An experimental trainer for counter-mortar operators

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RADIO AND ELECTRICAL ENGINEERING DIVISION

AN EXPERIMENTAL TRAINER FOR COUNTER-MORTAR OPERATORS

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OTTAWA

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ABSTRACT

This report presents an outline of the operating procedure and a brief technical description of a counter-mortar trainer currently under development. As yet, the equipment is more or less in breadboard form, but it appears that a final model, because of its simple circuitry, should occupy only about three cubic feet of space and weigh less than 100 pounds, exclusive of service packaging. Simulation of any mortar velocity or mortar trajectory is possible.

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AN EXPERIMENTAL TRAINER FOR COUNTER-MORTAR OPERATORS

C.R. Clemence

INTRODUCTION

1. This trainer is being developed as an aid to operator training in connection with the AN/MPQ-501 counter-mortar radar. It appears that the most difficult part of operating any of the two-beam counter-mortar radars currently being produced is in marking the position of mortar echoes on the cathode-ray tube and timing their interval. To date, it has been impossible to assess accurately this operator error which normally contributes a significant part of the total error in a mortar location. This trainer will allow student operators to be trained in this aspect of the drill without the expensive and slow procedure of having to fire mortars on a firing range. In addition, it provides a possibility not only of determining the individual student error but also of selecting personnel who can reduce this error to a minimum.

EQUIPMENT REQUIRED

2. At present the equipment consists only of parts necessary for simulating the bomb echoes, marking, and timing. These are:

a) a cathode-ray tube and high-voltage power supply;

b) calibrated controls for pre-setting the position of the simulated echoes;

c) a calibrated rate-controlled motor and cam device which causes the echoes to move across the cathode-ray tube;

d) an echo generator by means of which the size and shape of the simulated echo may be optimized;

e) appropriate d-c power supplies;

f) a hand-switch and calibrated dial for student timing;

g) a foot-switch to simulate insertion of differential data.

OPERATION

3. The operation of the equipment is as follows:

The instructor sets up the controls A_1 R_1 and A_2 R_2 (Fig. 1) as coordinates of the lower and upper beam intercepts, respectively. The voltages from these helipots are expanded in the amplifiers and applied to the student's cathode-ray tube by means of the flasher microswitch and hand control, in such a manner that the spot on the cathode-ray tube travels across the tube as an actual mortar-bomb echo does when it passes through the two beams of the radar. The dial readings of the calibrated controls A_1 R_1 and A_2 R_2 now represent the centers of the lower and upper beam, respectively. The speed of travel of the "echo" may be controlled by means of the rate servo and a potentiometer (50K) calibrated directly in time interval from about one second to six seconds. The cam is cut to represent a one-degree beam width and actuates the flasher microswitch accordingly. With this arrangement, the "echoes" may be placed anywhere on the cathode-ray tube and may travel any desired amount in any desired direction with a pre-set time interval.

As the echoes appear on the cathode-ray tube the student marks and times them as he would with the actual radar, and the instructor moves the "instructor-student" switch to "student" causing a spot representing the marker to appear on the cathode-ray tube. This spot is controlled by Azimuth and Range handwheels as shown in Fig. 2, which are geared to counters, and the spot may be moved to the marks representing the simulated bomb echoes. The counters and time dial are then read and compared with the pre-set values of A_1 R_1, A_2 R_2, and pre-set time to check accuracy of marking and timing. A foot-switch is provided for simulation of insertion of the differential quantity into a computer. This procedure departs from the standard drill presently used, in that coordinates of the first echo must be read off before the operator places his marker at the second echo.

