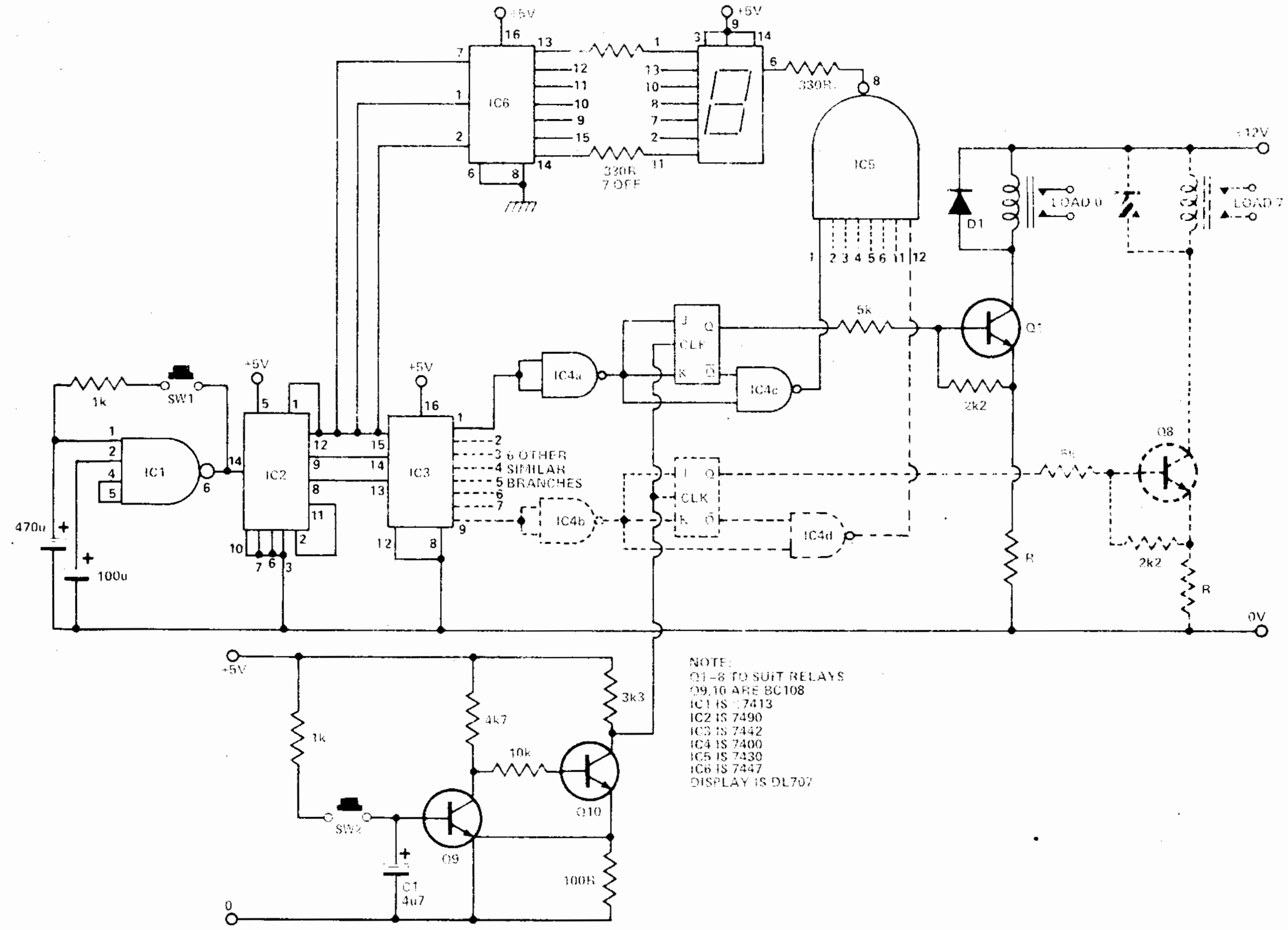
tech tips



NOTE:
Q1–8 TO SUIT RELAYS
Q9,10 ARE BC108
IC1 IS 7413
IC2 IS 7490
IC3 IS 7442
IC4 IS 7400
IC5 IS 7430
IC6 IS 7447
DISPLAY IS DL707

Electronic Switch

S. Yacu

This circuit provides remote switching of up to eight loads, and uses only two switches for selection. One switch is used to select the load to be controlled, the second controls whether the load is energised or not. If the state of one of the loads needs to be changed, SW1 is depressed until the number of the load appears on the 7-segment display. The decimal point then indicates whether or not the load is energised. To change the state of the load, SW2 is depressed (pressing SW2 again will change the loads state again).

The circuit is based on a 7442, 1 of 8 multiplexer and a 7490 binary counter. When SW1 is closed, the Schmitt trigger IC1 will oscillate and clock the 4-bit counter. This drives the 7-segment decoder and the 1 of 8 multiplexer. The outputs from the multiplexer are inverted and fed to the J-K flip-flops. When SW2 is pressed and released, a pulse will occur at the collector of Q10. The pulse will clock the selected flip-flop and activate or deactivate the relevant relay driver transistor (Q1-8).

An aerial rotator servo

by D. J. Telfer, A.R.I.C.

Lunar and Planetary Unit, University of Lancaster

This article describes a circuit for remotely adjusting angular displacements in a drive shaft, for use with 12–24V d.c. motors at continuous currents of up to 250mA. The system is well suited to a wide range of applications and has been very successfully employed as an automatic aerial rotator. The advantages of proportional control are available while preserving low cost and simplicity of design.

Sometimes there are applications in which the full potential of elaborate control equipment may not be fully exploited. In such instances, a less complex and more economical system could adequately perform the required operations. The control system to be described in this article is simple and yet has been found to be reliable in operation and particularly well suited for use in automatic aerial rotators. Although it was initially designed, while the author was with the Department of Physics, UMIST, for remote positioning of furnace charges, the circuit lends itself to many other possible applications, not least in the teaching laboratory as a technique for demonstrating the use of feedback systems and the principles of proportional control.

