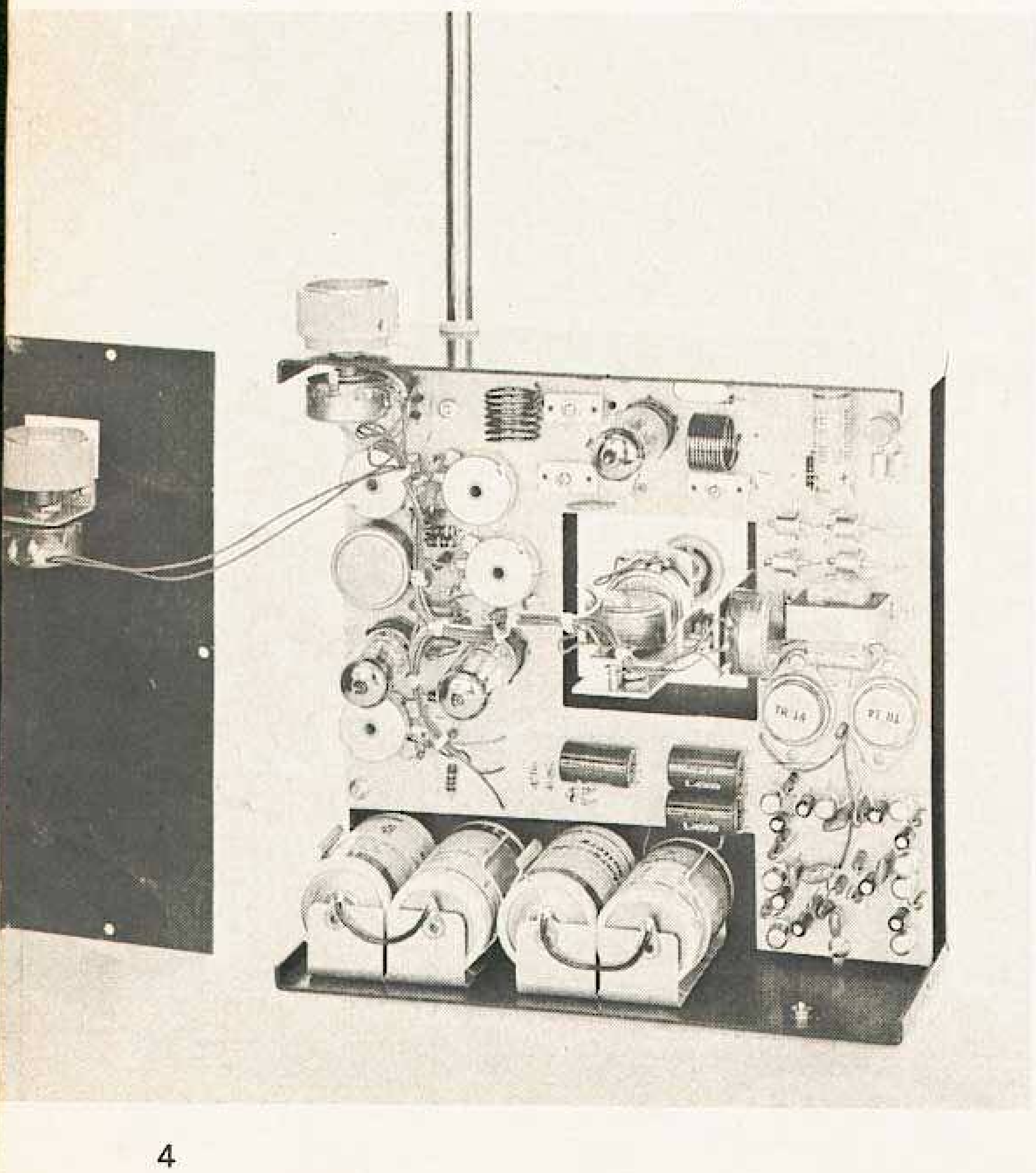
SAMPEY ON PROPORTIONAL

The year 1963 saw true proportional control comes into its own, establishing the world altitude record, winning the Nationals and the World Championship. Several systems are on the market—more will be announced soon.

By HARRY SAMPEY

Sampey 404 transmitter and receiver. There are four simultaneous channels, plus trim on pitch, roll, and yaw axis.

Inside the case. Commutator acts as ring counter, using 4 stages of circuitry each with a separate multivibrator.



Editor's Note: *When reed systems first appeared manufacturers had difficulties educating the consumer to use them properly. Proportional now is in the same stage. GL readers who have toiled to advance proportional do have an advantage in understanding the exotic multi-proportional systems now being manufactured but, in general, hobbyists have only a hazy idea of how these things work and how one system differs from another. Proper use, installation, care, maintenance, are important. For these reasons GL has invited an outstanding authority to discuss the field and explain his equipment.*

SINCE THE FIRST MODEL plane was "controlled" by radio, man has visioned himself as master over machine. From that first day on the flying field, he has dreamed of proportional control. He has explored every known region in an effort to equip himself with tools that would place him closer to achieving the reality—a device that would be the utmost in the control of models. Many attempts were made, but though some were successful within their concept none, however, was true proportional control as we know it now.

With the advent of reliable, inexpensive transistors and miniaturized components, men with creative talent in the field of electronics began to develop systems. Hours of hard work turned into months, and months into years, for the development of such a system that would provide necessary reliability and, at the same time, lend itself to modern production techniques. Years were spent in planning, developing and testing before the product was ready for production.

