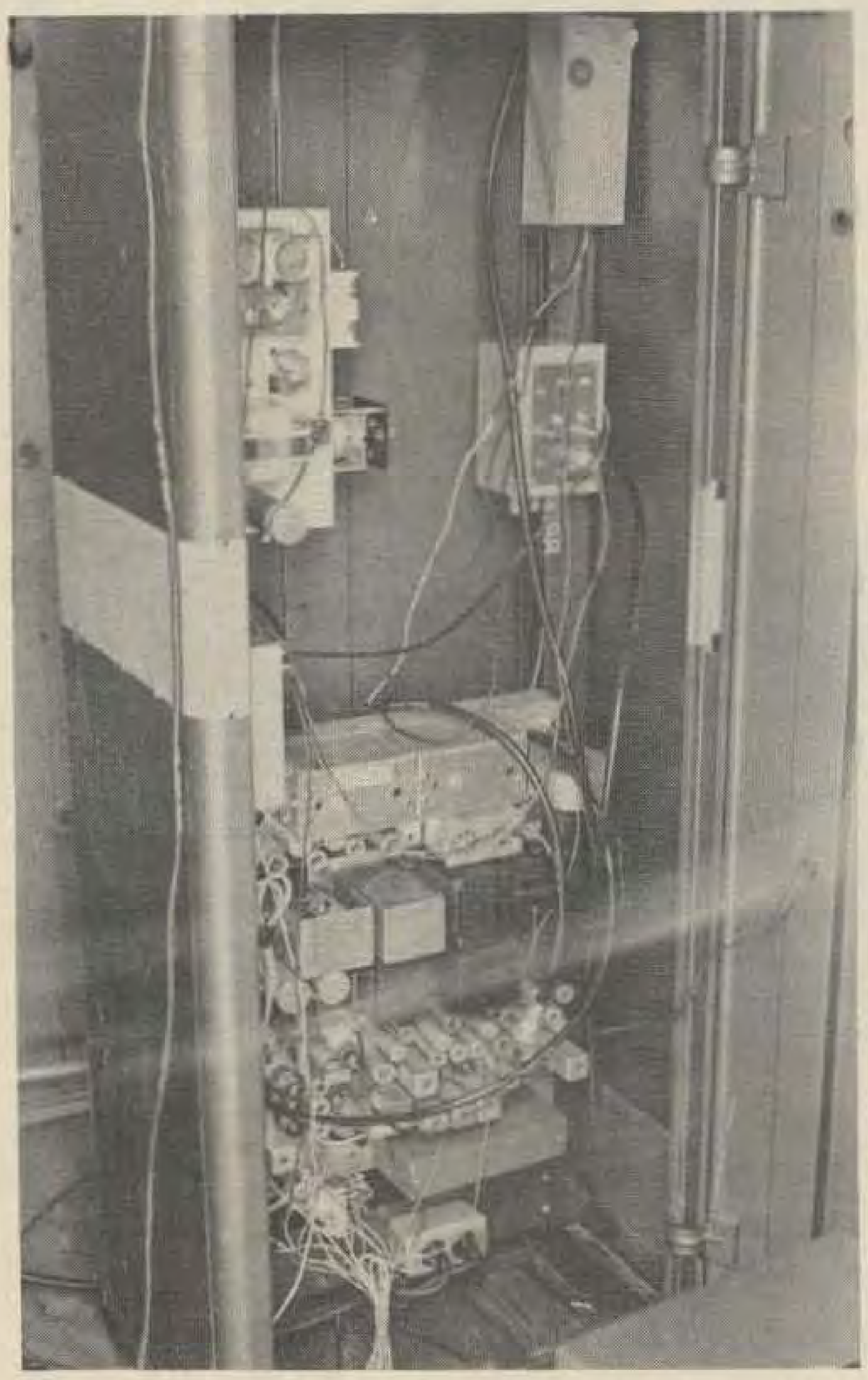

PHASE LOCKED LOOP DECODER

A continuous tone operated relay for the repeater or remote

A continuous tone squelch or relay is used in a repeater or remote base system where it is desirable to restrict use of the machine to only certain individuals, or to select one repeater if there is more than one system sharing the same channels. Commercial names for this system include Private Line, Quiet Channel, and Channel Guard. This is accomplished by transmitting a low frequency, low deviation, continuous tone along with the carrier and other modulation of the accessing transmitter. Only transmitters with the proper tone will activate the tone operated relay in the repeater.