Proportional control system

A block schematic diagram is shown in Fig. 1. Use of a Wheatstone bridge to provide positive or negative error signals follows conventional practice. The spindle of one potentiometer RV_1 is mechanically coupled to the final drive (signified by the dotted line) and the other potentiometer RV_2 is the final drive position selector. A difference in the relative positions of the wiper arms of RV_1 and RV_2 produces an error signal which is amplified, firstly by the differential amplifier A_1 and then by an output stage A_2 connected to the motor, whose direction and speed depend on polarity and magnitude, respectively, of the voltage applied across its terminals. The final-drive shaft keeps turning until the wiper arm position at the motor-driven potentiometer catches up with the selected setting of the control potentiometer. The error signal is thereby continually reduced until the motor stops with the final-drive shaft in the desired position. In the author's design, operational amplifiers are used for A_1, and A_2 consists of two pairs of complementary emitter followers. An additional feature is the

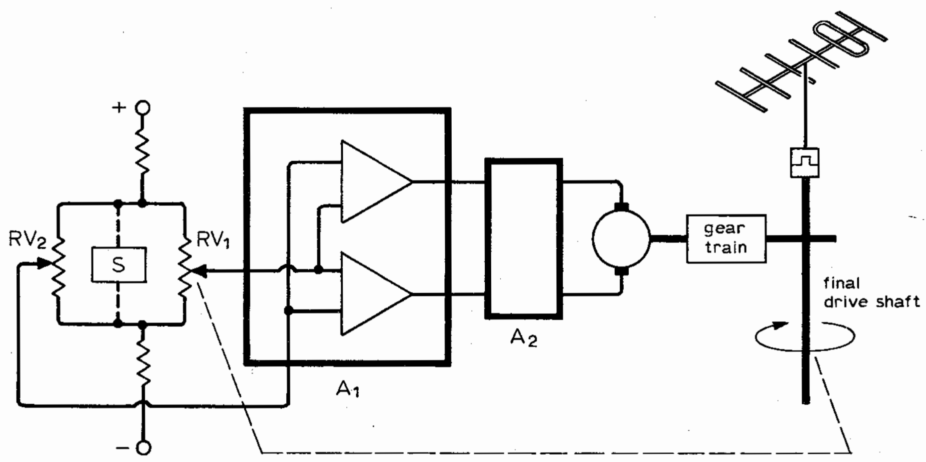


Fig. 1. Block schematic diagram of the proportional control system.

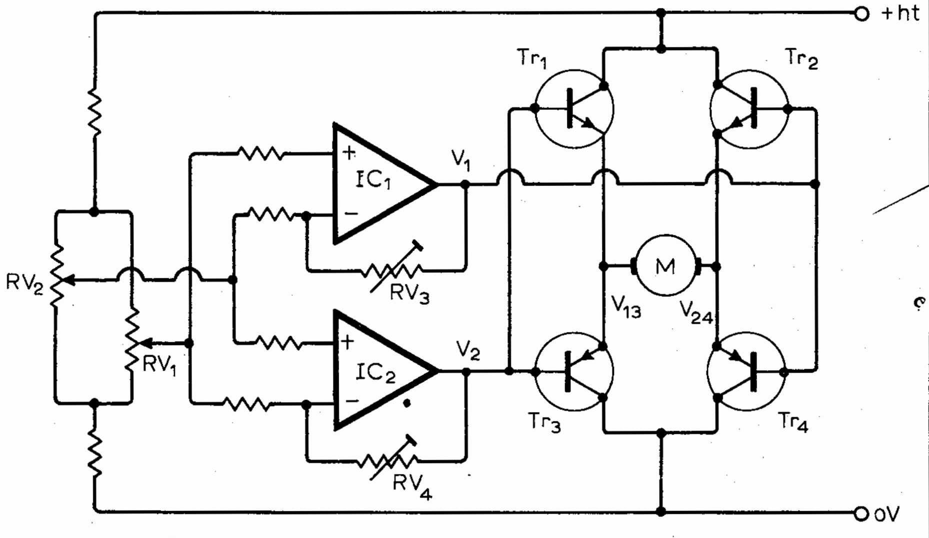


Fig. 2. The final drive shaft of motor M is coupled to the wiper arm of RV_1.

electronic bridge shunt *S*, which is activated at the final stage of operation to ensure that the motor is switched off.

Amplifier. In Fig. 2 the d.c. error voltage is taken to a pair of differential amplifiers IC_1 and IC_2, whose gain is adjusted with preset potentiometers RV_3 and RV_4 respectively. When the wiper arm of RV_2 is more positive than that of RV_1, the output of IC_1 goes negative and that of IC_2 goes positive. Under these conditions, Tr_2 and Tr_3 are turned off, while Tr_1 and Tr_4 are turned on, affording a low resistance path through which the motor is connected across the supply. If the wiper arm of RV_1 is more positive than that of RV_2, Tr_1 and Tr_4 are turned off and conduction is through Tr_2 and Tr_3, whereupon polarity of the voltage applied to the motor is reversed.

Proportional control. The mode of operation is conveniently described by assigning three states to the system. Fig. 3(a) shows how the output voltage of IC_1 (V_1) and of IC_2 (V_2) varies with angular displacement, θ, of the driven potentiometer spindle with respect to the setting chosen for RV_1, which is represented by $\theta=0$ at A.

In region D–C, the input signal is large enough to saturate both amplifiers IC_1 and IC_2. Motor voltage, which depends upon the difference between V_1 and V_2, is held at a maximum value. The final-drive shaft rotates at a constant angular velocity, and the spindle of RV_2 is driven towards the selected rest position that it will eventually ake up at A.

At an angle θ_2 from A, which is pre-termined by the setting of RV_3, the error ltage falls below that level required to turate IC_1, and V_1 steadily decreases. assage through C represents the onset of proportional control.

In the region B–A, amplifier IC_2 is no longer held at saturation. However, the setting of RV_4 is such that it has greater gain than IC_1. Its proportional control bandwidth, given by $2\theta_1$, is correspondingly narrower than that of IC_1. The value of $V_1 - V_2$ continues to fall, ideally reaching zero at A. If these conditions are faithfully transmitted to the motor, there is no residual current in the windings and the final-drive shaft comes to rest with the spindle of RV_2 exactly in the position determined by RV_1. In practice, the motor may stop when an appreciable voltage is still being applied to its terminals. Since at B the value of $V_1 - V_2$ is just over half its maximum value at C, this event will be captured within the narrow region BA, provided that mechanical loading is not xcessive and that the motor is not severely under-run. Although the author has experienced no difficulty on occasions when 24V motors were run using a 12V supply, it is recommended that the h.t. voltage should be at least 60% of the voltage rating for the motor.

The output voltages of IC_1 and IC_2 are not transmitted faithfully to the motor because of the emitter-base voltage drop incurred at the power transistors. In Fig. 3(b), the emitter voltages of transistor pairs Tr_1, Tr_3 (V_{13}) and of Tr_2, Tr_4 (V_{24}) converge to plateaux centred at A. The difference between V_{13} and V_{24} is therefore the voltage applied to the motor. However, the range of θ values over which the motor is stationary, SAS′, may be compressed by increasing the gain of IC_2. This will not affect the overall proportional control bandwidth of the system, which is given by $2\theta_2$, and is dependent on the gain of IC_1.

Protection of transistors. Quite low values of residual voltage across the motor can give rise to standing currents high enough to justify an automatic switching arrangement for protection of the conducting pair of output transistors, which will dissipate maximum power just before they become biased to cut-off, when the emitter-collector voltages approach their highest values. The motor may be made to cut out below a certain applied voltage, within the region BA of Fig. 3(b), by connecting a suitable relay across the motor. For example, a motor rated at 24V maximum was run with 20V on the h.t. rail of the circuit. Satisfactory action was obtained from a reed switch having a solenoid resistance of 800Ω, operating at 7V.