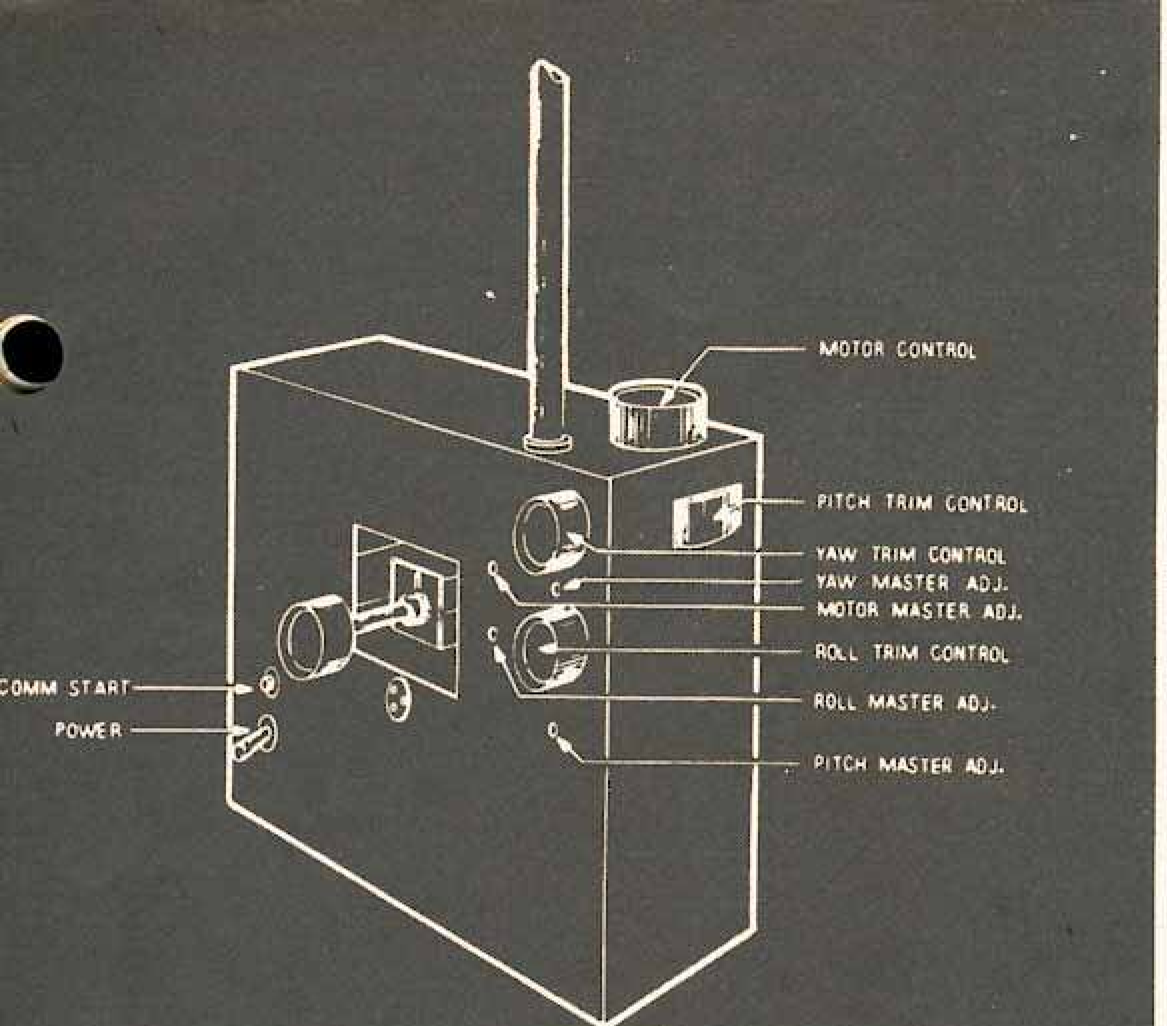
The developments of 1963 will inspire trends for the next decade. During the past year, proportional control demonstrated its superiority by establishing a new world's altitude record, winning first place at both the National and International contests. Several manufacturers are producing true proportional systems and others soon will be making their bid.

What is true proportional remote control? It is a system composed of three basic elements: Transmitter, receiver, and electromechanical servo.

The transmitter is so designed that the quantative output of the transmission is directly related to the quantity of the manual movement for which the mind has directed the desired displacement. The receiver is so designed that the reciprocal directions of the transmission can be formulated into data that has been originally requested by the desired displacement.

The servo system, which now has been determined to be the end result of the desired displacement, is an error-reducing closed-loop automatic control device so designed that the output element or output quality follows as closely as desired, the input to the system. The output is caused to follow the input by the action of the servo controller upon the output element in such a way as to cause the instantaneous error of difference between output and input to approach zero. The servo system is a dynamic system containing at least one feedback loop which provides an input signal proportional to the deviation of the actual output from the desired output displacement.

It is simple enough to demonstrate this logically, without going into further technical details. A true proportional operating system in most cases is assumed to be one in which the control surface of the aircraft is in direct displacement as to the displacement of the control handle. As the control handle is moved to any position of degrees, the aircraft control surface follows smoothly and exactly, the amount of degrees that the



TRANSMITTER FUNCTION CONTROLS

handle has been displaced from it's center position (center being considered as neutral). Probably playing the most important roll in this operation is the closed-loop servo. For, as the decoded information from the receiver requests the servo to move, a potentiometer (commonly called a feedback pot—located in the servo) records the error signal. The servo at all times seeks to reduce this error signal (voltage) to zero. Therefore, if the output error signal from the receiver is at zero potential, our servo will be at a neutral position.

However, if we cause the error from the receiver to be at a different potential other than zero, the servo will rotate because there is now an error potential existing and it wishes to neutralize this condition. When the servo has accomplished this task, the actuator will have been displaced from it's neutral position in direct proportion to the displacement of the control handle. Closed-loop servos, unlike reed servos, must rely upon balanced battery voltages for maintaining their neutral position. This property permits the closed-loop proportional servo to be a much more versatile instrument than the present day reed-type actuators.

Since most modelers couldn't care less about what goes on inside the radio gear, let's take a short flight with a proportional equipped airplane.