TECHNICAL DESCRIPTION

4. (a) Echo Generator (See Fig. 3)

This unit was designed to simulate as nearly as possible the appearance of a bomb echo on the cathode-ray tube. It consists of a 1-kc multivibrator with frequency multiplying up to 16 kc and appropriate horizontal, vertical, and brilliance drives. The horizontal drive is at the 1-kc rate, with two controls in parallel for azimuth expansion, if desired. The vertical drive is at the 16-kc rate, and is also variable. Signal brilliance takes place at the 16-kc rate, gated by the 1-kc signal (and the flasher), with amplitude and phase adjustment to obtain the most "natural" appearance of the "echo". This unit also contains the necessary relays actuated by the "instructor-student" switch, the "expand-azimuth" switch and the "Hi-Lo PRF" switch. A marker brilliance control is provided.

(b) Power Supplies (See Fig. 4)

The high voltage supply for the cathode-ray tube is a conventional "pump-type" circuit using metallic rectifiers and supplying about 2000 volts negative to the grid and cathode of the cathode-ray tube. The same power transformer is used for both the high voltage and low voltage, the output of the latter being +200 volts d-c and -200 volts d-c which supplies the multivibrator circuit described above and the student's and instructor's deflection circuits. Azimuth and range deflection adjustments are available so that reading accuracy may be as great as desired, or so that handwheel rotation may be made to conform to that used on the radar.

Plate voltages for the expanding amplifier and rate servo are presently supplied by external means since these were not included in the original design.

(c) Expanding Amplifier (See Fig. 5)

Expansion of the instructor's deflection voltages, A_1 A_2 (or R_1 R_2), is accomplished by utilizing about 50% negative feedback of each voltage with respect to the other. Standard d-c amplifier techniques are used with cathode-follower output. Two of these amplifiers are required.

(d) Rate Servo (See Fig. 6)

This unit supplies a pre-set time interval between the two echoes. A d-c voltage is applied in series with, but opposing, the d-c generator voltage which is proportional to generator speed. The resultant voltage is modulated and amplified to operate the motor to which the generator is coupled. Hence the amplifier input approaches a null as the generator voltage tends to cancel the applied d-c voltage, and a steady speed is established.

(e) Student's Timer (See Fig. 7)

This circuit allows the student to time the interval between echoes by momentarily pressing a hand-switch as the echoes appear. The motor is geared to a dial and cam which, when the hand switch is held, automatically stops the motor when it has made one complete dial rotation. This operation is similar to that used in the radar.

NOTE ON THE EXPANDING AMPLIFIERS

5. It has been indicated above that the expanding amplifiers modify the instructor's signal voltages in such a manner that the calibrated dials represent the centers of the beam intercepts. In practice, some difficulty has been found in making the instructor's (signal) dials and the student's (marker) counters track accurately over the complete range of values. However, the equipment is still quite usable if a number of problems are "prefabricated" by noting the start, stop, and center of the intercepts and correlating the indicated values of signal and marker in a table. A large number of problems could be made up in a few hour's work and used over and over as often as desired. In any case, whether or not these amplifiers are used, some preliminary work in making up the problems would be necessary on the part of

the instructor to obtain a reasonable relationship between target "travel" in azimuth and range, and timing interval.

POSSIBLE MODIFICATIONS

6. During development of this equipment, a number of possible modifications of the original design have been evident. Some have been incorporated and others are suggested here for future consideration.

a) Provision of extra cams on the rate servo-motor drive so that the effective beam width may be varied (simulating short, medium, or long range). A similar arrangement might also be used to put echoes from two bombs on the cathode-ray tube more or less simultaneously as a "confusion" test.

b) Elimination of the expanding amplifiers if present difficulties with calibration are not overcome (See para. 5 above).

c) Provision of cathode-ray tube signal controls (horizontal, vertical, brilliance, focus) on the instructor's box.

d) Marker brilliance (and possibly focus) controls to be brought out to the student's front panel.

e) Provision of additional counters and a clutching arrangement so that the student would not be required to read results before the operation was complete (as in the radar). Printing counters, which are available commercially would be convenient.

f) Provision of "background noise" on the cathode-ray tube if some simple method can be devised to do this.

g) Use of the instructor's box to control more than one student's panel. This has not been investigated thoroughly but it is thought to be quite feasible.