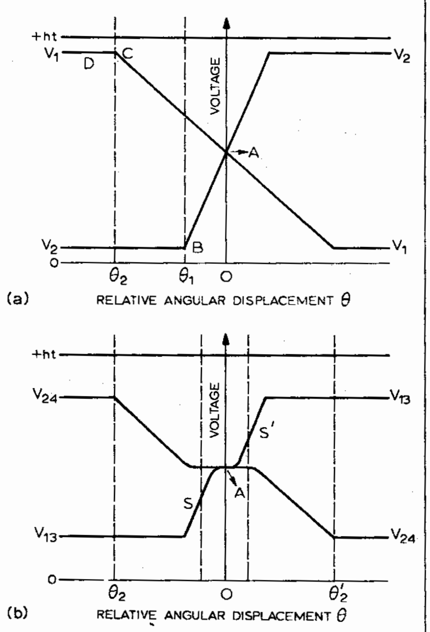


Fig. 3(a). Voltage at IC outputs plotted against θ; at (b) is shown the voltage at emitters of power transistors plotted against θ. Limiting voltage of the motor is reached at S and S′.

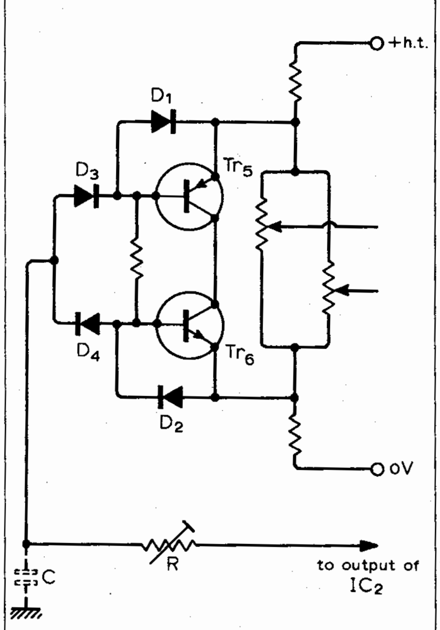


Fig. 4. Circuit diagram of bridge shunt.

Any such cut-out device must come into operation before the motor has actually stopped, resulting in a dead zone about A in Fig. 3(b) which is greater than SAS′. This state of affairs may be avoided by introducing a time delay so that the motor can stop at its limiting voltage before being switched off.

An alternative switching method, incorporating a delay, is shown in Fig. 4. This solid-state approach, which the author has found to be very effective, uses a complementary pair of transistors shunted across the bridge potentiometers. Conductance of the transistor pair Tr_5 and Tr_6 is appreciable only when both base voltages are within a limited range centred on half h.t. potential. The state of this circuit may first be considered with the input diodes D_3 and D_4 disconnected from the output of IC_2.

The bases of Tr_5 and Tr_6 are connected by a resistor through which most of the mutual base current will flow, since D_3 and D_4 are reverse-biased by the small potential difference reflected across this resistor. Base bias is forward at both transistors, which conduct and act as emitter followers. Their mutual load is the bridge, across which the voltage falls to a value approaching the sum of the voltages across the interbase resistor and the emitter-base junctions. In practice this total amounts to about 2V.

Next the connexion of D_3 and D_4 to the output of IC_2 is restored, via a limiting resistor *R*. No significant change will occur at the bridge shunt until the small reverse bias voltage at either D_3 or D_4 is cancelled by a voltage swing at IC_2, transmitted through *R*. When the output of IC_2 goes sufficiently positive, conduction through Tr_6 is maintained but Tr_5 is cut off. Conversely, Tr_5 conducts and Tr_6 is turned off during negative excursions. The diodes D_1 and D_2 protect Tr_5 and Tr_6 from Zener breakdown of their base-emitter junctions under reverse biasing conditions.

Finally, the onset of shunting action is delayed by introducing a capacitor *C* between the input of the shunt circuit and ground. A suitable choice of time constant for *RC* is about one-fifth of the duration of the proportional control régime.

Practical circuit

The circuit diagram of a practical design for use with 24V d.c. motors appears in Fig. 5. An electronic bridge shunt is employed and the unit may be run from a 15 to 28V supply. Feedback capacitors are included to lower the a.c. gain of the operational amplifiers in order to reduce transient response and provide a safe-