Single tone or "beep tone" is also used for this purpose, and this decoder can also be used as a single tone decoder. However, single tone is an inferior system since it creates an annoying audible tone. Also it defeats the purpose of tone access when an undesirable carrier can hold the repeater on, and anyone can access it by simply whistling.

The continuous tone system is usually inaudible, and cannot be activated by a whistle.

The System

This article describes a continuous tone squelch decoder–encoder system that is completely solid state with no expensive, unreliable mechanical reeds. The decoder is relatively easy to build, featuring a Signetics phase locked loop decoder integrated circuit. The decoder can operate consistently with a tone that is as much as 6 dB below the wideband noise level. The detection frequency and bandwidth are adjustable by external component selection. In this case

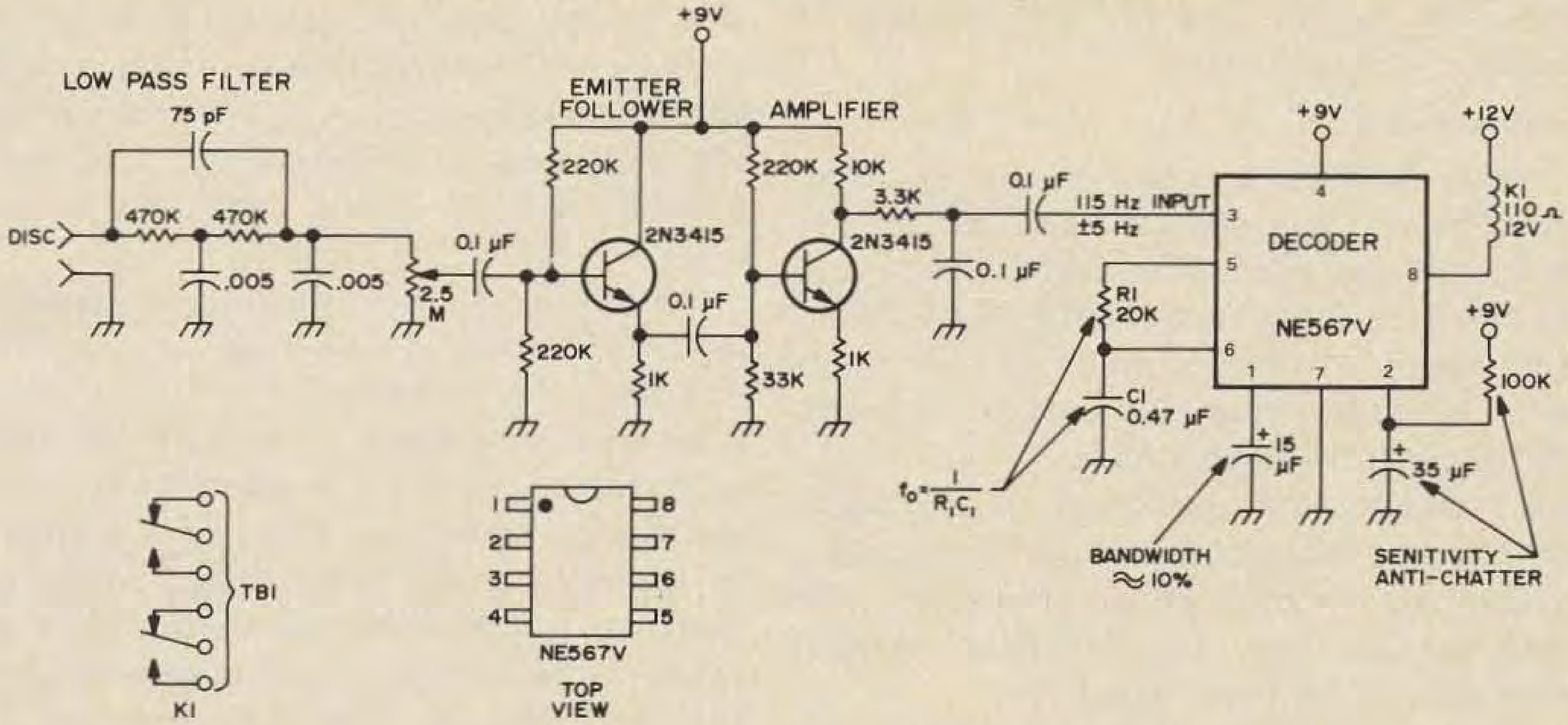

Fig. 1. Decoder schematic.

the bandwidth was set relatively wide to allow for frequency instability on the encoder. This allows the simplest possible encoder circuit to be used. This is a good consideration in a large group of repeater users where some members may not have the desire to buy or build an expensive, complicated encoder. The encoder uses a simple phase shift oscillator circuit.