PHOTOGRAPH

7. The accompanying photograph shows the instructor's control, student's console, hand-switch, and foot-switch. This photograph was taken prior to development of the rate-servo unit and, as shown, all items will fit inside the student's panel for transfer purposes.

ACKNOWLEDGMENT

The valuable assistance of QMS W.O.II Hillier, RRDE (England), who contributed to the design of the echo generator circuit, and of Mr. C.S. Chisholm who did the layout and wiring is gratefully acknowledged.

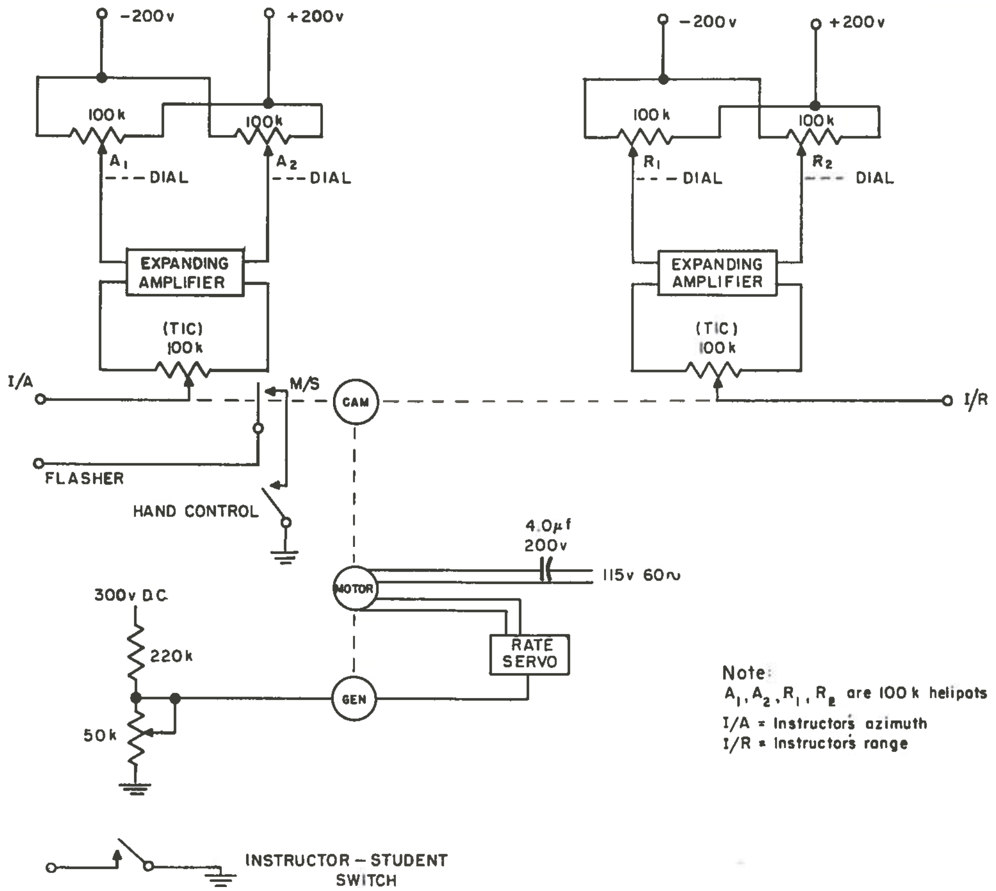

FIG. 1 INSTRUCTOR'S POSITION AND RATE CONTROL

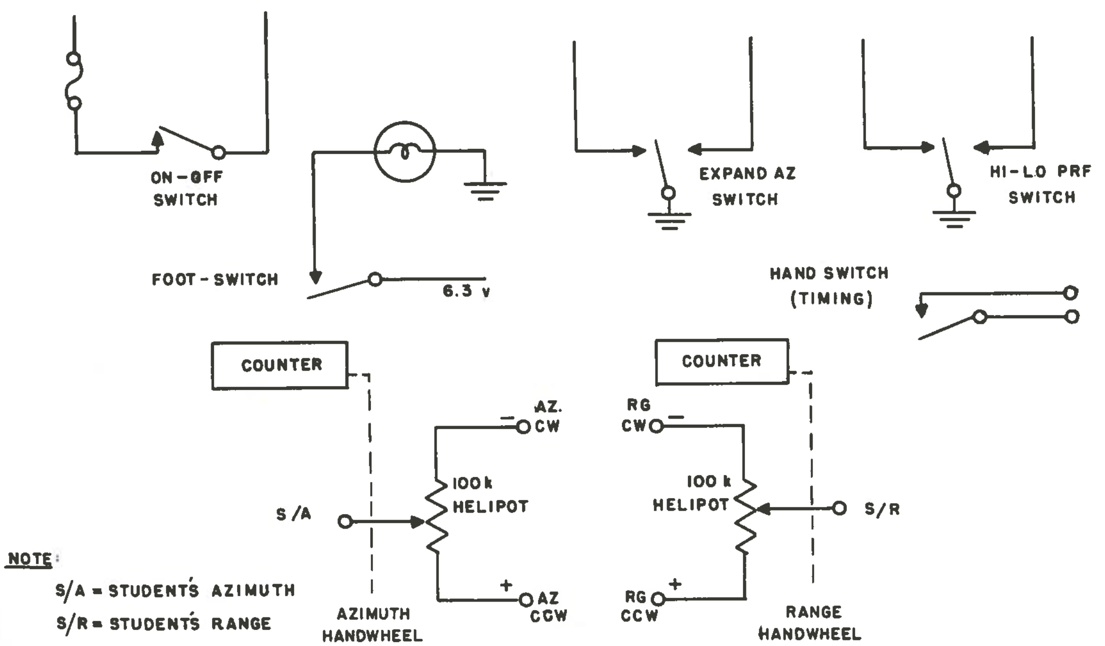

FIG. 2 STUDENT'S CONTROLS

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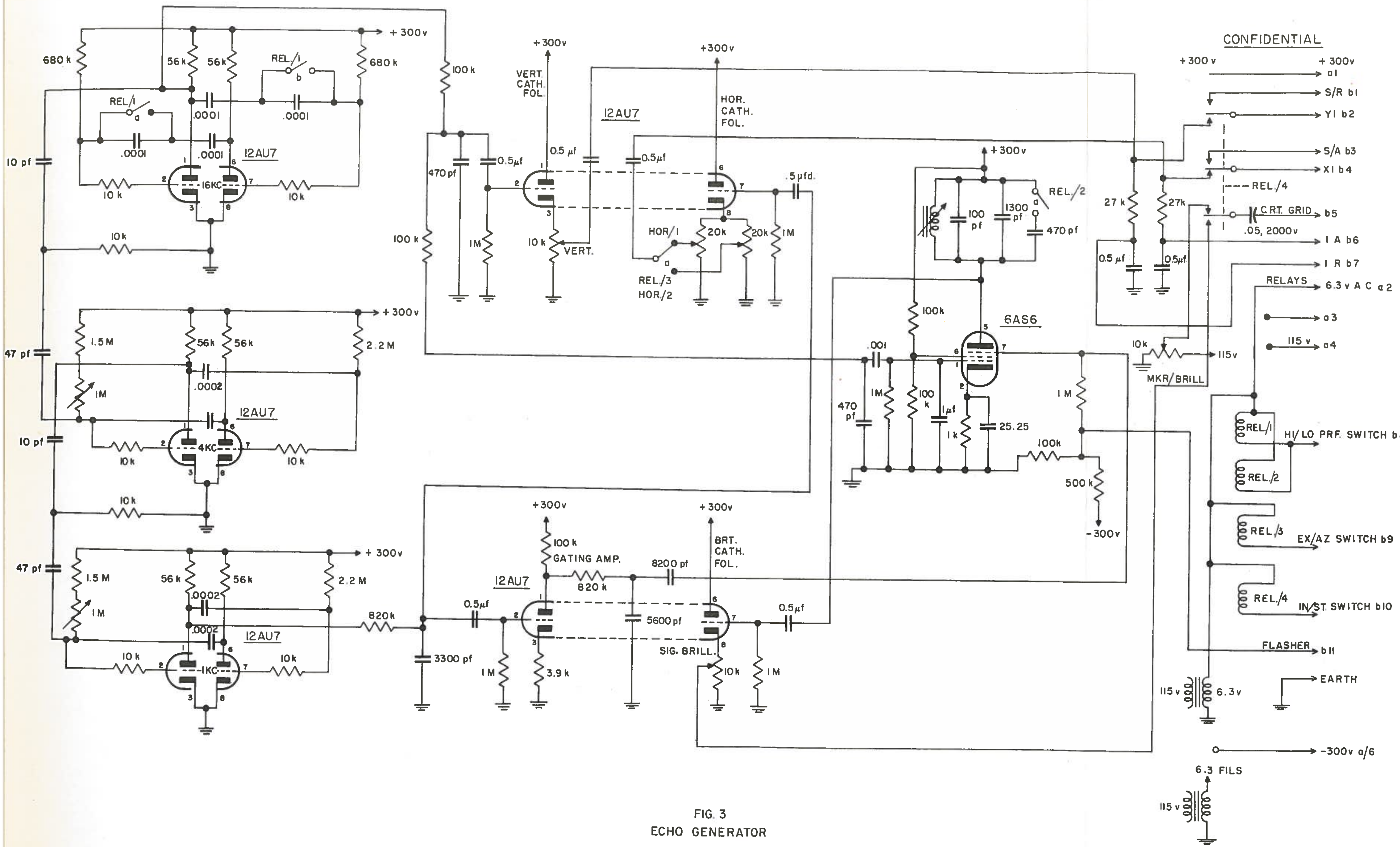