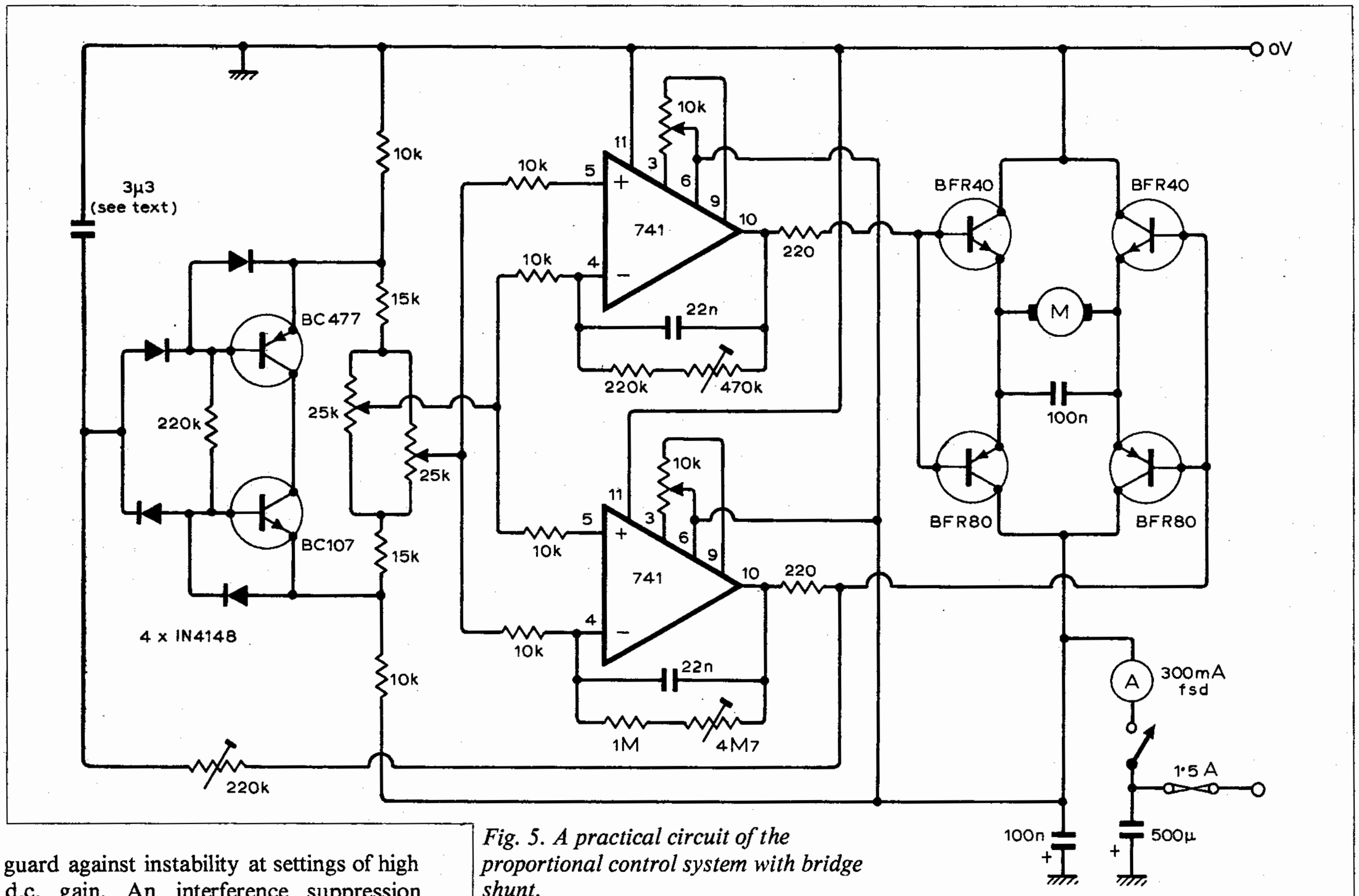


Fig. 5. A practical circuit of the proportional control system with bridge shunt.

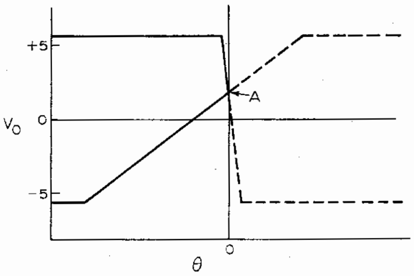


Fig. 6. Illustrating the effect of displaced crossover point A on the symmetry of the proportional control characteristics. Amplifier output voltage V_o has its zero of voltage reference at half h.t. potential. The zero axis of θ represents here the situation when both wiper arms are at the positive end of the bridge.

guard against instability at settings of high d.c. gain. An interference suppression capacitor is also connected across the motor terminals. Inclusion of offset null controls (the 10kΩ potentiometers) is recommended. Adjustments are carried out with the wiper arms of the bridge potentiometers brought to the centre of their tracks and then short circuited together. The offset null potentiometers are then set to give an output of exactly half h.t. potential at each operational amplifier.

A panel meter for monitoring the behaviour of the motor is a useful asset. Total current may be measured, as shown in Fig. 5, or, alternatively, motor voltage or current may be displayed, using a centre-zero instrument to follow directional changes.

The power supply should be capable of delivering 1A at the operating voltage and be well smoothed. Otherwise, requirements are not critical.

Performance. Operation with the bridge shunt is not critically dependent upon supply voltage, so long as the input capacitor value fulfils the time constant requirements mentioned above. Fine adjustments may be made with the 220kΩ preset potentiometer, which is normally set near mid-range. Efficacy of the shunt is improved if bridge resistance is high compared to the value of resistance presented by the shunt during its turn-on period. However, the values of bridge circuit resistors shown in Fig. 7 were found to be more than adequate and may be considered to represent an upper practical limit above which the performance of the differential amplifiers becomes adversely affected. This arises because of the differences in d.c. input resistance of the inverting and non-inverting inputs, and variation in amplifier gain with wiper arm position at the bridge potentiometers. The operational amplifiers see highest source resistance, and experience concomitant reduction in gain, when the wiper arms are near track centre. In this region, therefore, the proportional control bandwidth becomes relatively expanded.

Measurements of amplifier output voltage were made with the bridge wiper arms positioned at similar track intervals and then shorted together. Experimental conditions and data are summarized in Table 1 for an h.t. of 15V and feedback resistors of 680kΩ (IC_1) and 4.7MΩ (IC_2). The behaviour pattern shown in Fig. 6 represents the situation with the wiper arms at the positive end of the bridge. The crossover point did not deviate markedly from the $\theta=0$ axis, but was displaced in voltage, being more positive than the half-h.t. potential axis, which is taken as the zero of voltage reference. At the negative end of the bridge, an approximately equal negative displacement relative to a centre offset potential of 0.25V was observed. The bridge shunt was removed during these measurements, which confirmed that the effective common mode gain of the amplifiers was near to unity. This tends to produce a degradation in symmetry of the proportional control characteristics, which change progressively from one end of the bridge to the other. Therefore, the ratio of voltage across the bridge to peak swing at the amplifier outputs should not exceed 0.15 if good symmetry is to be preserved.

	Deviation of output voltage from half-h.t. potential		
	positive end of track	centre	negative end of track
IC_1	1.9V	0.25V	−1.5V
IC_2	2.0V	0.25V	−1.5V

Voltage reflected across the bridge is directly proportional to the supply voltage whether or not the bridge shunt is used, so that proportional control bandwidth at given gain settings remains practically constant above 20V h.t. At lower h.t. voltages the discrepancy between peak output swing of the operational amplifiers and the supply voltage must be taken into account. During conduction, approximately 1.5mA base current flows at the power transistors. This loads the amplifiers sufficiently to produce a total discrepancy of about 1.5V. As the supply voltage is reduced, there is little change in this value, but its effect in decreasing the bandwidth becomes more noticeable.

In addition, the difference between h.t. and peak motor voltage amounts to approximately four volts, and this becomes an important consideration when using the circuit to drive motors at lower peak voltages.

Circuit properties are considered further in the light of other practical experiments. A small 24V d.c. motor (see Fig. 4) was connected to the circuit of Fig. 7, which was operated at 24V h.t. and with fixed feedback resistors; 330kΩ for IC_1 and 4.7MΩ for IC_2. Maximum potential across the bridge was 3V, falling to 0.7V at cut-off, when the motor current was reduced to less than one microamp.

An *xy* plot of motor voltage against amplifier input voltage V_i measured at the bridge wiper arms is presented in Fig. 7. Total proportional control bandwidth CC′ was 82 degrees, centred at mid-scale, for a driven potentiometer electrical rotation of 280 degrees. The bandwidth of IC_2 was seven degrees, giving a practical dead zone of ±2.5 degrees for a limiting motor voltage of 3V.

Potentiometer drive. There are various possible mechanical arrangements at the bridge potentiometers, and only the rotary type is considered. To cover rotation through a complete circle, a 360-degree potentiometer with 1:1 coupling is required at the final-drive shaft and also at the control box. Alternatively, the more usual pattern with electrical rotation in the region of 280 degrees may be used in conjunction with pulley, chain or gear coupling of the correct ratio. If the absence of a 90-degree sector from the rotation range can be tolerated, direct 1:1 coupling may be retained, as in the rotator.

