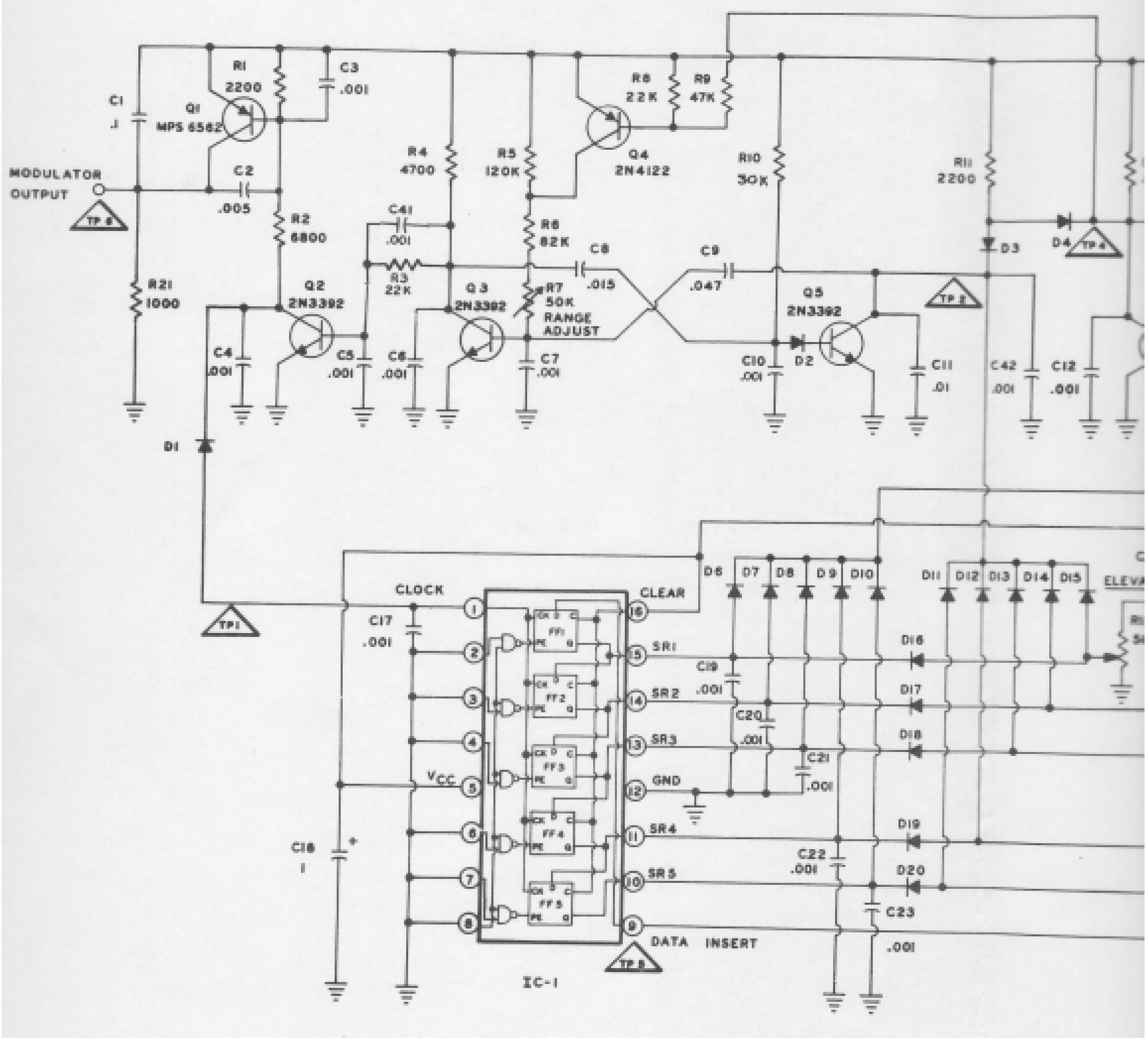
5 CHANNEL ENCODER



ENCODER

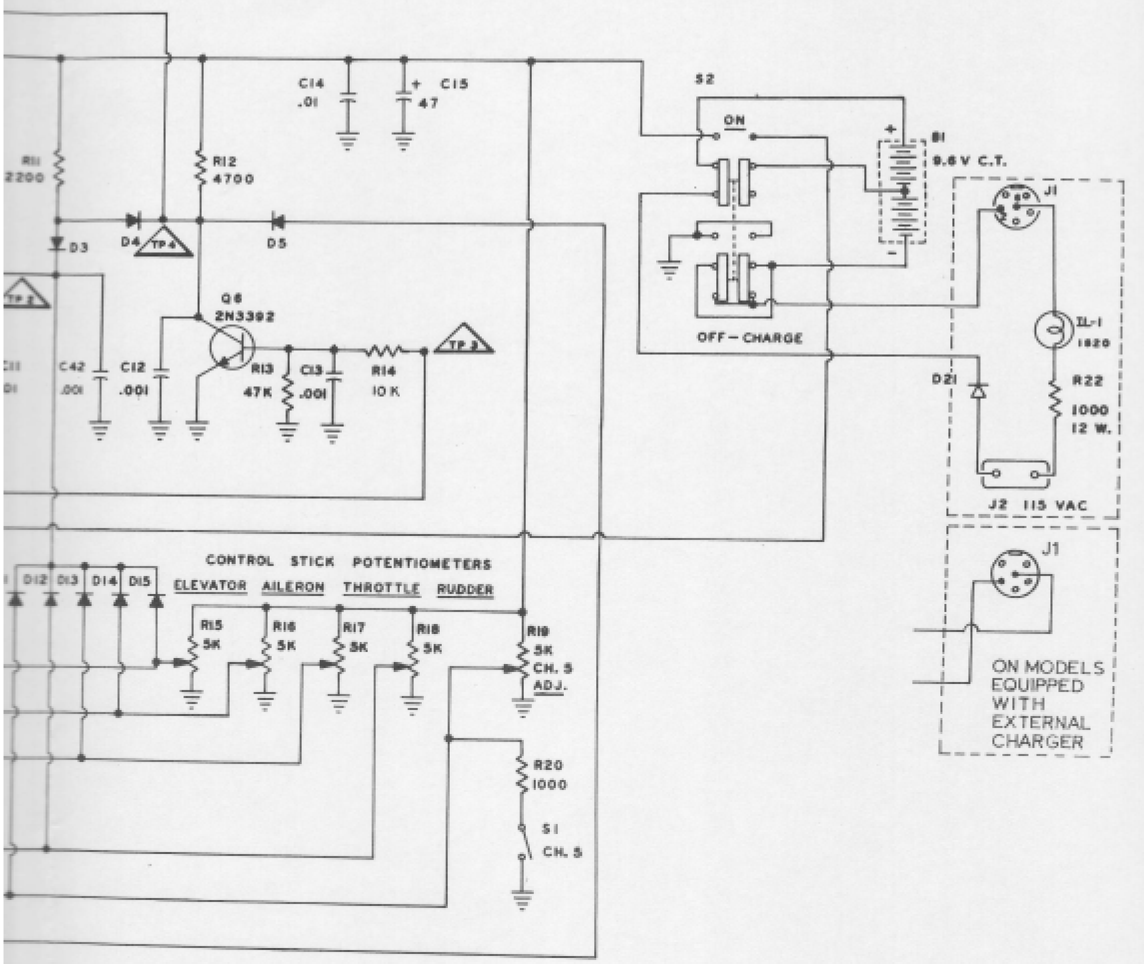


Figure 1

KP-5 SPORT SERIES

Designed as an economical, basic R/C system, the KP-5 was the first unit in the Kraft Sport Series line. The KP-5 is supplied in only one form, a two-stick Mode II transmitter. It was first supplied with KPS-11A servos (designated KPS-11A-S). In 1974, the KPS-15 servo was made available with the KP-5, and, in 1975, both the KPS-14 and the KPS-15. The KPS-11A-S is no longer supplied with the KP-5.