FIG. 3
ECHO GENERATOR

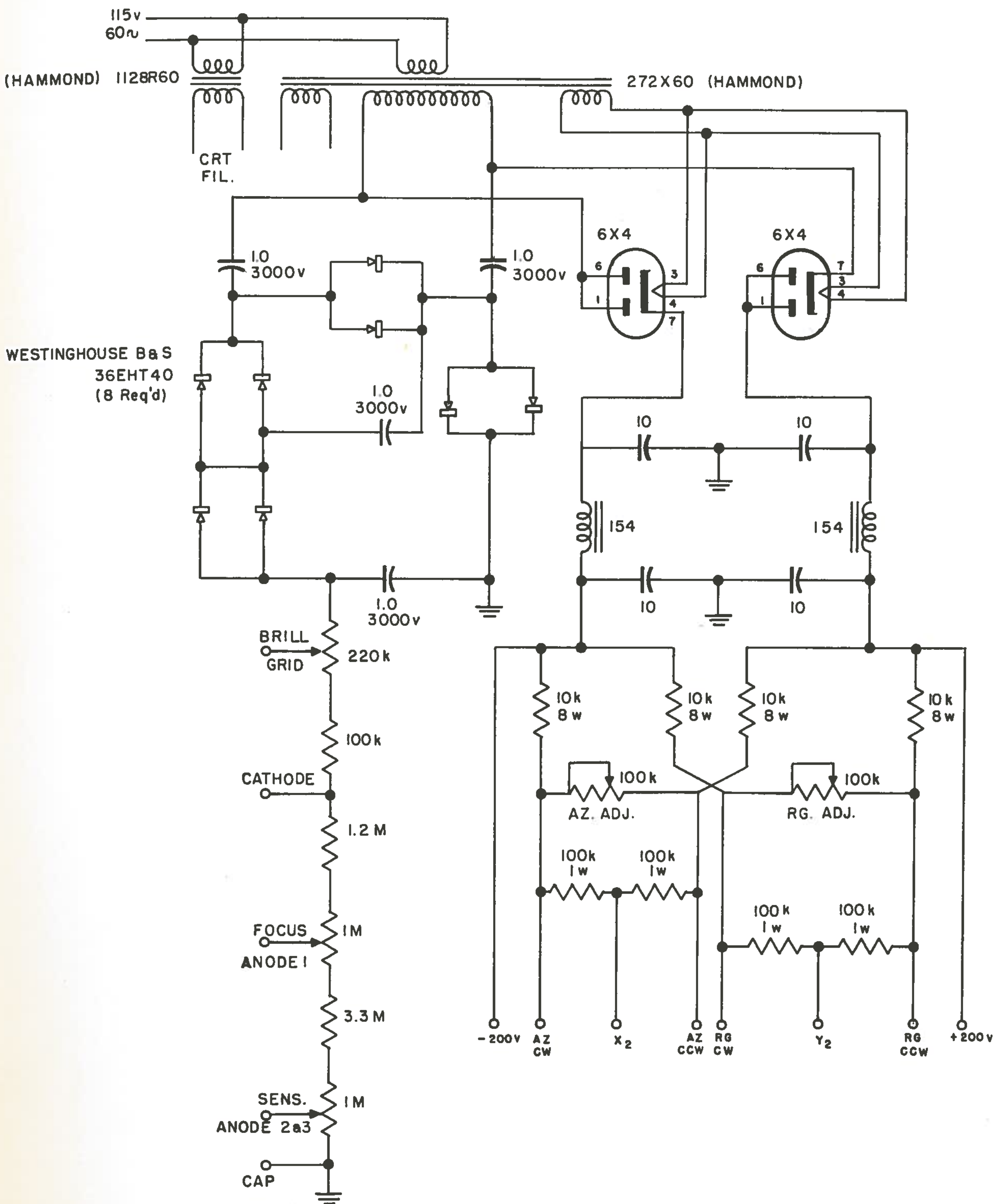

FIG. 4 POWER SUPPLIES

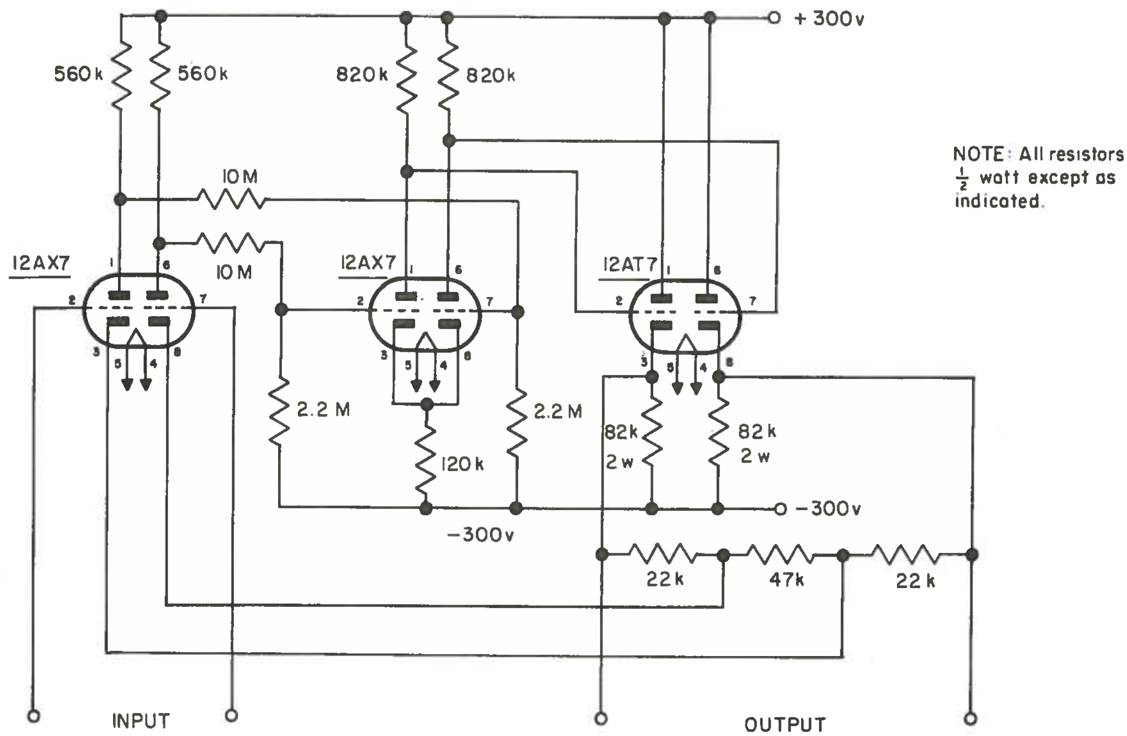