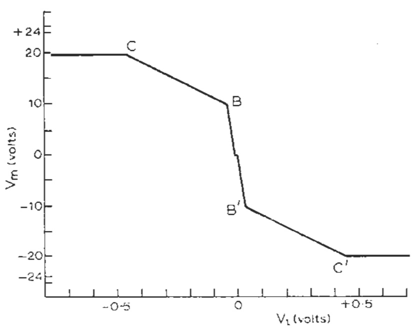
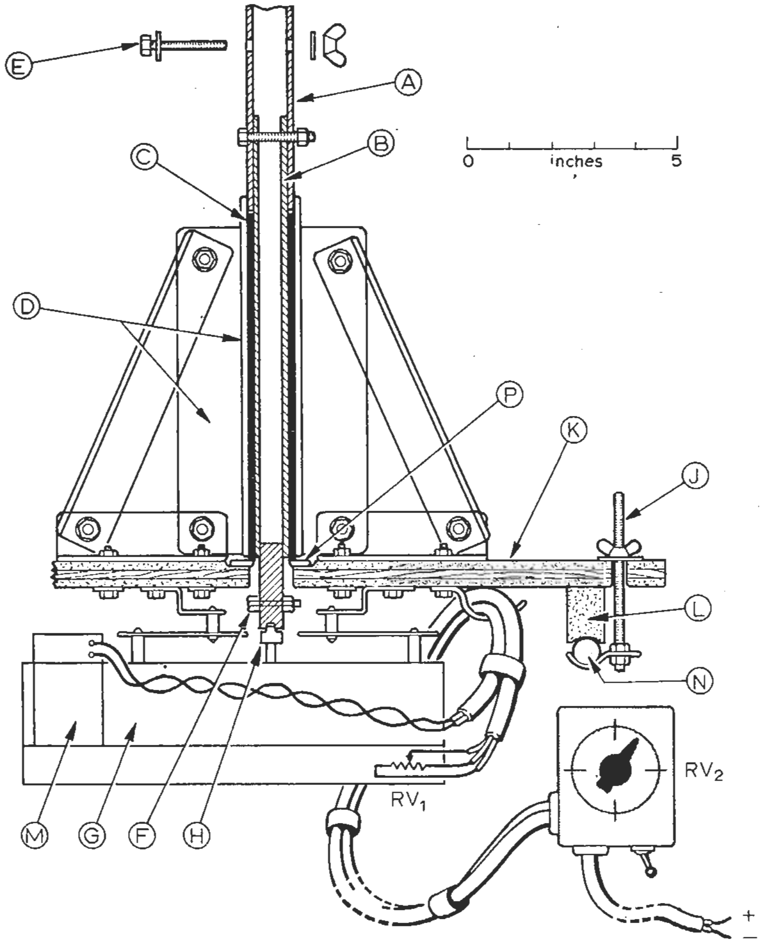


Fig. 7. XY recorder plot of motor voltage V_m against input voltage V_i.

Fig. 8. Schematic diagram of portable aerial rotator. Material is mild steel unless otherwise specified. Tubing is of $\frac{1}{16}$-in wall thickness. Nuts and bolts are steel, $\frac{1}{4}$-in BSF, except those fastening the gearbox support bracket to the deck, which are 2BA.



Aerial rotator

In point-to-point v.h.f. and u.h.f. communication, well-sited portable equipment incorporating a low-power transmitter can be capable of very encouraging results, particularly if a high-gain directional aerial is used, in conjunction with a reliable and accurate means of turning the mast. In aerial rotator applications the servo system may be used in conjunction with a variety of mechanical arrangements, depending on the requirements of the operator.

Basic construction of a portable aerial rotator for mounting on the roof-rack of a stationary vehicle is shown schematically in Fig. 8. The drive unit is readily demountable and an alternative type may be fitted if desired; Fig. 9 shows how the gearbox adapted by the author was installed. This was part of an ex-government switching unit having rubber mounting bushes and a 24V d.c. motor coupled to the final-drive shaft through 625:1 reduction gearing.

Removal of the lower cover plate exposed the switch wafers, which were then discarded to allow a feedback potentiometer to be coupled to the final-drive shaft through the 1:1 gearing as illustrated. Drive was transmitted to the mast through a simple dog clutch. A similar arrangement was employed at the potentiometer spindle, into which a slot was cut to accommodate a blade filed on the end of the coupling shaft. Although the potentiometer could have been mounted in a carefully positioned hole drilled in the lower cover plate, compactness was preserved by fixing the potentiometer case to the inside of the cover plate with soft solder, in the position shown. In order to mount the component in this way, the threaded part of the spindle collar was shortened. The spindle was of nylon to minimize damage in the event of accidental servo overruns at track limits.

Above the deck, short lengths of mild steel slotted angle were bolted together to act as a support for the vaned tube containing the aerial mast socket bush (Fig. 8). Grease was applied liberally to the mast socket bearing before fitting it to the bush. Positioning of the lower retention bolt allowed the mast socket assembly to be lifted just clear of the gearbox dog to permit easy and rapid alteration of the aerial reference direction by 180 degrees. An upper retention bolt was also fitted to secure the mast. Steel J-clamps were used to firmly fasten the rotator to a secure vehicle roof-rack (Fig. 10) and dimensions of the grooved mounting blocks were adjusted to suit the type of rack. Protection from the weather was afforded by fitting an aluminium cover over the gearbox and applying paint to external surfaces.

Upper torsional limits for the above

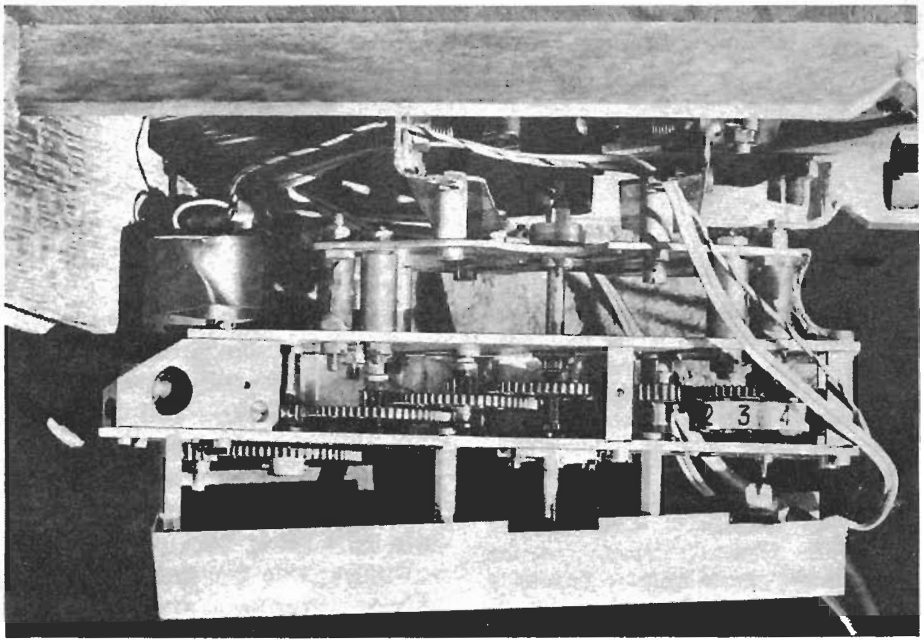


Fig. 9. Underside view of rotator showing adapted gearbox unit with lower cover plate detached to expose the feedback potentiometer (bottom right). Final drive shaft and dog clutch are in the centre, with the motor at left centre.