THEORY OF OPERATION – TRANSMITTER

(see Fig. 1)

Encoder-Modulator

The encoder consists of a clock generator (Q2-Q5), a data insert sync stage (Q6), and a five bit shift register (IC-1). The stages, combined with five control potentiometers generate five channels of control information and a sync period for locking the receiver decoder to the transmitted information.

Clock Generator

Transistor Q3-Q5 form an astable multivibrator providing clock pulses through Q2, which drive shift register IC-1. The "off" time of Q5 is determined mainly by C8 and R10. the "off" time of Q3 is determined mainly by C9, R5, R6, R7, and the state of transistor Q4, and by the D.C. voltage at the collector of Q5 (TP-2). The components determining Q5's "off" time are selected to provide a positive pulse at Q5's collector of 350-400 microseconds. This also appears as a negative going pulse at the collector of Q3. This pulse is inverted by Q2, and serves to drive the shift register, IC-1.

The "off" time of Q3 is determined in part by the voltage at Q5's collector. The voltage at this point is determined by the stage of each shift register output and the setting of the potentiometer wiper connected to it. At one point during each frame of information, this time is also determined by the state of transistors Q6 and Q4. To illustrate the action of the encoder, a typical frame of information will be described in detail below. Since the circuit is free-running, this information frame repeats itself continuously as long as power is applied.

The waveform at the collector of Q2 is shown below:

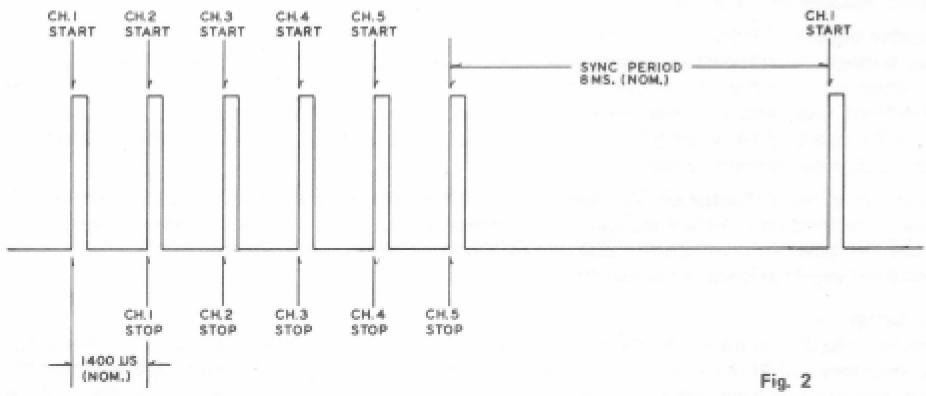


Fig. 2

The operation of the encoder will be described beginning just ahead of the point labeled "CH1 Start".

The state of the free-running multivibrator at this point is Q3 and Q4 off, and Q5 on. Shift register outputs SR1-SR5 are all low causing Q6 to be held off, its collector voltage at nearly supply voltage. The collector of Q6 is connected to pin 9 of IC-1, date input, through diode D5. This positive voltage at Q6 is applied to the data insert terminal, to insert "high" data into the first stage of the shift register as soon as a positive-going clock pulse appears at the clock input. This point is labeled CH1 start in Fig. 2. At this point, Q3 and and Q5 reverse states causing SR1 output of IC-1 to go "high" in response to the high data present at pin 9.

◁—— Fig. 1 *(fold-out at left)*

Q5 will be off for approximately 350 microseconds. During this time, the high output at SR1 of the shift register causes Q6 to turn on immediately through diode D6. Q6 will remain on as long as any shift register output remains high due to the diode "OR" gate of diodes D6-D10. The collector of Q6 is then decoupled from Q5's collector by diode D3, and the wiper of potentiometer R15 is now coupled to Q5's collector via diode D15. The data insert terminal of Ic-1 is now low due to the state of Q6, and "low" data will be clocked into the shift register following succeeding clock pulses.

Since the wiper of R15 is now connected to Q5's collector, capacitor C9 will charge to the voltage at the wiper, less the voltage drop due to diode D15.