FIG. 5 EXPANDING AMPLIFIER

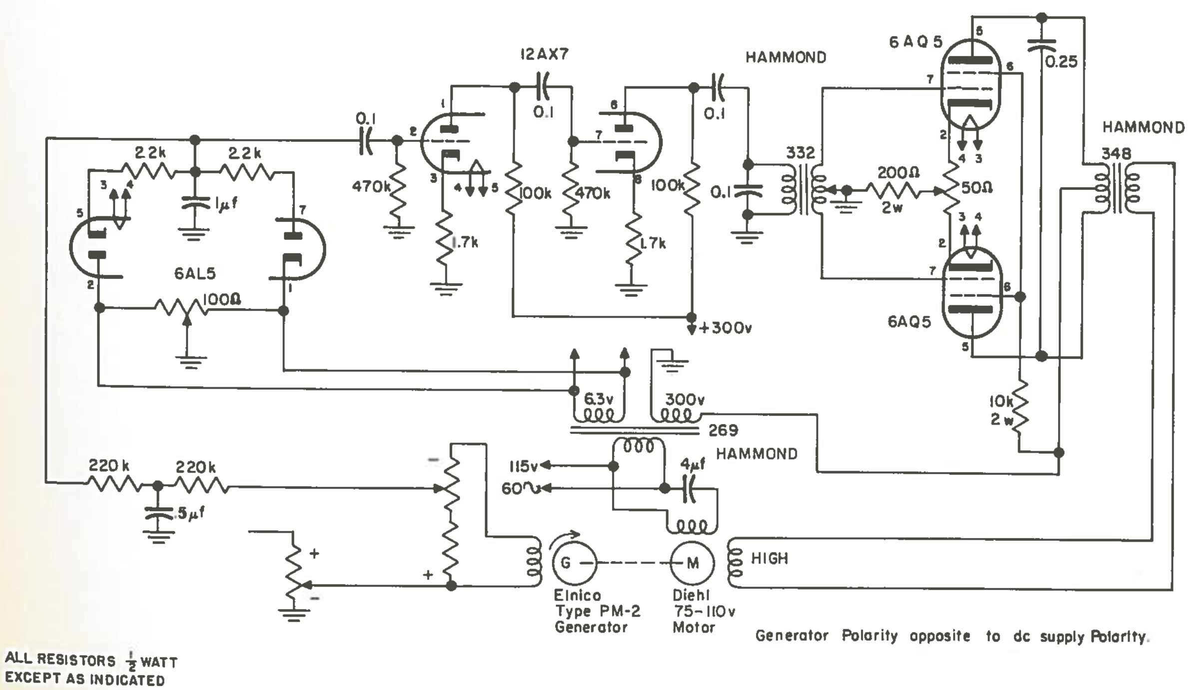

FIG. 6 RATE SERVO

POTTER AND BRUMFIELD
"INSTANTANEOUS START AND STOP MOTOR"