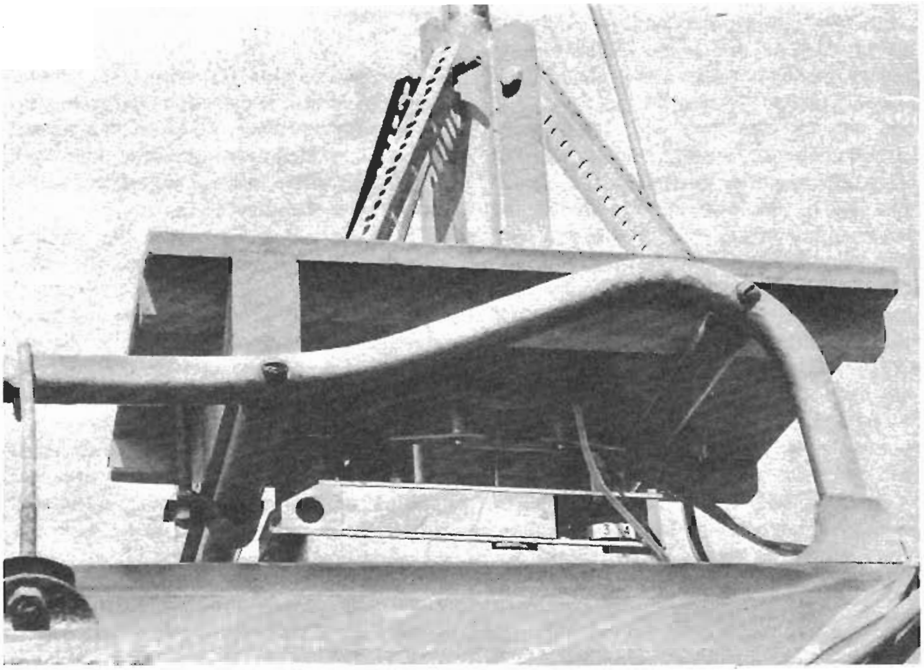


Fig. 10. Rotator secured to horizontal roof-rack bars.

gearbox were approached in normal weather conditions with an eight-element conventional Yagi array cut for the two-metre amateur band, which was supported at its centre of gravity on a five-foot mast. Aerials of greater physical size were not considered practicable on a free-standing mast fixed to this type of rotator.

Mechanical backlash in the blade and slot feedback potentiometer coupling has the effect of allowing the aerial to overrun its selected heading, but by judicious use of the relative sizes of blade and slot, can be made to correct any slight lag which may otherwise be present.

Feedback and control potentiometers should preferably have a linearity better than 2%, and the system be calibrated before operation.

In practice, the portable rotator has performed with consistent reliability in conjunction with the control unit described. Aerials have also included a 16-element aerial for the 70cm amateur band, using a five-foot mast.

When the portable rotator was used with the above proportional control unit, time taken for complete rotation of a 2m eight-element Yagi array was about 20s at 15V h.t.

Circuit assembly. Components in the prototype were mounted on a $2\frac{1}{2}$in square piece of 0.1in matrix Veroboard, in a $4\frac{1}{2} \times 3\frac{1}{2} \times 2$in diecast box, with the control potentiometer and dial on the largest face. A five-cored cable from the motor and driven potentiometer was plugged into a DIN socket on the control box, allowing different motor units to be activated.

If the motor connections are reversed, an aerial rotator will become an automatic beam heading avoider. Care must be taken to connect the control and driven potentiometers in the correct sense, and to prevent mechanical damage to the latter component, operational checking should be carried out with both wiper arms near track centre.

Other applications

In common with other proportional control systems, the above design commends itself to a wide variety of possible functions. Simple modifications may greatly extend its range of capabilities.

By connecting a suitable amplifier (such as another 741) in place of the driven potentiometer, the system may be coupled to external probes or sensors. For instance, the e.m.f. across a thermocouple junction may be used for remote automatic positioning of a furnace charge. Position is manually pre-set with the control potentiometer.

If the driven potentiometer is mechanically disengaged from the motor, the unit becomes a manually adjustable reversible motor speed controller.

Law and insurance

It is of the utmost importance to ensure that, as a load attached to a vehicle roof-rack, the rotator and aerial conform to legal requirements.

There must be no danger to people inside or outside the vehicle. On a public highway the aerial and rotator also become illegal if any part extends beyond the front, rear or sides of the vehicle by more than 12in.

Any effect that the presence of the aerial and rotator may have on the vehicle's insurance should be ascertained.

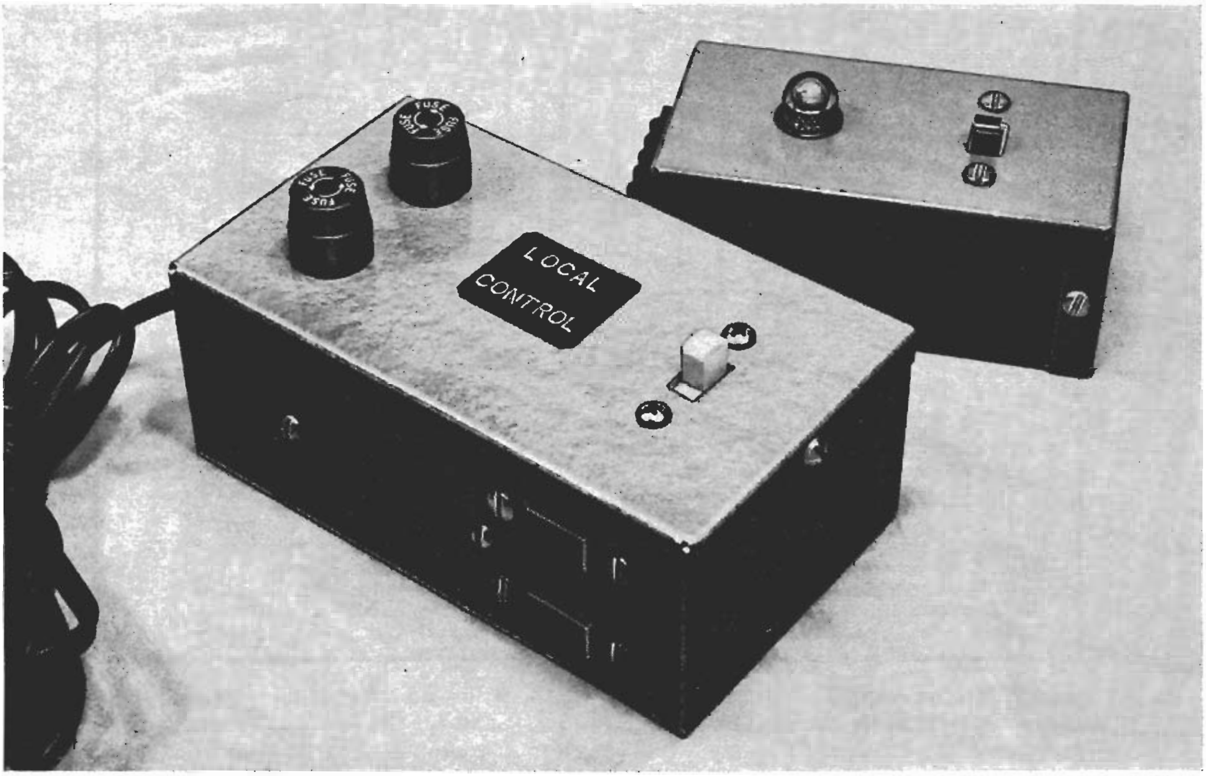
The author has found that the authorities are very willing to help in these matters, and if the operator has any doubts about his position, he should not hesitate to seek advice from the Traffic Department of the local police.