The Circuit

Figure 1 shows the schematic of the decoder. The signal must be taken directly from the discriminator of the receiver. The low pass filter removes most of the higher frequency signal components that may be at a higher level than the tone signal. The filter prevents strong out of band signals from desensitizing the decoder. The emitter follower provides a high impedance input to minimize loading effects on the discriminator. An amplifier is necessary to bring the signal up to the proper level for the decoder.

Although the decoder has more than fifty transistors in its integrated circuit, only a few external components are necessary to set the desired operating conditions. The detection frequency is: fo = 1/R1Cl. From the values shown in Fig. 1: fo = $1/(20 \times 10^3)(.47 \times 10^{-6}) = 107$ Hz. In actual on the air tests with an audio oscillator and frequency counter, a center frequency of 110 Hz was measured. R1 and C1 can be varied to select the desired frequency, but R1 should be kept between 2000 and 20,000Ω for best stability. The 15µF capacitor affects the bandwidth, which was set at about 10%. Tests again show a frequency response from 105–115 Hz. A smaller value capacitor would narrow the bandwidth. The 35 µF capacitor and the 100 K resistor circuit affect bandwidth, sensitivity, and help prevent chatter. Information on this was obtained from Signetics application notes, and final values were obtained experimentally.

The output of the decoder can sink up to 100 mA, so it is used to drive a relay directly. Nine volts is used to power the decoder and preceeding transistors, but 12 volts is used as a voltage source for the relay. The output of the decoder on pin 8 of the integrated circuit can operate to as high a voltage as 15 volts without damage, but the rest of the IC must be held to less than 10 volts.