When C8 has charged sufficiently to turn Q5 on, Q3 turns off for a time determined by the time constant of R6, R7, and C9, and the voltage at the wiper of R15. Since Q4 is now "ON" and saturated, R5 has no effect on the time constant at this point. The time Q3 remains off is nominally 1,400 microseconds, however, depending on the allowable set limits of R15, it may be anywhere between 900 and 1,800 microseconds.

After this half of the timing cycle, Q3 turns on, Q5 turns off and a clock pulse appears at pin 1 of the shift register. This causes the high data present at SR1 output to be transferred or "shifted" to SR2, and low data at pin 9 to be inserted into stage one, simultaneously appearing at output SR1. This effectively grounds the wiper of R15 and disconnects it from the collector of Q5.

The wiper of R16 is now connected to Q5's collector due to the "high" output present at shift register output SR2. Capacitor C9 now charges to this new voltage present at R16's wiper. The duration of the timing cycle with Q3 off is then dependent on the setting of this second potentiometer.

The action described above continues through all five stages of the shift register in the same manner as described above.

After the fifth timing interval, all shift register outputs are once again low. Q6 now turns off connecting R11 to the collector of Q5, and simultaneously turning Q4 off and inserting high data at pin 9 of IC-1 in preparation for the next information frame. C9 now must charge to the supply voltage through R11. Since Q4 has been turned off, R5 is now added to the resistance in the base of Q3, causing a longer "off" time for Q3 than would otherwise be the case. This generates a sync period approximately 8 milliseconds long, to clock the receiver decoder to the transmitter encoder.

The movable wipers of R15-R18 are mechanically linked to control sticks on the front panel of the transmitter to encode desired mechanical movements into pulse spacings, which when decoded in an appropriate receiver, drive servomechanisms to position mechanical elements of the device being controlled. The setting of R19 is fixed internally and this channel is operated by switch S1 located on the top of the transmitter. Resistor R20 shunts R19 when S1 is closed to cause the pulse timing in this channel to change between 900 and 1,800 microseconds when S1 is operated.

The waveform at the collector of Q2 contains the desired information for transmission, but is of the incorrect polarity to modulate the RF section of the transmitter. Q1 performs the necessary invert function, and also slopes the waveform sufficiently due to the action of Miller capacitor C2 enabling the information to be transmitted within allowable bandwidth constraints.

Encoder Setup

A particularly good feature of the KP-5 is the ease with which the encoder is set up. Only one range adjustment is necessary for all five channels. To ensure repeatability, wirewound control pots are used in the gimbals since wirewounds have inherently better linearity than carbon or cermet elements, although resolution is somewhat poorer.

To begin the setup procedure, set the oscilloscope to 1 volt/division vertical, 200 microseconds/division horizontal, positive trigger. Connect the scope "hot" lead to SR1 output (see Fig. 1 and Fig. 3). Turn the transmitter on, and observe the positive-going square wave pulse. The falling edge should be at the seventh horizontal division corresponding to 1,400 microseconds. Check all stick trim controls to see that they are centered. Operate the elevator control over its entire range less trim. The pulse at SR1 should vary from 4-¾ to 9-¼ horizontal divisions.

This represents 950 to 1850 microseconds. If the pulse is not at 1400 microseconds with the elevator at neu-