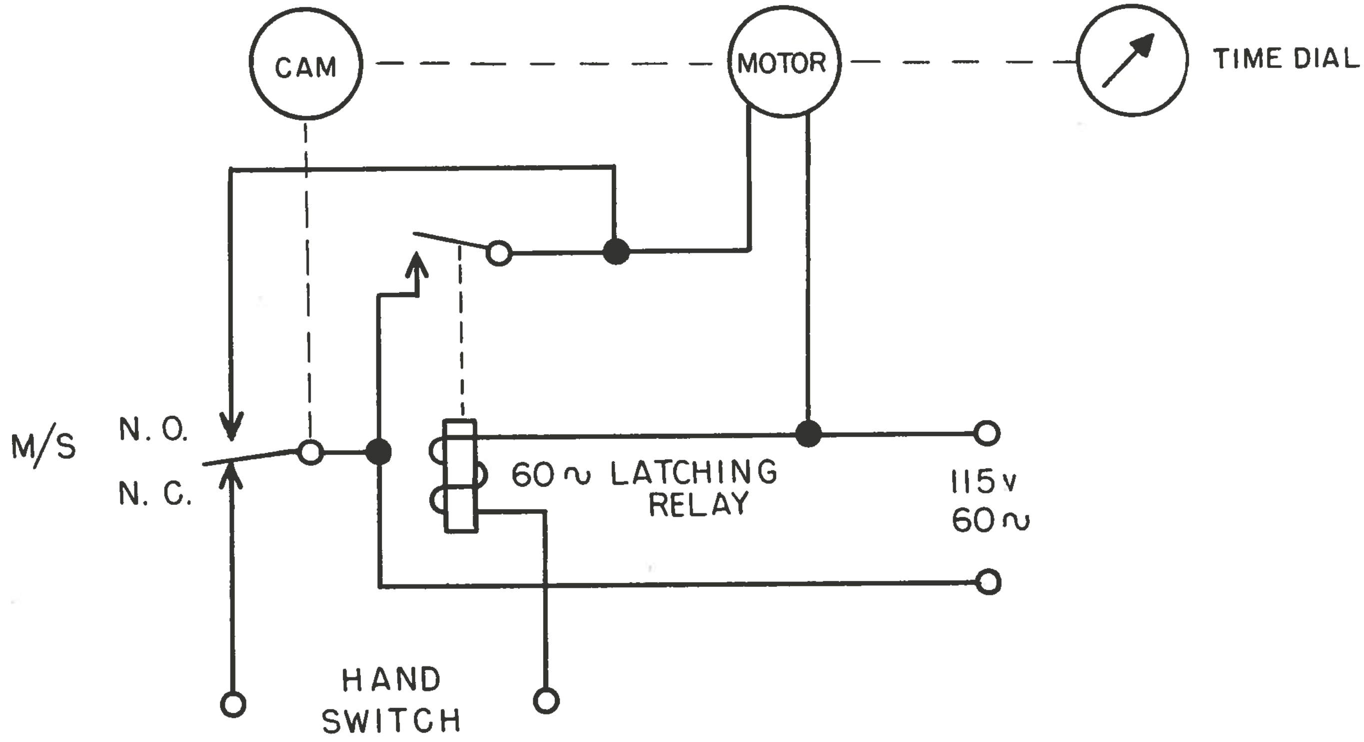

FIG. 7 STUDENT'S TIMER

TRAINER COMPRISING FOUR UNITS — STUDENT'S CONSOLE (RIGHT)
INSTRUCTOR'S CONTROL (LEFT) AND HAND AND FOOT SWITCHES (CENTER)