The circuit of the encoder is shown in Fig. 2. The circuit shows a phase shift

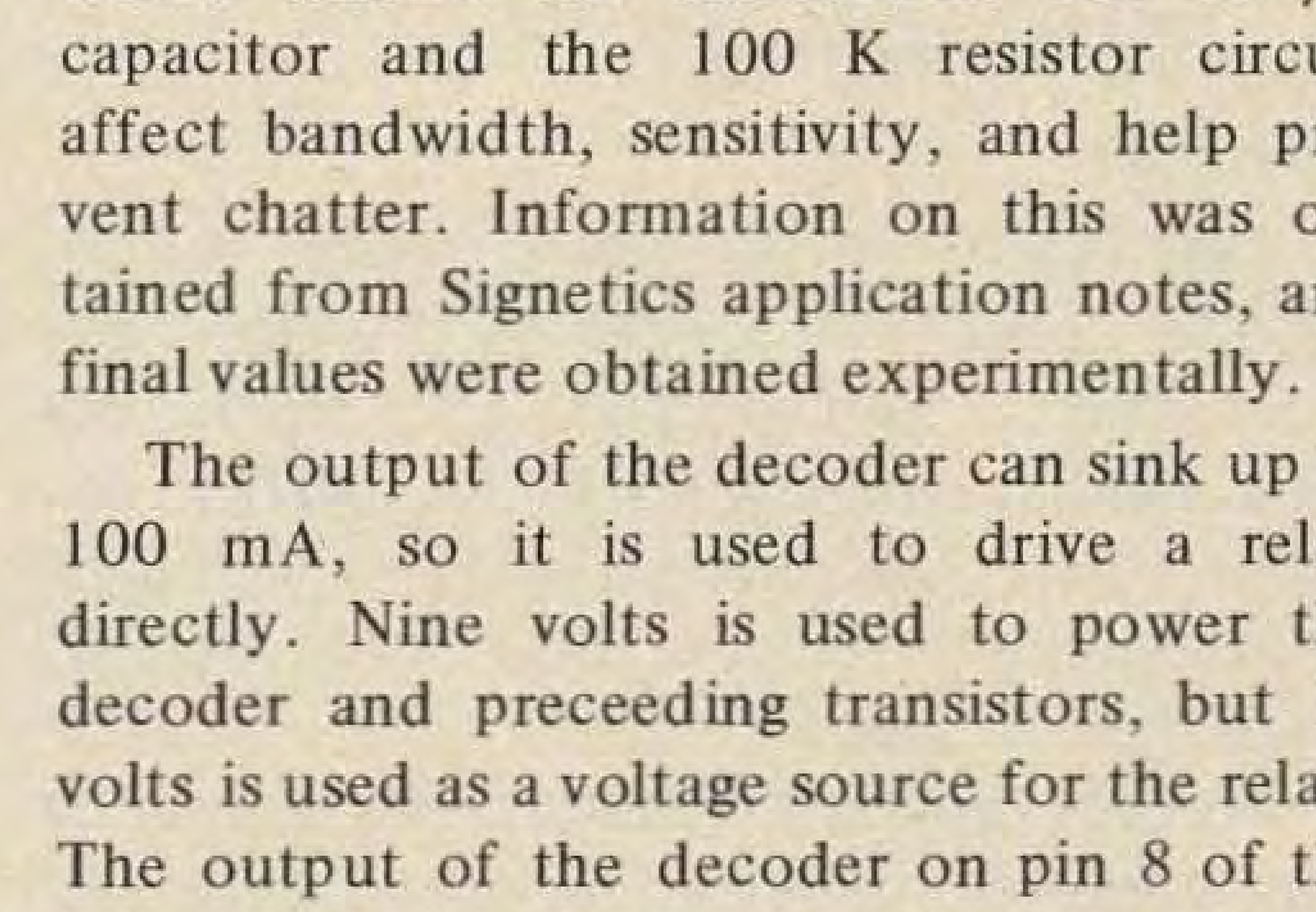

Fig. 2. Encoder schematic.

oscillator followed by an emitter follower. The 20K variable resistor sets the desired frequency of oscillation.

Construction

Since such low frequencies were involved, parts layout was not critical. The decoder was built on a piece of Vectorboard and mounted inside a small LMB chassis box. The integrated circuit and application notes were obtained from Solid State Systems, Inc. Capacitors smaller than 0.1 μF can be disc ceramic, but capacitors in frequency determining circuits should be of as high a quality as possible. Mylar capacitors were used in this case. The capacitors marked with polarity were electrolytic.

If the encoder oscillator is put near a strong rf field it may not oscillate. This can be cured by bypassing the power leads with a .01 μF capacitor, or shielding the entire circuit if necessary.

2N3415's were used for the two transistors in the decoder and for the emitter follower in the encoder. A 2N2924 was used in the oscillator circuit.

Operation

The input of the filter circuit in the decoder unit is connected to the discriminator of the receiver. This circuit has been used with RCA CMU15 and Motorola T44 receivers, and should work as well with other similar receivers that have enough discriminator signal.

The encoder in the transmitter should be connected as directly as possible to the phase modulator. It is usually connected to the deviation control.

To adjust the levels, the tone deviation of the transmitter should be set to 500 Hz, and the *combined* tone and voice deviation should be set to a maximum of 5 kHz. Triple these numbers for a 450 wideband system, remembering to keep the combined deviation below maximum limits, since the tone and voice signals add on peaks.

With the transmitter deviation set properly, and a combined voice and tone signal coming from the receiver, increase the level control until the relay holds in without dropping out on voice peaks. If the level is advanced too far, the decoder may give false outputs from the filtered noise sent to it. Setting levels may take considerable trial and error if proper test equipment is not available. In any case, the objective is to set the transmitter tone deviation as low as possible without having voice peaks false the decoder off, and to have the decoder as sensitive as possible without giving false outputs on noise.

After the system is operating, it should be impossible to hear the tone in a receiver listening to the repeater. If a buzzing sound is detected on a signal, it is usually the result of distortion in the transmitter audio, causing audible harmonics. If the tone is applied to the microphone jack of the transmitter, the tone will probably be audible since the tone level must be increased in proportion to the voice signals. This is because the frequency response of most transmitters is limited below 300 Hz. Also, if the tone signal received at the decoder is very distorted, the level may have to be increased to hold in the relay.

At different times the relay may pull in almost instantly or may take as long as a few tenths of a second to activate. This depends upon the phase relationship between the signal from the encoder and the signal of the internal oscillator in the decoder integrated circuit. This effect is unpredictable.

The decoder should make a good single tone decoder also. This might be done by eliminating the low pass filter from the input, and changing R1 and C1 to different values for the desired frequency. The two electrolytic capacitors should be changed from 15 and 35 μF to 2 and 5 μF respectively. It would be necessary to provide output latching for the circuit, and unlatching by the COR.

Conclusion

This project only took a few days to make operational, and has been operating reliably for about four months now. The integrated circuit was the most expensive item, and it only cost a few dollars. Integrated circuit prices have been getting lower every month. Construction of the encoder is a simple task, and would make an ideal club project. When compared to the price of a tone reed that may have to be replaced in a few years, the solid state system is a real bargain to protect the input of your system.

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