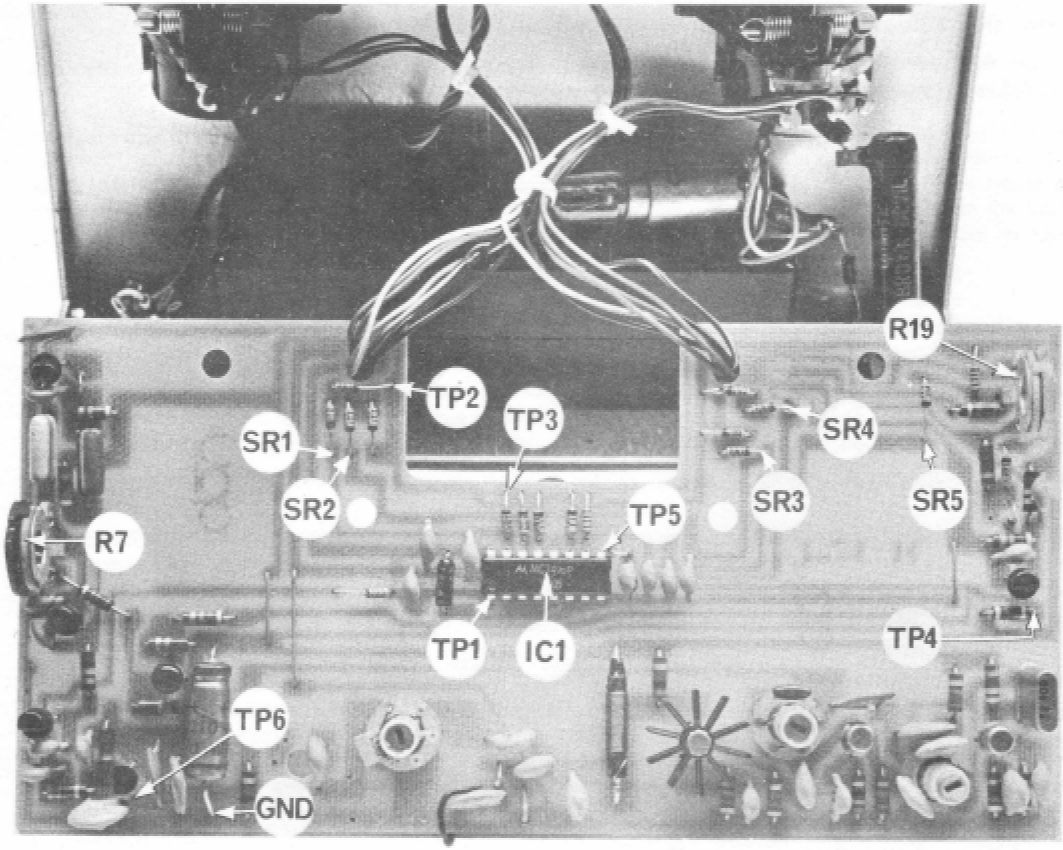


Fig. 3

tral, adjust the control pot housing tab on the elevator to obtain the correct pulse width. Check the range (less trim). It should be 950 to 1850 microseconds (±10 microseconds). If it is not within this range, adjust range pot R7. If total throw was too short, adjust R7 to make the pulse wider, readjust the control pot for correct neutral, and check range. If throw was too long, adjust R7 for a slightly shorter pulse, re-center the control pot, and check range. Go back and forth between centering and range adjustments until proper throw is obtained. **ONCE THE ELEVATOR CHANNEL IS SET, DO NOT MAKE FURTHER ADJUSTMENTS TO R7.**

Connect the oscilloscope to SR2 output. The pulse at this output with aileron stick at neutral should be 1400 microseconds. If it is not, adjust only the control pot housing tab on the stick. Check total throw to see that there is no severe nonlinearity, but do not adjust R7.

Connect the oscilloscope to SR3 output. Since the throttle channel is non-centering, simply check pulse width at the extremes of stick travel. Adjust the control pot tab if necessary to obtain proper pulse width (950 to 1850 microseconds).

Connect the oscilloscope to SR4 output. Set up exactly as SR2 above.

Connect the oscilloscope to SR5 output. Since this channel is switched, throw is set up at the extremes only. Adjust R19 to give proper travel as the switch is operated in both positions.

Set up is now complete. Check the sync period by connecting the oscilloscope to TP4. The positive portion of the waveform should be a minimum of 7 milliseconds. Check modulator pulse width at TP6. The negative pulses should measure between 350 and 425 microseconds. If either sync period or modulator pulse period are not within the above ranges, change the value of R5 to R10 respectively. Increase the resistor values to increase the pulse width or decrease the resistance to decrease pulse width.

> NOTE: If the transmitter has been changed to a Mode I configuration, begin set up of the encoder with channel No. 2 (aileron) as you would channel No. 1. Then set up the first channel as described for throttle above.