Our model is all fueled up and ready for flight. All radio equipment is off. We manually move the throttle to a full open position and, with a flip of the prop, the engine begins to wind up to full rpm. As soon as the receiver is turned on, the engine throttle reduces immediately to idle and our control surfaces are in neutral. (In the Model 404 System, the pre-program condition of the servos, when the transmitter is off, is slow motor and neutral control surfaces).

With frequency clearance established, the throttle knob is rotated to about 15 percent power and our plane begins to taxi. Now for a little left turn out onto the runway, No left turn? Forgot to press the start button! Now all controls are operating. Don't want to ever forget to press that start button again. (The 404 uses a start button for full operation, other systems provide similar or different methods.) Wind about 5 mph and about 3 degrees of up trim should provide a nice takeoff.

Rotating the throttle to 100 percent power, our plane zooms down the runway and takes off. Moving the stick a few degrees to the left, we begin a gentle turn, coming back overhead. Still climbing, we rotate the Pitch Trim knob for a little down trim. Now she's on the step, grooving perfectly. Seems like we might have a little bit of a right turn, so in with a little left trim. Now she's trimmed out.

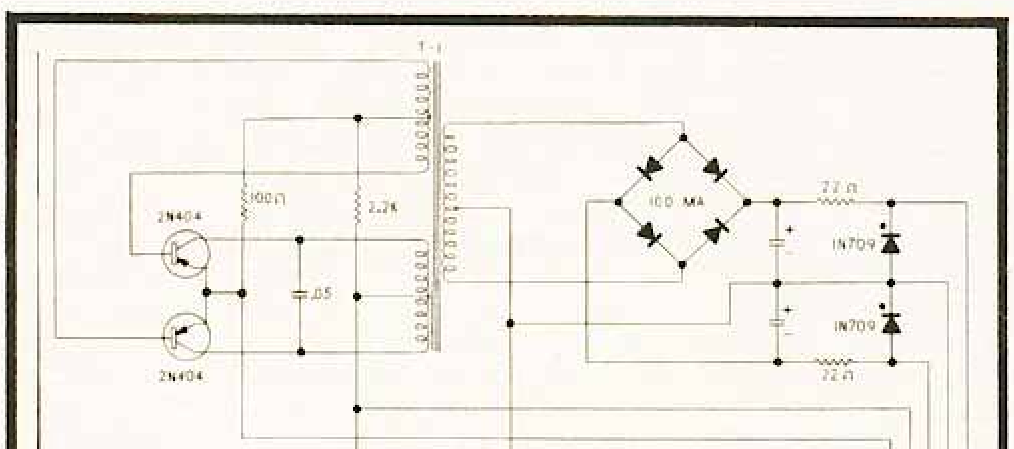
A few rolls, Some cuban eights, and some more practice on those side slips. Fuel running low, ready for landing. Power reduced to about 30 percent, maintaining altitude at 100 feet. Gently banking into the cross-wind leg, another graceful turn into the final leg, altitude still 100 feet. Reducing power now to 15 percent with about 5 degrees of up trim, 200 feet from touch-down, altitude 10 feet. She's lined up perfectly. 100 feet from touch down, altitude 5 feet. Reduce power to zero, ease gently back on the stick, a little more now, stick all the way back . . . . touch down. Nose high, our plane touches on her main gear, slowly rotating nose down until the nose wheel touches 50 feet farther down the runway. Only now do you begin to appreciate the realism of proportional control.

Amazing as it may seem, many people are not fully aware of the difference between the operation of proportional control and reed systems. The most asked question is: "How many channels does a proportional system have?" Naturally, if it is a "full-house" simultaneous system, it employs four channels. However, this can be misleading since a proportional channel cannot be related to a reed channel. It becomes difficult to properly answer such a question. The common proportional system available is an antilog system whereas the reed system is a digital system. (There may be arguments over this definition.)

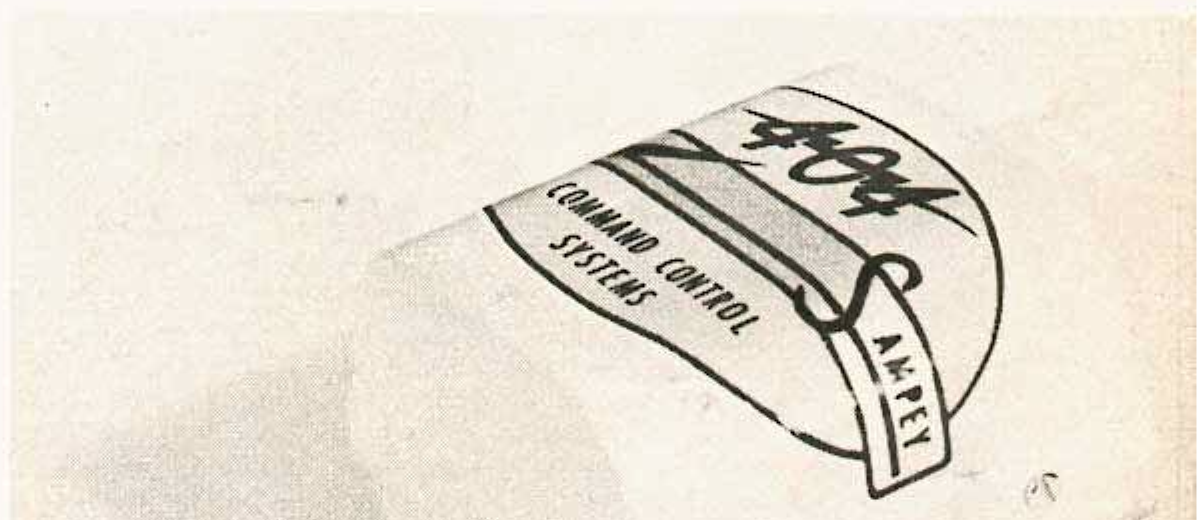
Lets analyze the number of channels that are available in our Model 404. Basically, there are four channels that can be operated simultaneously. These are Motor, Pitch, Roll and Yaw. These functions can now be compared to an eight-channel reed system. Also available with the 404 system is Pitch Trim, Roll Trim and Yaw Trim. With these additional functions the reed system must now have 14 channels to be equivalent. The biggest advantage really is within the airborne package, for here, only four servos are equipped to accomplish the same operations that a 14-channel reed system with seven servos would provide.