Suppliers

Transistors and integrated circuits were obtained from Texas instruments. Minimum size of heat sinks for the power transistors will depend on circuit applications, and manufacturer's literature should be consulted. For the rotator, the TO-92 plastic encapsulation may be bonded to the diecast box with epoxy adhesive.

The surplus gearbox unit, and also separate d.c. motors, were obtained from North West Electrics, 769 Stockport Road, Manchester.

An extensive range of small gearboxes is manufactured and supplied by S. H. Muffet Limited, Mount Ephraim Works, Tunbridge Wells, Kent. For driving the rotator, the author recommends that a unit is chosen with an output ratio of 500–1,000 which is capable of delivering at least 30lb. in. continuous torque at the output shaft.



LOW-VOLTAGE
Remote Power Control

AVOID SAFETY PROBLEMS AND COSTLY REWIRING

BY NEIL JOHNSON

MOST HOUSES and apartments come with an adequate (if you're lucky) wiring system already concealed within the walls and floors. There usually comes a time, however, when what you have isn't enough and you need a two-way switching system for remote control.

The first thing that comes to mind is a conventional two-way circuit that involves running a pair of power-carrying leads from the remote to the local switching point—sort of a super extension cord. Such a system is definitely out, since you are creating a real safety hazard, not to mention violating the National Electrical Code and running the risk of making your insurance man very unhappy.

Of course, you can always hire an electrician and do the thing properly; but you may not want to spend that much money—and there is a way out, for less than $10.

The secret of this remote power switching unit is a step-down transformer that also contains a relay. It is perfectly safe to run low-voltage, low-current wiring around the house without elaborate protection—the high-power portion of this system is located as close as possible to the 117-volt outlet. A typical circuit using the transformer relay is shown in Fig. 1. The relay contacts can handle up to 600 watts at 120 volts ac, but the control winding is safely isolated from the power

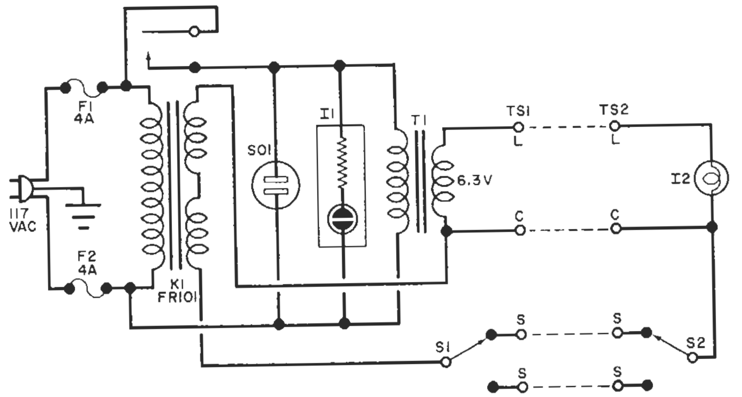


Fig. 1. Relay K1 also contains a step-down transformer. Wiring to I2 and S2 is low-voltage type. Power can be switched from either end of circuit.

PARTS LIST

F1,F2—4-ampere fuse and holder
I1—117-volt neon indicator lamp
I2—6.3-volt indicator lamp
K1—Remote control isolation relay (ALCO FR-101, Lafayette 30F12002)
S1,S2—Spdt slide or toggle switch
SO1—120-volt ac chassis mounted outlet
T1—6.3-volt, 1-ampere filament transformer
TS1, TS2—4-terminal barrier strip
Misc.—Suitable enclosures (2), length of 4-wire cable (Belden 8741 or similar), 3-lead ac power line, mounting hardware.

line. When the control winding has a very low resistance in its circuit, there is sufficient pull-in power in the relay winding to close the contacts.

The system is divided into two sections: (1) the high-power circuit with transformer, relay contacts and the component to be controlled (plugged into SO1); and (2) the low-power remote section containing a switch and indicator lamp. A conventional 4-wire intercom cable can be used for the connections to the remote circuit. If 4-wire intercom cable

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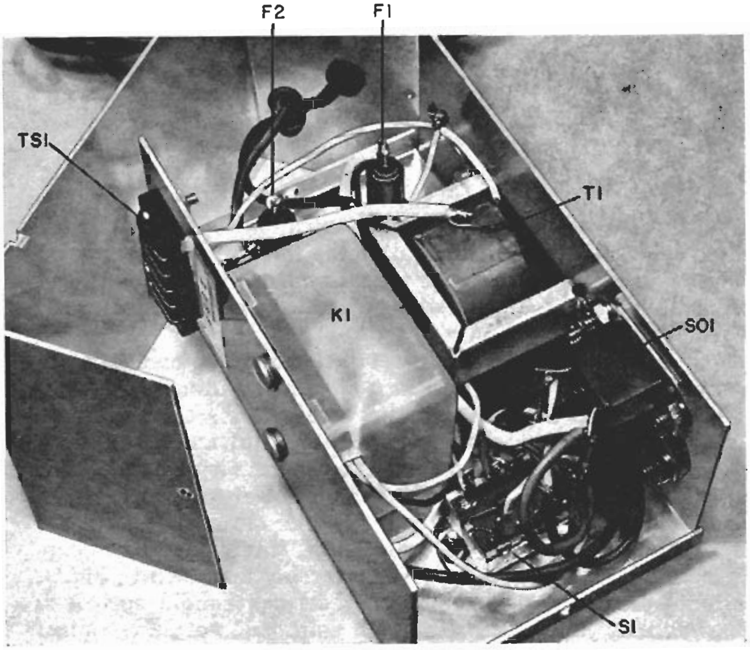

Enclosure for power unit must be either non-metallic or units must be properly insulated to avoid contact. Both sides of power line are fused with ground conductor connected to chassis.