Encoder Trouble-Shooting

The encoder circuitry is such that difficulties in one portion of the encoder usually cause failure of the entire encoder. Because of this, trouble-shooting can be difficult without a thorough understanding of the circuit operation. It is important to read and thoroughly understand the Theory of Operation section above.

Most field problems will consist of semiconductor failures. Other components, however, should not be overlooked.

The inter-dependent nature of the entire circuit makes a dual-trace oscilloscope very helpful in determining the nature and location of a fault. If your oscilloscope is not equipped with dual trace, an inexpensive accessory chopping dual-trace adapter such as the Heathkit ID-101 is a worthwhile addition.

Most of the waveforms in this section were photographed in dual-trace to provide a clearer reference for analysis of the specific problems covered.

Perhaps the most telling test point for trouble-shooting is the programming line-TP2 on the schematic. See Fig. 4 below for the normal waveform at this point. Notice there are four pulses of equal height (all controls at neutral) followed by two pulses which are higher in amplitude. The fifth pulse represents the landing gear channel. Depending upon the switch position, this pulse will be higher or lower in amplitude than the first four pulses. The sixth pulse is the sync channel and is of fixed amplitude. Below are several normal waveforms at various points in the circuit. All show the program line on the upper trace as a reference.

Fig. 5 shows channel 1 (SR1) below the program line. This pulse runs from the leading edge of the first program pulse to the leading edge of the second. All other "SR" outputs are alike but occur in sequence down the line.

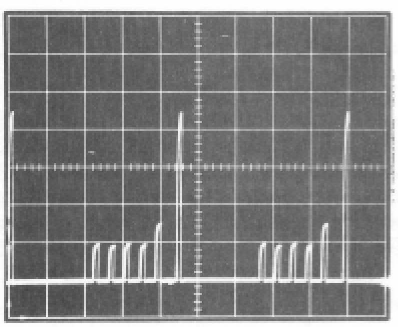


Fig. 4

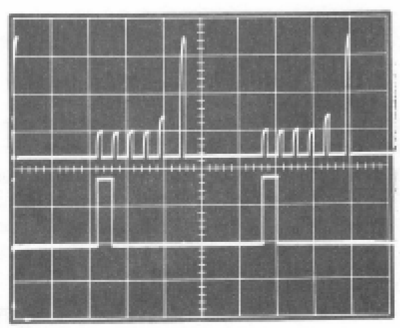


Fig. 5

Fig. 6 shows the collector waveform of Q6-TP4 in relation to the program line. The data insert for IC-1 is also derived from this point.

Fig. 7 shows the waveform at the base of Q3 above the waveform at TP4. Notice the large change in the slope of the recharge during the sync interval compared to the slope during channel information. This is due to the turn-off of transistor Q4 during sync, adding 120K to the timing resistance.

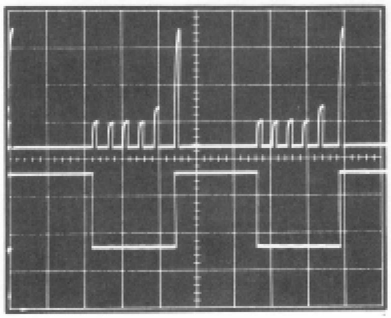


Fig. 6

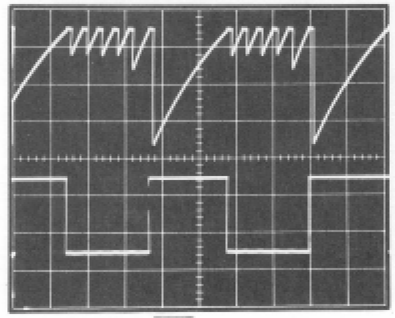


Fig. 7

Fig. 8 shows the clock waveform at the collector of Q2 below the program line.

Fig. 9 shows the waveform at the wiper of R18 (Rudder pot) below the program line. The height of the pulse varies with the position of the control stick. A simultaneous variation occurs on the fourth pulse in the program line waveform.

