II. Specific Control Circuitry

A. Power Source

1. Battery Operation

In order to realize adequate torque from the reel drive and head engage motors, a power source of 7 to 7.5 volts at 500 MA is necessary. This includes power for proper operation of all circuits. Therefore, a battery supply would not be recommended for any continuous or extensive usage applications. However, for short-term, intermittent operations over long time periods, a battery supply would be feasible.

2. AC Source

An AC power adaptor consisting of a step-down transformer with full-wave rectification provides an economical power source from the AC line. One such unit providing the required power is the SPS–1185 Model available from Dormeyer Industries. This unit, combined with a large capacitor and a solid-state regulator, makes an ideal power supply for operation of the Phi-Deck.

Because reasonably stable voltage and minimum ripple are a requirement for proper operation of the circuits described herein, the following inexpensive circuit is recommended:

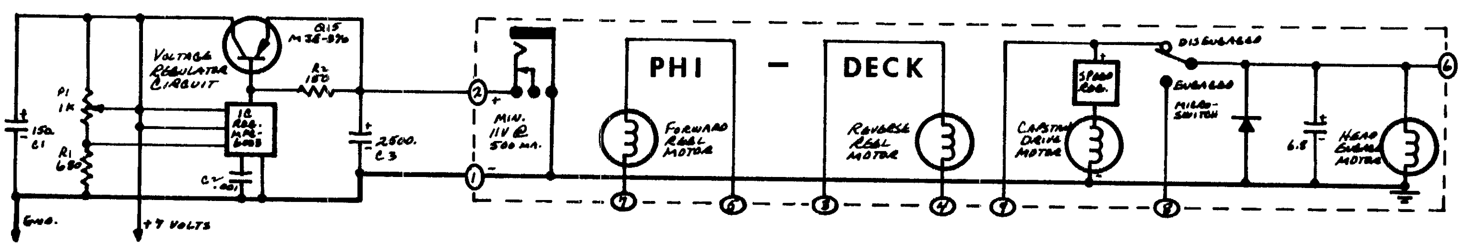


FIG. 1 SIMPLE REGULATOR

The output voltage commonly used for deck control is 7.0 volts. The circuit above requires an input voltage of 11 volts minimum when a 500 MA load is placed on the 7-volt output.

B. Head Engage-Disengage Control

1. Manual Switch Control

The most simple approach to head engage control is through the use of a double-pole, double-throw toggle switch, connected to the head engage motor and microswitch as shown below in Figure 2:

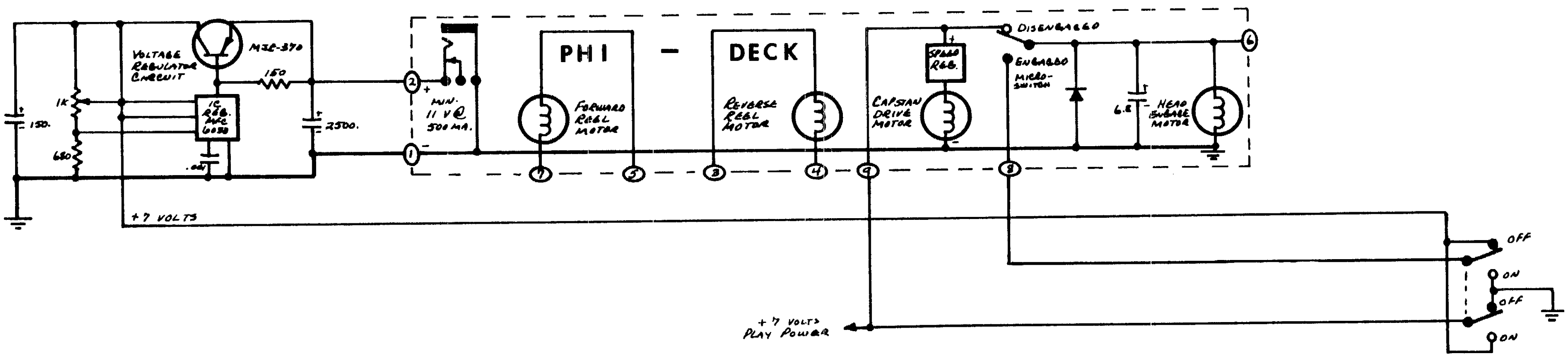


FIG. 2 TOGGLE SWITCH HEAD ENGAGE

This arrangement allows for proper dynamic braking of the motor to ensure stoppage in the middle of the crests and valleys of the starwheel. The toggle switch in this case may be the power switch of the unit.