Remote Control Power Switching using Speaker Cables

by R. A. Joss

It is not unusual in complex home hi-fi installations to have several sets of speakers. In my system there are two in the main living room, two in the downstairs TV room, two in the upstairs bedroom, one in my daughter's bedroom, and one in the laundry chute! The bedroom speakers are great for late-night listening to FM, but there used to be one unfortunate drawback. When the time came to go to sleep, someone had to desert a nice warm bed, don bathrobe and slippers, and trudge down the corridor to Command Central to turn off the hi-fi.

A number of remote switching techniques were investigated, such as the gadget that shuts off the system when the record changer switches off (which doesn't do anything for FM listening); the Audio Robot, which wasn't on the market very long and which I couldn't understand anyway; and a long AC extension cable which I didn't trust because of the high power consumption of the system, the excessive distance from the bedroom to the power amplifier and an unwillingness to string more cables to the bedroom.

So it was decided to use some sort of relay control, using the return speaker wires to carry the control voltage. The speaker wiring consisted of a 4-conductor Belden cable neatly fastened along the baseboard and connected to the Dynaco Stereo 70, one each to the two 8-ohm taps, and one each to the two ground connections. Various electrical and audio experts were consulted, who kept talking about "latching relays" worked by 6-volt batteries and similar meaningless (to me) things, but I have one simple tenet of faith—if I don't understand it I don't do it—and I was almost ready to give up, until . . .

Until one day I happened to have a room in a Toronto motel which had a Philco TV set, and, lo and behold, a little rocker switch on the headboard of the bed marked "TV-on — TV-off." Sure enough, this switched the set on and off from the bed, and was obviously what I was looking for. I couldn't determine the manufacturer of the switch but a letter to Philco Canada brought the prompt reply that switch and relay were simply stock General Electric low-voltage house wiring components and maybe G.E. could help me.

The author's hi-fi system is attractively built into an otherwise unused part of his home. It consists of:

Sources:
Scott LT-111 FM Stereo Tuner
Seabreeze SB-1000A AM Tuners (2)
Muset TV Sound Tuner
Ampex 960 Tape Recorder
Grado Model B Cartridge in AR tonearm/turntable combination
Shure M3D in Garrard Type A Mk II Record Changer
Ronette R-88 with voltage step-down network in spare Garrard plug-in shell for 78's.

Heathkit Model 681 Color TV
Source Selection and Pre-Amp:—Dynaco PAS-3

Power Amplifier: . . . . Dynaco Stereo 70
Speaker Selector: . . . . . . Olson SW-234
Speakers: AR-2X (2)
University Diffusicone (1)
ITT R. 888 (2)
unidentified (3)

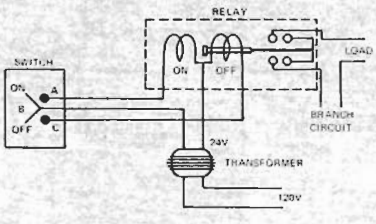

Figure 1

Parts List (all GE part numbers)

Remote switch — RFS-6 in RA-13 surface mount

Local switch — RFS-6 in RP-1 wall mount

Relay — RR-3

Rectifier — RA-9

Transformer — RT-5

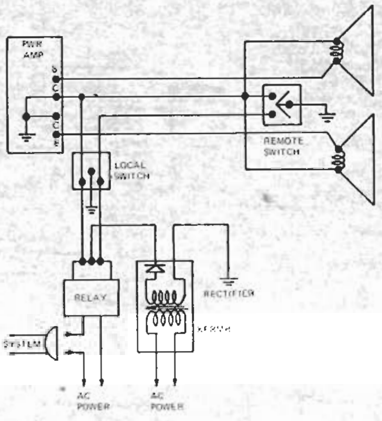

Figure 2

They could and did, my original inquiry being answered by return, with a one-dollar architect's manual enclosed, free of charge. ("Remote Control Wiring," Reference AIA File No. 31-D-47, from Wiring Device Dept., GE, Providence, R.I., USA.) The manual explained the whole philosophy of G.E.'s approach to the low-voltage control of power circuits, and being written for architects, I as a chemical engineer had no difficulty whatever in understanding the well-prepared diagrams. I now set out to adapt their hardware to my own needs. The principle of low voltage control is shown on the attached reproduction from the G.E. manual (Figure 1). Obviously, three wires are required —one source wire and two return

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Remote Switching *(from p. 16)*

wires. Connect B to A and you switch on—connect B to C and you switch off. In the normal position of the switch, no current is drawn. Now I had two wires available, the two *from* the speakers to the amplifier grounds, but an investigation of the Dynaco schematic indicated that the two ground terminals in the amplifier were internally connected, meaning that my two return wires were not electrically independent.

I stewed over this for a while and various schemes were concocted including breaking one of the ground connections from one of the Dynaco transformers but when queried as to the feasibility of this, Dynaco replied by return to the effect "Keep your cotton-picking fingers out of our fine equipment, you'll mess up the feedback". Not knowing just what effects messing up the feedback would have, and not really being prepared to underwrite the experiment, I returned once more to the drawing board.

Suddenly a great light dawned. If the two return wires wound up internally connected at the amplifier, only *one* return wire was really needed, since both speakers could use a common return wire, thus freeing one of the four wires for other purposes. This still only gave me two of the three wires I needed however, since I didn't relish the idea of passing a 24-volt signal through the voice coil of either speaker. Well, when all else fails, consult an electrical power man. He quickly pointed out that I had another common circuit throughout the house—the ground side of the AC wiring.

The rest was simple mechanics. The equipment was purchased from one of G.E.'s wholesalers, and connected up as shown in the final diagram (Figure 2). A switch was installed near the hi-fi, and another on the headboard of the bed. It worked exactly as predicted—there is a slight hum in the speakers when the "off" button is pressed—but aside from that I can enjoy the intensely sybaritic luxury of lounging in bed and turning the system on and off at will. In addition, extra switches can be installed at any of the speaker locations for remote switching from any of the listening areas.

Now if there was only some way of remotely selecting different stations on the FM tuner . . . ■

Remote Control Switching

Dear Sir,

Re your October article on "Remote Control Power Switching Using Speaker Cables" by R.A. Joss. The system won't work because one of the return wires on the relay is always grounded to the amplifier's "C" terminal (page 16, figure 2). This way the system will always stay in the "on" or "off" state depending on the relay hook-up.

Louis Andre,
Alouette, Que.

It certainly looks like that but in fact the system does work. The problem is in a small matter of symbols. The relay return wire is not grounded as it appears to be because the ground shown inside the amplifier is actually a chassis ground. It is independent of the other grounds, which connect to the ground wire in the ac system. The diagram should have been drawn like this: