There's more than one way of "skinning a cat" (as the old saying goes) and there are lots of ways of achieving multi-control utilizing some of the newer developments in the field of radio control. Here a noted expert brings you up to date on the "M-P" parade.

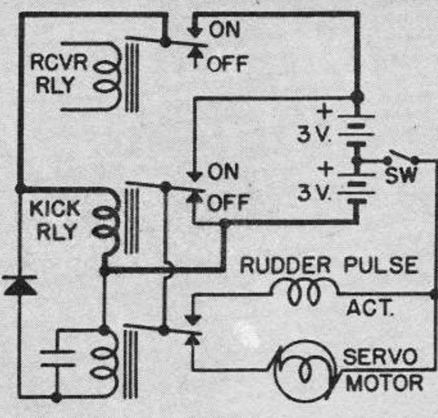

FIG. 5

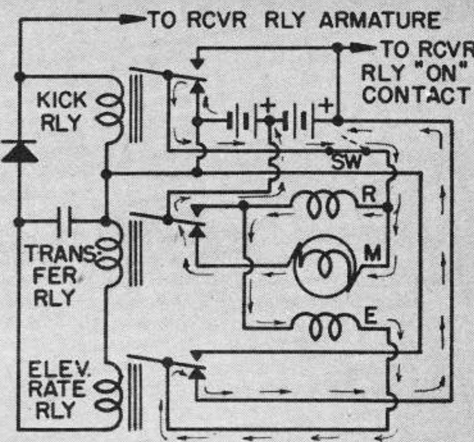

FIG. 6

FOR THE RADIO CONTROL EXPERIMENTER (Conclusion)... By JOHN WORTH

Multi-Pulse Control Systems

■ In the preceding section of this report, we traced the beginnings of the "inductive kick" principle as a simple and flexible method of separating pulse rate signals from the pulse length system. This series of two articles is intended to provide the working information needed, with application to several recently developed control systems.

So, let's continue.

Fig. 5 shows a kick relay circuit which provides more control with a single channel outfit than is presently being obtained with many multi-tone systems! In this system the receiver relay merely switches the 6 V. battery supply on and off through the kick relay (this portion of circuit shown in heavy lines.) The kick relay then provides the kick for the delay relay and also acts as a polarity reversing switch for the actuators, using each 3-volt half of the battery supply alternately. The delay relay is adjusted so that it pulls in and holds during any pulsing above approximately 2 cps. so that the switching action of the kick relay is directed through the on contact of the delay relay to the rudder pulse actuator. Note that only a single coil actuator is required—dual coil types may be wired with both coils in series or parallel.

Since the kick relay follows the receiver relay exactly, the rudder actuator similarly responds as if directly switched by the receiver relay and so is controlled proportionally by pulse length signals. Full signal on or off results in no energy from the kick relay, causing the delay relay to drop out and disconnect power from the rudder actuator. The power then transfers through the off contact of the delay relay to the second actuator which is a servo type connected to an elevator. The polarity of this power is determined by whether the kick relay is in or out (signal on or off). The obvious choice of hookup is to have signal-on drive the servo toward down elevator and signal-off to drive it toward up.

Elevator movement continues for as long as solid signal is maintained, until the travel limit is reached. Resumption of pulsing at any time pulls the delay, or transfer, relay in again and switches power back to the rudder actuator, leaving the servo in whatever position it has reached when the full signal-on condition ends. Therefore, the elevator servo can be trimmed to any position desired by interrupting the rudder control pulses with a solid signal in the appropriate direction, then resuming pulsing to restore rudder control. During the elevator movement, the rudder springs back to neutral. Signal failure would thus result in neutral rudder and elevator moving toward up position. Note that limit switches are not used on the servo, as breaking the circuit prevents the restoration of control. Instead of switch contacts, bumpers or springs may be provided to limit the travel. Rather than being linked to elevator control, the servo may also be used to operate a trimmable engine control. With this arrangement, the engine speed is variable as desired since any setting can be obtained and held. Other variations of the circuit are possible. For instance, the pulse length rudder control and full on or off control of engine speed may be retained and pulse rate of elevator control added! The basic circuit is shown in Fig. 6.

All we've done is include another rate relay in series with the one shown in Fig. 5 and connected to this second relay a pulse type elevator actuator which operates exactly as in the previously described dual proportional system. The proper delay action is obtained by mechanical adjustment of the two rate relays. The transfer relay is adjusted to pull in and hold during all pulsing, the elevator rate relay is adjusted with stronger tension and/or more armature clearance to pull in and drop out during each cycle of pulsing. Several unusual circuit features are worth noting. Only one condenser is used across both relays. This is satisfactory although the value may be a little more critical since it must be adequate for both relays even though they operate differently. The general idea is to experiment with as low a capacitance as possible—25 mf. or less—to permit pulsing of the elevator relay while allowing sufficient delay time to keep the transfer relay pulled in. Spring tension and/or armature clearance on the transfer relay may have to be reduced to bare minimum to prevent dropping out at lowest pulse rates.

The use of different resistances in the rate relays will help separate the action—with the more sensitive relay used as the transfer unit, its adjustment is usually simple and attention may then be concentrated on the rate relay which requires more fussing for proper adjustment. With only a single battery supply, this circuit should use reasonable drain actuators, such as Southwestern commercial units for rudder and elevator and a Mighty Midget or Distler motor for the servo type engine control.

Due to the complex hookup of this system an unusual signal on and signal off condition results. As shown, with signal off all actuators go to full extreme. In our hookup, this is arranged to provide full up with low-speed engine and full-over rudder opposite the model's natural turn tendency. This is a comparatively safe-failure condition and prevents a flyaway very effectively. However, not much rudder action should be used as it is more effective than the elevator and a lot of rudder causes a steep spiral despite the countering effect of the up elevator. With full signal on, the rudder and elevator actuators neutralize and the

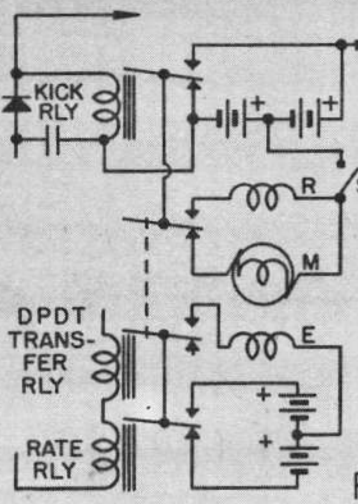

FIG. 7

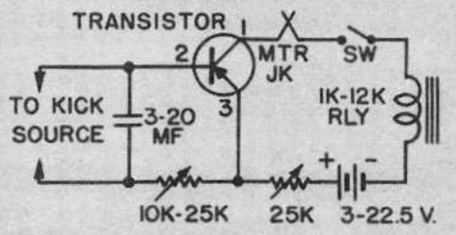

FIG. 8

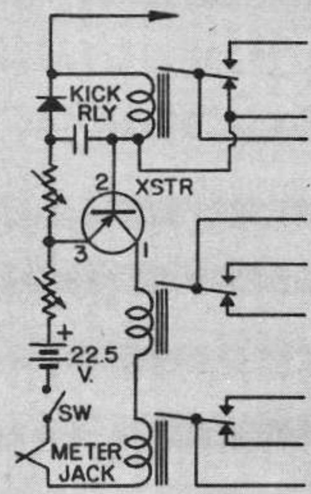

FIG. 9

engine control servo drives toward increased speed. The difference in the two signal conditions is caused by the fact that with signal off the kick relay provides a common 6 V. circuit through the pulse actuators, besides the normal 3 V. circuit through the servo, but with signal on the kick relay disconnects the common circuit. Tracing through the circuit is tricky, as indicated by the small arrows in Fig. 6 showing the common circuit condition.

In use, the different full signal conditions work out fairly well. When increased engine speed control is given (solid signal on) the rudder and elevator surfaces neutralize, which is desirable since this condition would be encountered on takeoff, climb out of stalls, touch and go landings, etc. On the other hand, low engine speed is usually not given unless the plane is in a safe attitude, such as after a climb from takeoff or low altitude, preparing for landing, etc. Therefore, the up elevator and full-over rudder that results when low-speed engine control is given would not be a dangerous condition .

However, for those who would prefer the rudder and elevator going to neutral when engine speed is changed either high or low, a Double Pole Double Throw transfer relay may be used, to eliminate the common circuit by isolating the elevator actuator, as shown in Fig. 7. One satisfactory relay for this type circuit is made by Price and is generally available in a resistance of 8500 ohms. It is sensitive enough for fine adjustment in receiver or rate type circuits, if the spring tension is considerably reduced, yet is smaller and lighter than the Sigma relays. There is also a Sigma 22 relay which is suitable, but they are hard to find in surplus stock and are usually quite expensive. Another possibility is a recently announced British DPDT relay which seems to be reasonably sensitive and low in cost.

When two relays are used in the rate circuit, if one is of high resistance (over 5000 ohms) the other should be lower, so that the total resistance is held to about 10,000 ohms. This much total resistance in the kick circuit requires a really hefty kick and unless all components are optimum the relay adjustment problem can be critical. A good solution has been found by employing a transsistor to boost the kick action. The basic transistor circuit is shown in Fig. 8 and is applicable to all the previous circuits, as indicated by a typical hookup in Fig. 9. Good primary circuit practice for obtaining a strong kick is still necessary, but with much more leeway in the choice of components, enabling relay selection and adjustment to be made more freely. The delay condenser value need be only 3 or 5 mf., which permits the use of subminiature electrolytic condensers, such as the IEI or Barco makes, for space and weight savings.

A 10k or 25k pot is used following the condenser and this also may be a subminiature type. The pot provides two actions. It presents a bias resistance necessary for proper action of the transistor—each transistor is slightly different and by varying the pot setting adjustment is easily made for greatest kick. The pot is also used instead of the relay resistance to combine with the condenser to determine the time delay action. With the pot, the delay is variable so that the capacitance value is not critical. We have used values from 3 to 20 mf with similar circuit action, compensating for different values with the pot. However, if too much compensation is required the kick is greatly reduced due to excessive resistance so it is preferable to use the pot first to obtain the greatest kick, then to experiment with capacitance values for desired relay action, with final trimming by means of slight pot readjustment so long as the kick action is not killed.

A second pot is shown in the circuit, although it is not needed if the transistor battery voltage is kept to 6 volts or less. We prefer the use of two pots as the circuit is very flexible and permits instant adjustment to compensate for a wide variation in components and voltages. The battery in the transistor circuit may be as low as 3 volts, but the real benefit of the circuit is obtained with about 6 to 22.5 V. Actually, we don't use the full 22.5 volts, but cut it down with the second pot to about 15 volts or less, depending upon how much kick we need. One subminiature hearing type cell may be used which is lighter than the two penlite cells it takes to get 3 volts. We like the Burgess Y15 battery which fits in a standard one pencell Acme case. With this pot and battery combination, dropping of voltage as the battery ages is not serious as immediate adjustment can be made at any time, although it should be noted that current drain is not excessive but about the same as in most receivers.

The transistor is the cheapest kind available, the pnp junction type. The Raytheon CK722, GE 2N107 and the 2N222 have all given excellent results and they are available for about $1 from most radio supply houses. You can expect considerable variation from one transistor to another even within the same type and make range. The pots in the circuit take care of this and eliminate the need for special selection and testing of transistors. The major difference in transistors that may be noted is that the idling current differs considerably. For instance, one CK722 idled at about .7 ma., another idled at .3 ma.; a 2N107 idled at about 1.3 ma., another idled at .1 ma.! All kicked up to 3 ma. or more, depending upon the relays used and the voltage in the relay circuit.

Another characteristic is that when pulsing of the transistor circuit stops the idling current may be quite low—anywhere from about .2 to .8 ma. lower than the initial steady signal value. After pulsing stops the current slowly creeps up and stabilizes at the original idling value. Whatever current range is obtained, from highest idling to average kick value, the relays should be adjusted to operate well within the spread. Since the kick value is so much higher than the highest idling value, relay adjustment is quite conservative, with pull-in at 2 ma. or more—better than most receiver relay adjustments. With this kind of performance, the weight cost of the transistor circuit is surprisingly low—a little over one ounce, using subminiature components—and well worth carrying around.

In checking transistor kick circuit operation, the idling current will be shown on the meter when the relay is held in the signal-off position. When the armature breaks contact, the current should momentarily kick higher. If the kick results in less current, reverse the polarity of *both* the primary battery and the diode. The transistor polarity, however, must be as shown—with minus to the collector terminal. The collector terminal is identified differently on various transistors. It is usually spaced further away from the others and it may also be in-

(Continued from page 59)

Multi-Pulse

(*Continued from page 33*)

dicated by a red dot. When numbered, it is the first terminal. The base is the next lead to the collector, or No. 2, and the emitter is the third terminal. Transistors and diodes should be handled as tubes. We prefer to use flea clips or subminiature tube sockets rather than soldering leads, but they may be soldered if care is taken to avoid overheating. A simple prevention method is to leave the leads about an inch long, or more, and hold the lead being soldered with pliers while applying heat. Use a well-tinned and well-heated iron so that the joint may be made quickly yet well fused.

Never let your soldering iron linger when joining components.

Once a pulse rate system is checked out satisfactorily, don't be alarmed if the next time it is switched on the operation is erratic. Let the system pulse a while and normal operation will be restored shortly. It takes an initial warmup period for the delay condensers to settle down, particularly after a few hours or days of inactivity. As a final note, it should be realized that any rate system depends upon a good pulser for consistent operation. One with linear pulse length and rate variation is needed. Our best results have been obtained with Walt Good's circuit, originally presented in schematic form in the Jan. '55 *ATH* and in a finished version by Howard McEntee in the Oct. '55 *Young Men.* The circuit by Al Diem in the Jan. '56 *Young Men* may also be a good one to try. Most of the mechanical motor-driven types can be used if a pot is used in the motor circuit to control the motor speed.