2. Relay Control

The use of relay contacts in place of a DPDT toggle switch allows a more versatile system, especially for remote control. Additional contacts on the same relay are useful for other system control functions, as will be outlined in later sections. Most plug-in type cradle relays are highly reliable and economical, and sensitive coils are available for nominal power consumption.

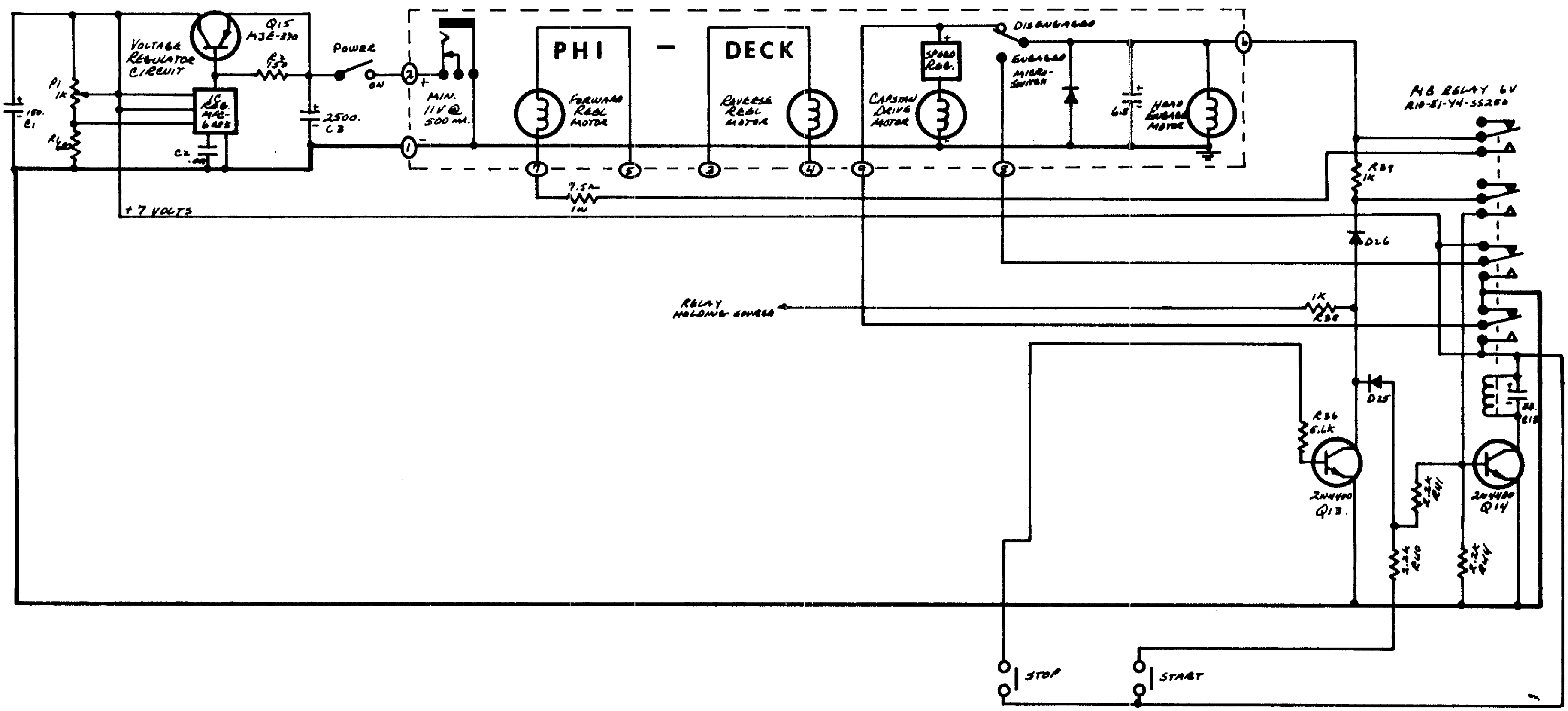


FIG. 3 RELAY HEAD ENGAGE

Total engage or disengage period with this arrangement is approximately 100–120 milliseconds, including the relay delay. This time may be reduced to as low as 40–60 milliseconds by using 12–15 volts supply (head control only) and special adjustment of microswitch leaf.

3. Solid State Control

A more sophisticated control system utilizing discrete transistors may be used. The complementary pairs must have a current capability of at least 600 MA with low VCE saturation. The relay time delay would be eliminated with this circuit.

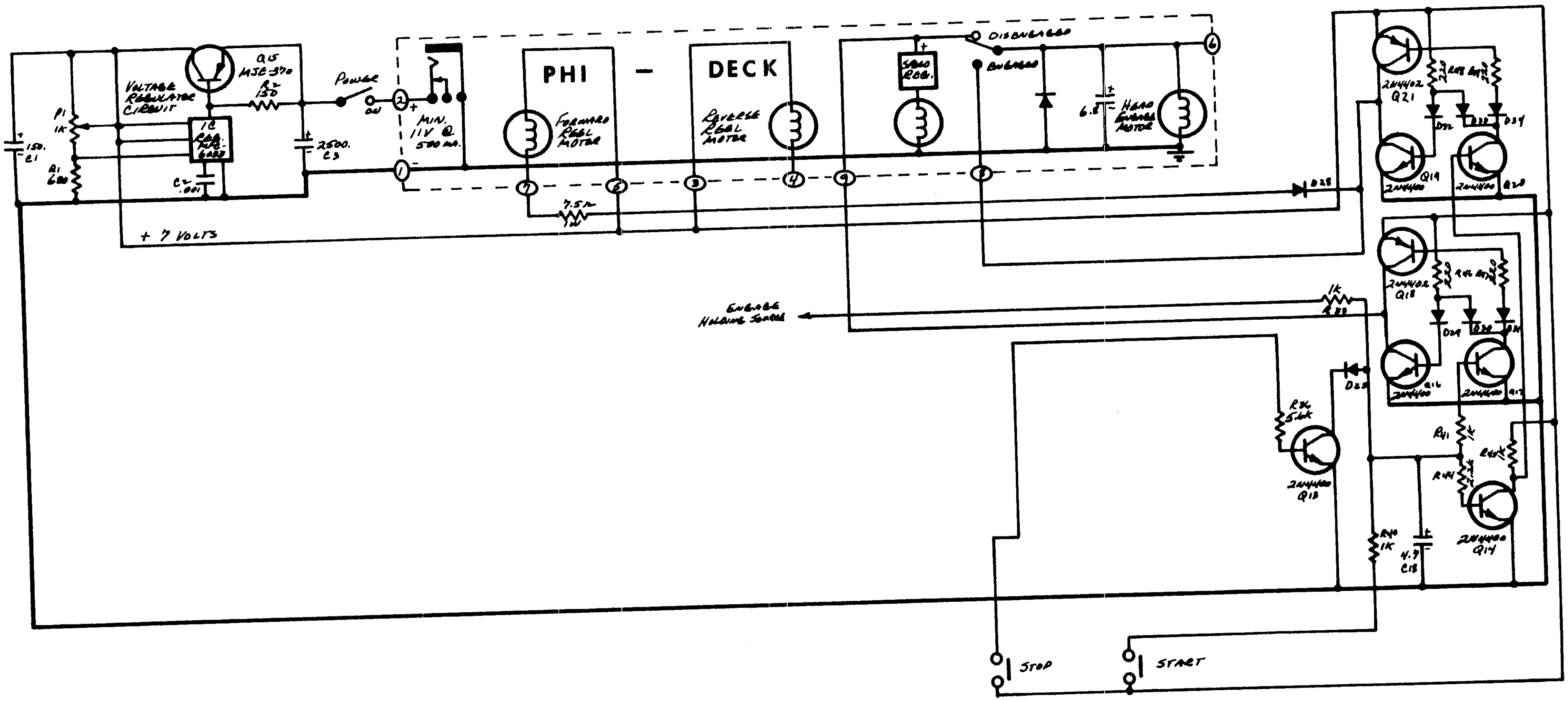


FIG. 4 SOLID STATE HEAD ENGAGE

4. Manual Head Engage

If remote operation were not required, the head engage motor, gear box, and starwheel could be eliminated and a manual lever control system substituted. A complete circuit for the simplest manual control is included in Section E.

C. Reel Motor Circuits

1. Manual Switch Control

The simplest form of rewind and fast forward control is with SPST normally open push-button switches. However, because dynamic braking is required when the button is released, additional circuitry must be used. Figure 5 shows an arrangement utilizing a transistor for the braking function.

When either switch is closed, the corresponding motor runs until the switch is opened. The switch release allows a positive pulse to be coupled to the transistor base, causing current to be conducted through both motor windings. Thus, each motor tries to move the tape but cannot because of the restraining action of the other. The result is that the tape stops instantly and is held tight. The current is resistor limited, and motor torque is not sufficient to strain the tape or cause movement due to torque unbalance between full and empty reels.