If we were technical about it we could start an argument by saying that the average true proportional system, mathematically speaking, is equal to 480 or more channels. True or false, it would depend upon who had the longest slide rule.

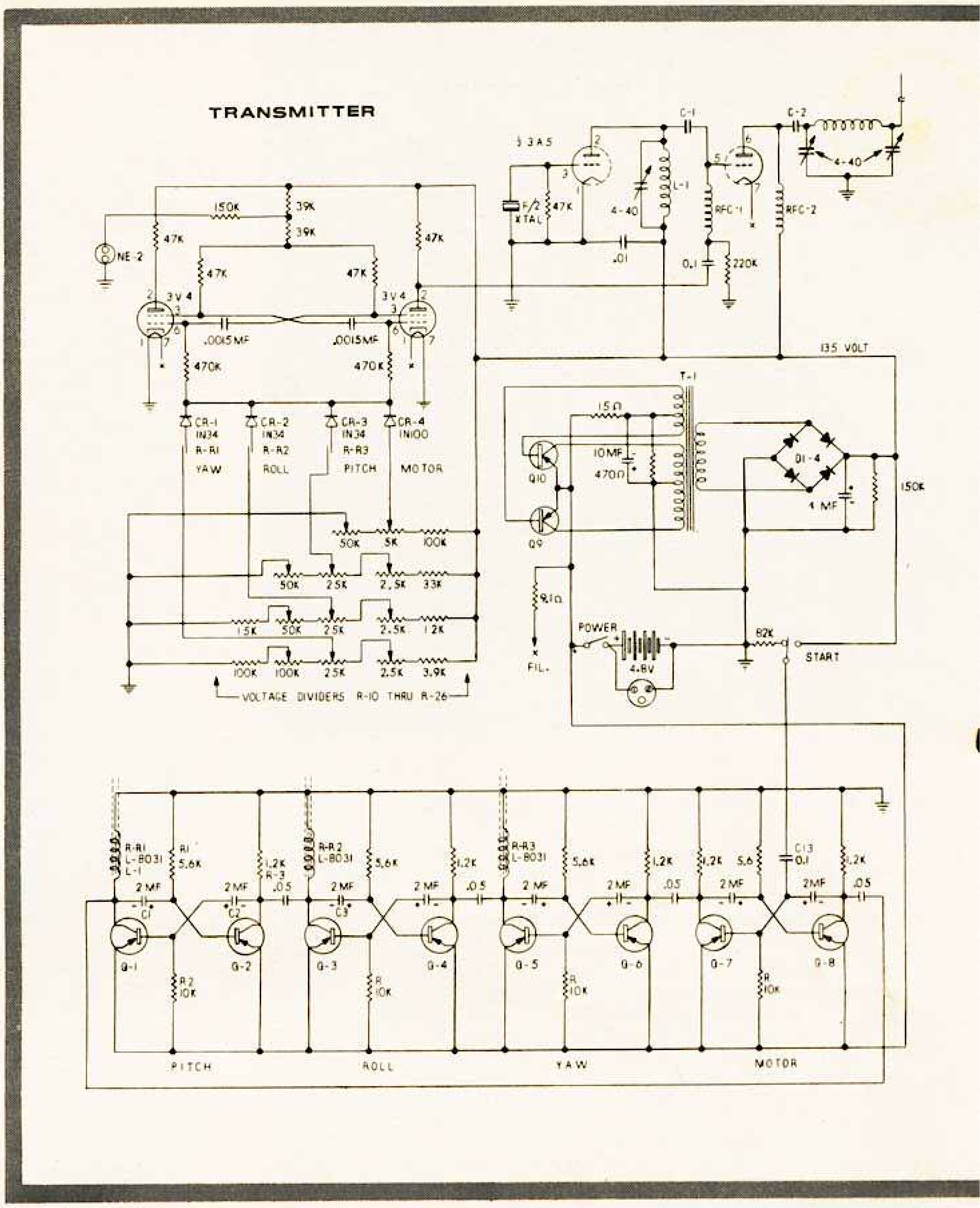
Another question is: "Why does proportional control equipment cost so much?" Proportional offers much more in a smaller package than do present-day reed systems and with much more reliability, contrary to current belief. Incorporated into each system are more components than two television sets put together and, unlike the television receiver, the modelers equipment must withstand the *(Continued on next page)*



MODEL 404-PP POWER PACK



SAMPEY ON PROPORTIONAL continued



rigid environmental conditions of temperature, vibration, and 50,000-G force crashes. Unless there is a major break-through in electronics, it is difficult to see how the price of proportional equipment can be reduced from what it is today.

Choosing the proper model for proportional is not as easy as one may think. For example, the Taurus is not a very good airplane on proportional. The Taurus was designed to perform smoothly as possible with reed equipment—which it does very well. The airplane does not detect the jerkiness as would a more sensitive airplane. Since proportional systems are not jerky and we have control over the amount of degrees that the control surfaces deflect, we need a more sensitive type of airplane. Three good examples of really fine flying proportional airplanes are Jim Kirkland's Beachcomber and Jerry Nelson's Sultan and Safari.