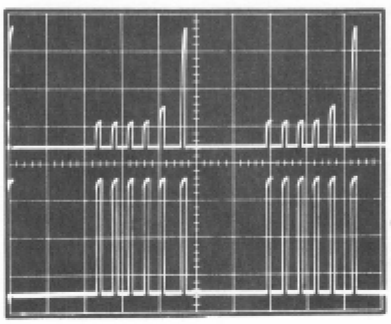


Fig. 8

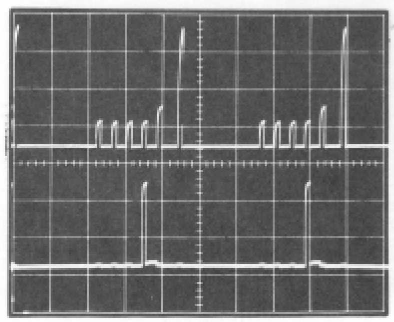


Fig. 9

Fig. 10 shows the waveform at the modulator output-TP6-below the program line. This waveform was taken with the RF Section operating. With the RF section disabled, the negative tips of the pulses will be much more rounded.

Below are a series of waveforms in which various diodes were open or reversed. Although this type of difficulty will rarely be found in the field, it can occur, and locating the defective part can be difficult. Waveforms when a diode is shorted are not included, since it is fairly easy to find the defective diode because the same waveform appears at both ends of the diode. All waveforms below show the program line on the upper trace.

Fig. 11 was the result of a reversed select diode (D19) in the rudder channel. The lower waveform appeared at the same place as the waveform in Fig. 9. By noting the one pulse which appears to be different, in this case the fourth, a clue can be found to the location of the fault.

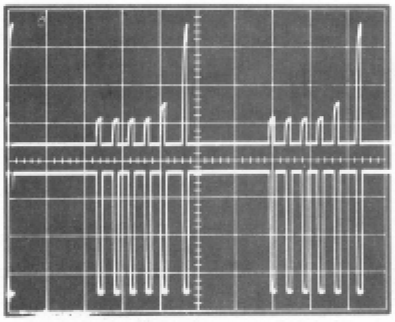


Fig. 10

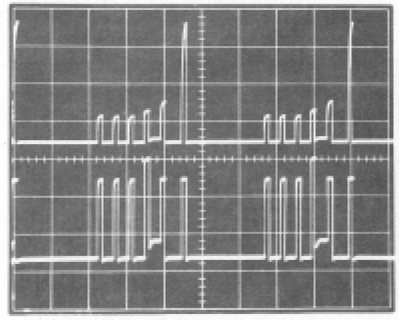


Fig. 11

Fig. 12 shows the result of D19 being open. In this case, the first three channels will not work normally, the fourth controls all channels and the fifth channel usually operates abnormally.

Fig. 13 was the result of program diode D12 being reversed. The severe pulse clipping on the program line is the result of the rudder channel holding all other outputs lower than normal. Here again, the channel location of the fault is obvious since the fourth pulse is different from all the others.

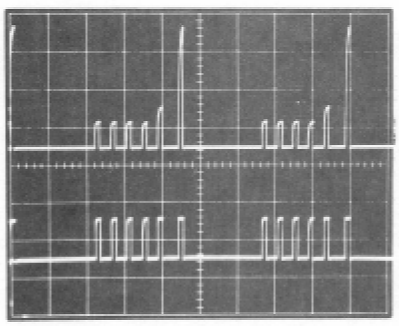


Fig. 12

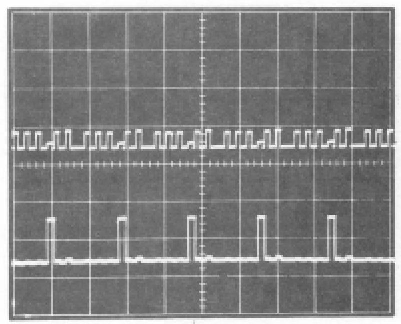


Fig. 13

Fig. 14 shows the effects of D12 being open. In this case, the rudder channel simply doesn't operate. All other channels work normally.

Fig. 15 shows the result when data insert diode D9 is open. The last two channels are inoperative. Although the sync period is unchanged, the frame rate has shortened by two channels. The lower waveform appears at TP3.

Fig. 16 shows the result of a reversed data insert diode D16. The lower trace is TP3, the common cathodes of the data insert diodes. The clue to the defective diode is to observe the register outputs SR1 through SR5. Only one output will have a rectangular pulse similar to the lower trace in this photograph. All other register outputs will have very large steps on their output signals. The one which appears almost as a simple rectangular pulse without large steps indicates the location of the reversed diode.

Other failure conditions in the encoder will generally be confined to IC failure, or the free-running multivibrator. IC defects are usually confined to failure to clock data into the register. In this case, the signal at TP6 (Modulator Output) will be a continuous stream of pulses. This is due to the free-running nature of the astable multivibrator which runs regardless of the state of the shift register IC. If no pulses are present at the collector of Q3, it should first be assumed that the problem lies in the free-running multivibrator.

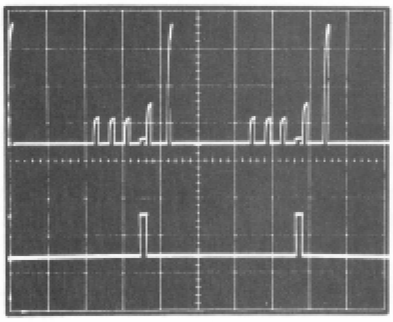


Fig. 14

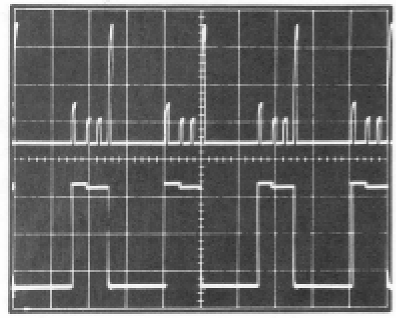


Fig. 15

RF Sections — Tuning and Adjustment

WARNING: It is unlawful for any person to tune or make any other adjustments to any 27 or 72 MHz transmitter which affects RF output unless that person is the holder of a valid 2nd class or higher radio telephone license issued by the Federal Communications Commission, and possesses the necessary equipment to ensure operation within frequency and bandwidth limits as specified in Part 95 of the Rules.

27 MHz (See Fig. 17)

The 27 MHz RF Section is a three stage type utilizing a 27 MHz oscillator, a buffer, and a final power amplifier. All tuning adjustments are slug-tuned coils, accessible from the rear of the P.C. Board. A ceramic bladed tuning tool is recommended to minimize inductance changes caused by metal in the adjustment tool. The use of a tuned diode wavetrap and oscilloscope are recommended as a tuning indicator, although a meter type wavetrap may be used.

Oscillator

With power switch off, rotate the slug in oscillator coil L1 clockwise several turns. Apply power and rotate the slug counterclockwise slowly until the oscillator starts. Continue CCW until the output **just begins** to fall off.

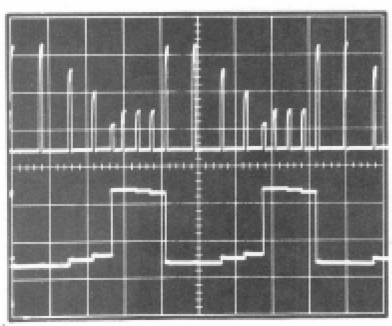


Fig. 16

Buffer

Adjust buffer tuning coil L2 for maximum output then adjust the tuning **very slightly** capacitive (CW) for optimum stability.

Fig. 17 *(folds out from next page)* →

Final

Adjust final tuning coil L5 for maximum output indication.

Re-check tuning of all adjustments beginning with the oscillator to make certain all tuning coils are in correct alignment as outlined above. Check output frequency with modulation removed to be sure frequency is within .005% of nominal.

72 MHz

The 72 MHz RF section is a three stage circuit using a 36 MHz oscillator, buffer-doubler, and final power amplifier. A tuned wavetrap and oscilloscope should be used to indicate output.

Tuning procedure is identical to the 27 MHz unit with the exception of the buffer tuning. The buffer tuning should be set at the peak point to minimize 36 MHz output.