Every modeler who owns, or hopes to own, a proportional system should educate himself to the differences in maintenance and flying between proportional equipment and reeds. It has been said that it is easier to train a man to fly who has never flown than to teach an old dog new tricks. This is proving true now that we are entering into the day of proportional control.

When reed systems first became available the manufacturers were plagued with the task of educating the modeler to use the equipment. With the advent of proportional control, the manufacturers again are faced with the same problem.

The past several years have brought out a few basic problems that most proportional flyers have experienced. For precision flying or just Sunday flying, all movable control surfaces and linkages should be free of frictional drag. A closed-loop servo must have these conditions met before it can perform satisfactory.

In some model installations an electrical noise condition may be present that will cause momentary loss of signal during flight. It is important that the user be aware of the possibility of this condition even though RF range tests have indicated normal range. Static noise is an odd phenomenon of radio and when it occurs near an R/C receiver, the result is an ever increasing problem whose origin may never be suspected.

Proportional operating receivers require the reception of signal information 100 percent of the time and when this signal is interrupted for any period, deviations will begin to occur. Although this condition may not always be evident it can exist during certain propagated attitudes of flight and certain engine vibrations. The rate at which this condition exists will, of course, depend upon the amplitude of static noise being created within the area of the receiver. It is therefore important that all necessary steps be taken to eliminate any potential areas that may be suspected of being capable of generating static noise.

It is recommended that the following precautions be taken during the installation of the equipment prior to flight.

A. *Do not use long lengths of metal push rods.*

B. *Always connect metal to metal with some sort of insulator such as a nylon clevis.*

C. *Never allow metal to come in contact with other metals that may be capable of generating static noise.*

D. *Keep the receiving antenna as far from metal as possible.*

Periodic checks should be made of the servo feedback potentiometer. It should be cleaned occasionally and replaced when evidence of wear is noted.

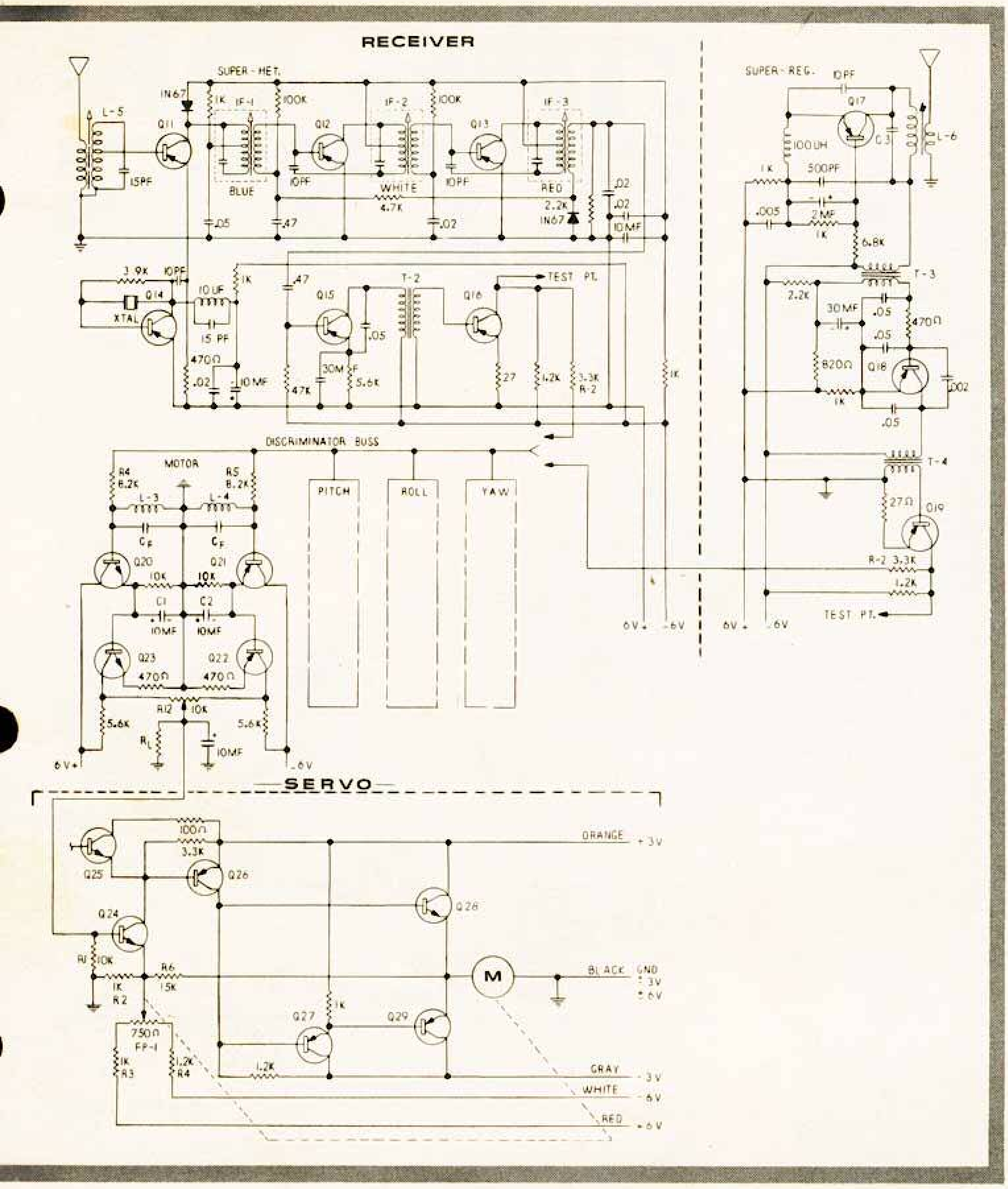
Transmitter Section: In the transmitter, resistor elements R-10 through R-26 make up the voltage divider chain. Incorporated into each divider is the control-axis potentiometer, a trim control potentiometer, and a broad-tune potentiometer that provides wider voltage adjustments utilized in tuning to different multiplex receivers. All four dividers are connected directly to the 135-volt buss.

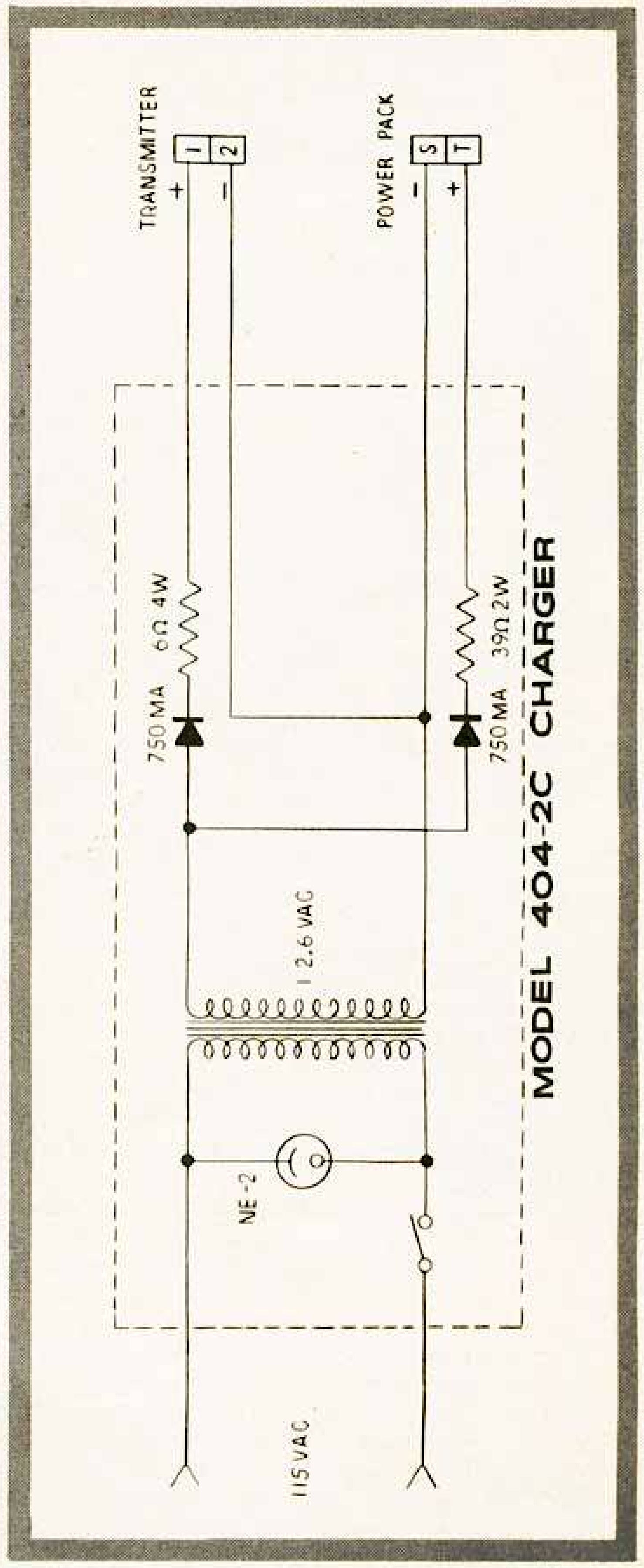
The output control voltages from the dividers are connected directly to the heart of the system, the commutator. The commutator operates as a ring counter and is very simple in operation since all four stages are identical in circuitry. This circuitry is made up of four separate one shot multivibrators. The one shot multivibrator, also called a univibrator, differs from the conventional multivibrator (which is free running) and the flip-flop (which is bistable) in that it is a monostable circuit. That is, the univibrator may be pulsed into operation, but after delivering one output pulse, it reverts to its zero output resting state after the actuating pulse has passed. Thus, the one-shot multivibrator delivers an output signal pulse each time it is triggered into operation by an input signal pulse.

To reduce some of the circuit description, only one of the common circuits will be analyzed. When the circuit is in its quiescent state, transistor Q2 conducts current because of the connection of its base to the negative terminal of the DC supply through series resistor R1; transistor Q1 is biased in the opposite direction by resistor R2. Since capacitor C2 is now in a charged state, transistor Q1 remains off. Coil L1 makes up the collector load for transistor Q1. Enclosed within this coil is a very small magnetic reed switch, which has gold plated contacts and is encapsuled in glass. As the magnetic field of the coil increases from collector current, the switch snaps closed and remains so until the collapse of this field.

When a positive pulse is applied to the collector of Q1, this reduces the negative potential at the base of Q2 and reduces the charge on C2. Transistor Q1 begins to draw collector current through coil L1. The transition is rapid, Q1 switching on and Q2 off. The reed switch is now closed.

Immediately after this switching operation, Capacitor C1 begins to discharge and as it does, the negative voltage on the base of Q2 begins to rise once more toward the supply potential. At the end of this discharge interval, Q2 again is conducting and Q1 nonconducting, the quiescent condition of the circuit. As we begin to





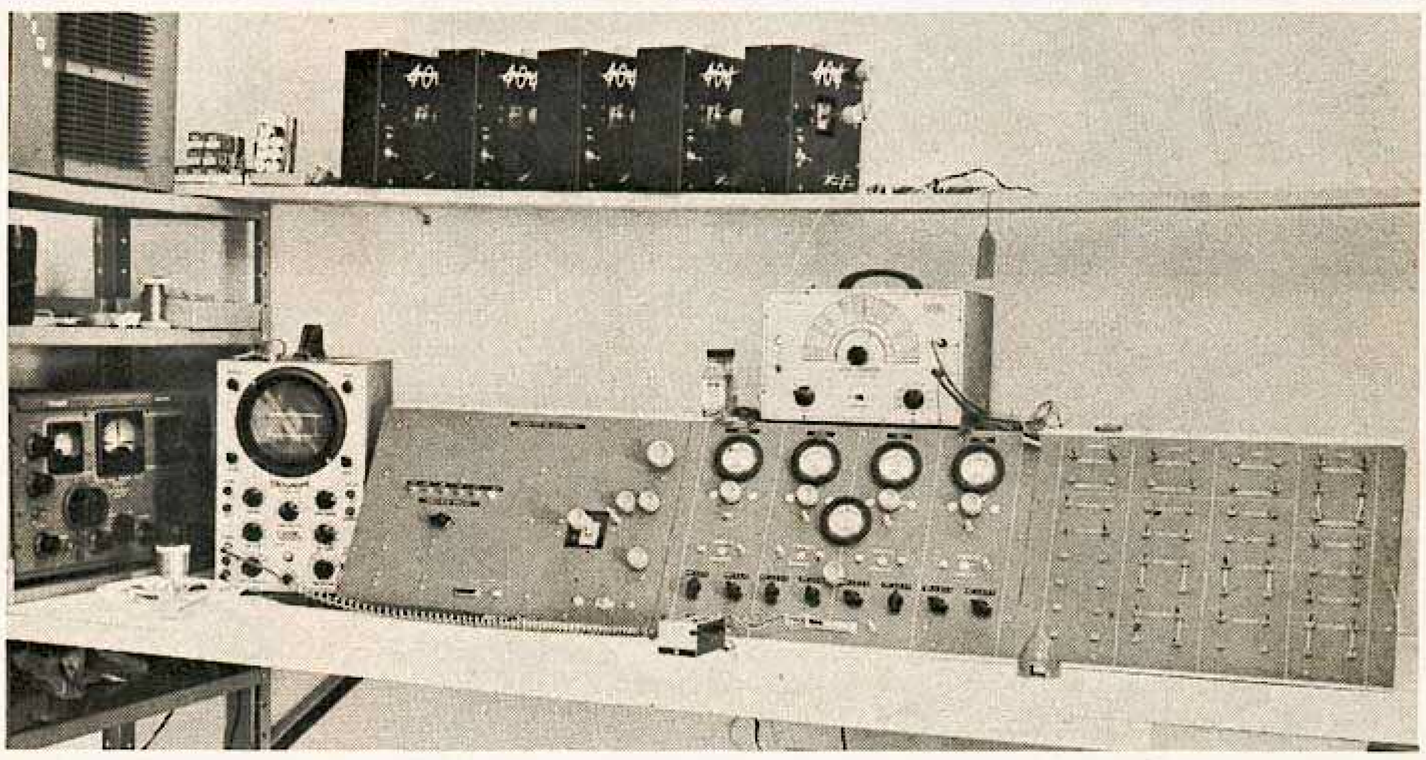
approach our quiescent state (Q2 on) a positive pulse is generated at the collector of Q2. This pulse is coupled to the second univibrator circuit by capacitor C3 causing it to flip-flop as did the first circuit when a positive pulse was applied to its collector. Each stage is coupled together as described and so the sequence begins. First, circuit one, then two and so on until the end of circuit four. Here we do the same thing. The final positive pulse is coupled back to the first circuit and the sequence is started over and the chain reaction continues endlessly. Since the flip-flops are not free running, a starting pulse must be applied somewhere to start the operational sequence. This pulse is easily provided by coupling B voltage through capacitor C13. When the start switch is depressed, this shock is enough to jolt the commutator into operation.

With the values indicated on the schematic, the commutator operates at an average of 25 pulses per second (samples per second); however, none of the multiplex systems is considered critical. Therefore, operation of the commutator from 15 to 40 samples per second would not impair the final performance.

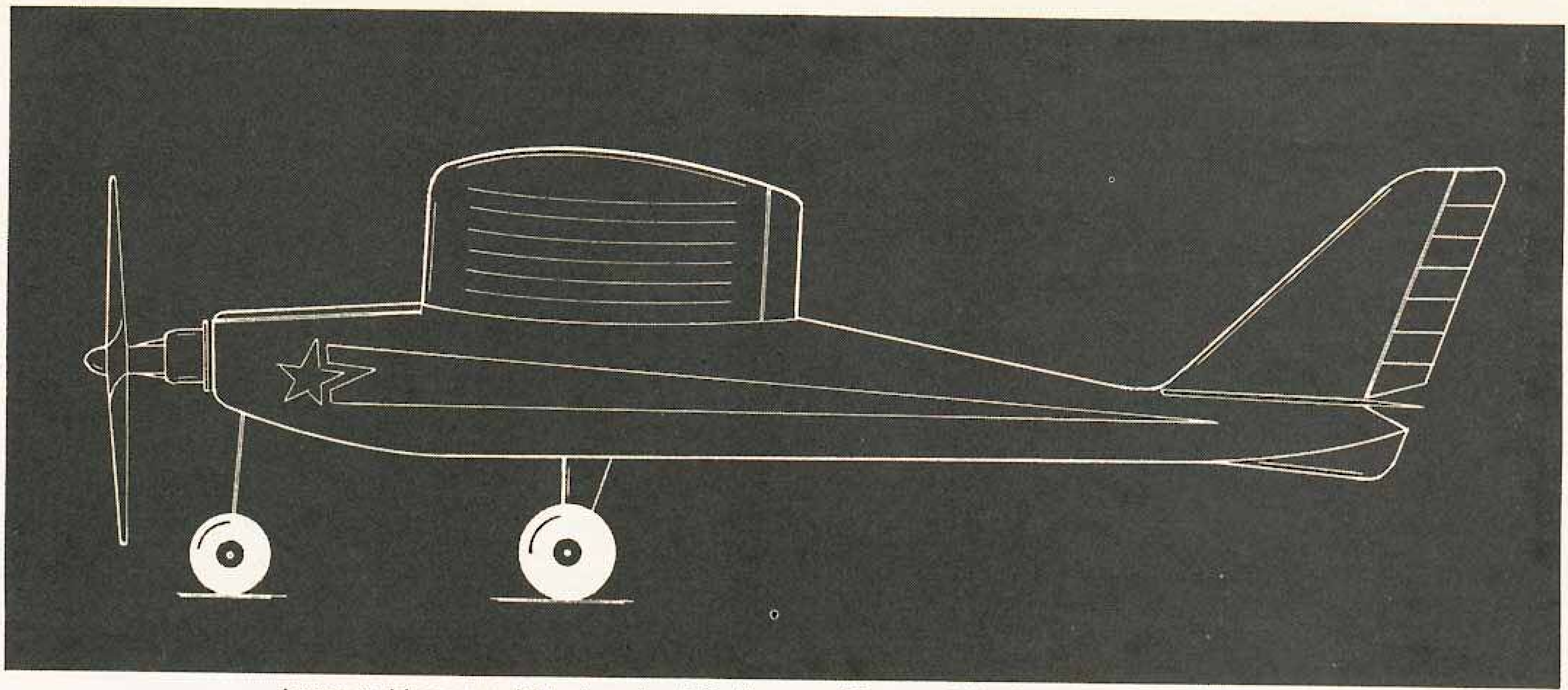
In the transmitter each control voltage is series connected through steering diodes which provide proper isolation for each voltage channel. Channel 1 (motor) does not pass through a switch. The reason for this is that the channel 1 is the lowest voltage and can be supplied directly since all other channel voltages are higher in potential. So, if channels 2, 3, or 4 are activated, they will override the motor channel voltage, although, it must be mentioned, that the motor control time interval still must be maintained by the commutator time sequence. By employing this method the need for an additional coil and reed switch are eliminated. All control voltages, after passing through the commutator, are connected to a common buss which is connected directly to the control oscillator circuit.

The control oscillator consists of a single voltage controlled electron coupled multivibrator circuit employing two 3V4 tubes. The derived frequency of this circuit is directly proportional to the quantity of applied voltage.

Multiplex Receiver Section: The purpose of this multiplex *(Continued on page* 29)



Proportional equipment must be carefully checked out. Shown is some test equipment.



Jenny rudder or multi trainer by deBolt: span 57, area 520, for engines .19 to .45.

Sampey on Proportional

(*Continued from page 7*)

receiver is the same as with any receiver except that in this case, there has been added a few extra stage discriminators. The first function of my receiver is to demodulate the incoming radio frequency signal. However, in the multiplex receiver no important circuit changes are required since one important feature of sequence transmission of each tone is the ability of the receiver system to maintain an effective 100 percent modulation for each channel transmitted. A second feature sidesteps the problem of audio harmonic generation that is present with systems transmitting more than one tone simultaneously.

The limiter stage of the receiver plays a very important function. It provides a constant output signal whether it be from plain noise or a high-powered 50,000 microvolt RF signal, even though AGC may be employed elsewhere within the receiver circuit.

From the limiter stage, the clipped signal is connected through series resistor R2 to the input buss of the four discriminator stages. Resistive coupling is used instead of capacitive coupling because the capacitor charging and discharging current would result in a transient bias on the input to the discriminators when the effective signal level changed.

The most important design consideration is the ability of the discriminator to select only the channel it is interested in and to retain, for a period of time, what information it has decoded. This is evident since each channel is provided with information only 25 percent of available time.

The clipped signal is applied through isolation resistors R4 and R5 to the two filters in the discriminator. Each of these filters are tuned so they will resonant at a given frequency. As an example, the center frequency of motor channel is 1150 cps. To provide discrimination filter L3 is tuned to resonant at 1100 cps. Filter 14 is adjusted to 1200 cps. When the input frequency is 1150 cps, there will be equal transfer of energy to the following stages by each filter. Or in other words, a balanced condition will exist. But if we shift the incoming motor channel frequency more toward the resonant frequency of L4, then L3 passes a smaller portion of signal than before, while L4 passes a larger amount of signal. To allow these filters to operate at their maximum efficiency, they are followed in the circuit by transistors Q20 and Q21. These transistors operate in a normal emitter follower circuit that provides a high impedance for the tuned filters. Transistors Q22 and Q23 provide the necessary amplication for their respective filters. Connected between the collector of these two transistors is potentiometer R12. Since Q22 is a PNP transistor, a negative potential is present on one side of R12. On the other side of R12 is a positive potential derived from NPN transistor Q23. With no input present to the discriminator, and R12 adjusted for a balanced condition between Q22 and Q23, the output voltage, is zero. As long as the input frequency applied is exactly between the filter resonant frequencies, the output voltage will still be zero. But, if we shift the input frequency toward the frequency of one filter or the other, it will shift the discriminator output voltage polarity proportionally. Electrolytic capacitors C1 and C2 are charged by the burst of incoming information that is passed by the filters and will remain in a near charged state, thereby allowing the circuit to retain a derived voltage over the time period between the frequency burst.

Servo System Section: A typical linear servo system is composed of an error-sensing circuit, amplifier, motor and load.

SUBSCRIBE NOW!

and Get Two Issues Free

Don't Miss a Copy in the Coming Months

R/C MODELER

Will Bring You

Plans · Articles · Exclusive Features · Photos

By the Biggest Names in Radio Control

12 BIG ISSUES

ONLY

$4.00

R/C MODELER • P.O. BOX 487 • SIERRA MADRE, CALIF.

☐ 1 YR. $4.00 ☐ 2 YRS. $7.50

NAME__________

ADDRESS__________

CITY__________ STATE__________

☐ REMITTANCE ENCLOSED ☐ PLEASE BILL ME