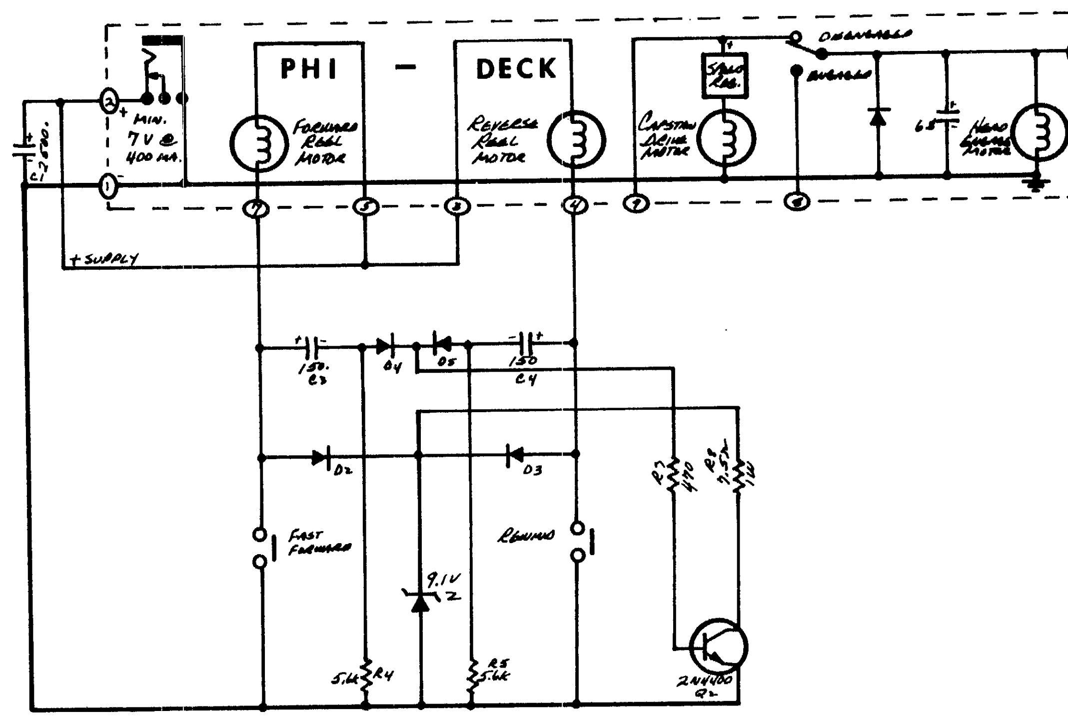


FIG. 5 SIMPLE REEL DRIVE

The Zener diode shunting the braking transistor circuit is for end-of-tape slow-down. When one motor is being driven, the tape is pulling the other motor, which acts as a generator. Thus, the voltage at the diode junction (D2 and D3) between motors rises to several volts above the supply voltage, depending upon the speed of the motor being pulled. When the voltage reaches the Zener level, current is drawn through the motor being pulled, thereby slowing the tape movement. Because the motor will be pulled faster toward the end of the tape, it is forced to run slower by the Zener diode until it drops below the Zener level. The Zener voltage (8.6 to 9.1 V) is chosen to cause a speed that is safe for the leader-hub junction.

The circuit in Figure 5 is not complete in itself but must, of course, be integrated with other functions of the system. For example, in a normal play or record mode, the rewind motor supply should be disconnected and the braking transistor activated to drive the forward motor for the take-up function. The take-up function requires current limiting, and the value of R8 is sufficient for this purpose.

RFI from the reel motor brushes can cause static if the audio circuit is not muted during rewind or fast forward. Different layouts, wiring, etc., may allow static pickup from the forward take-up motor during play or recording operation. If this occurs, it can be remedied by inserting small chokes (20 to 30 microhenries, DC res. max. .3 OHM) in series at each terminal of the forward motor. Further reduction could be realized by the addition of .001 capacitors from each terminal to chassis ground.

2. Solid State Reel Drive

A more comprehensive circuit may be employed, allowing greater remote utility in combination with other functions. This circuit, shown in Figure 6, uses transistors to drive the reel motors with efficient braking. The transistors must have low VCE and be capable of 600 MA, such as type 2N4400. To avoid damage from voltage spikes, the transistor should also be shunted with a large-value capacitor. This circuit is a basic building block for a variety of control options, as will be seen in later sections.

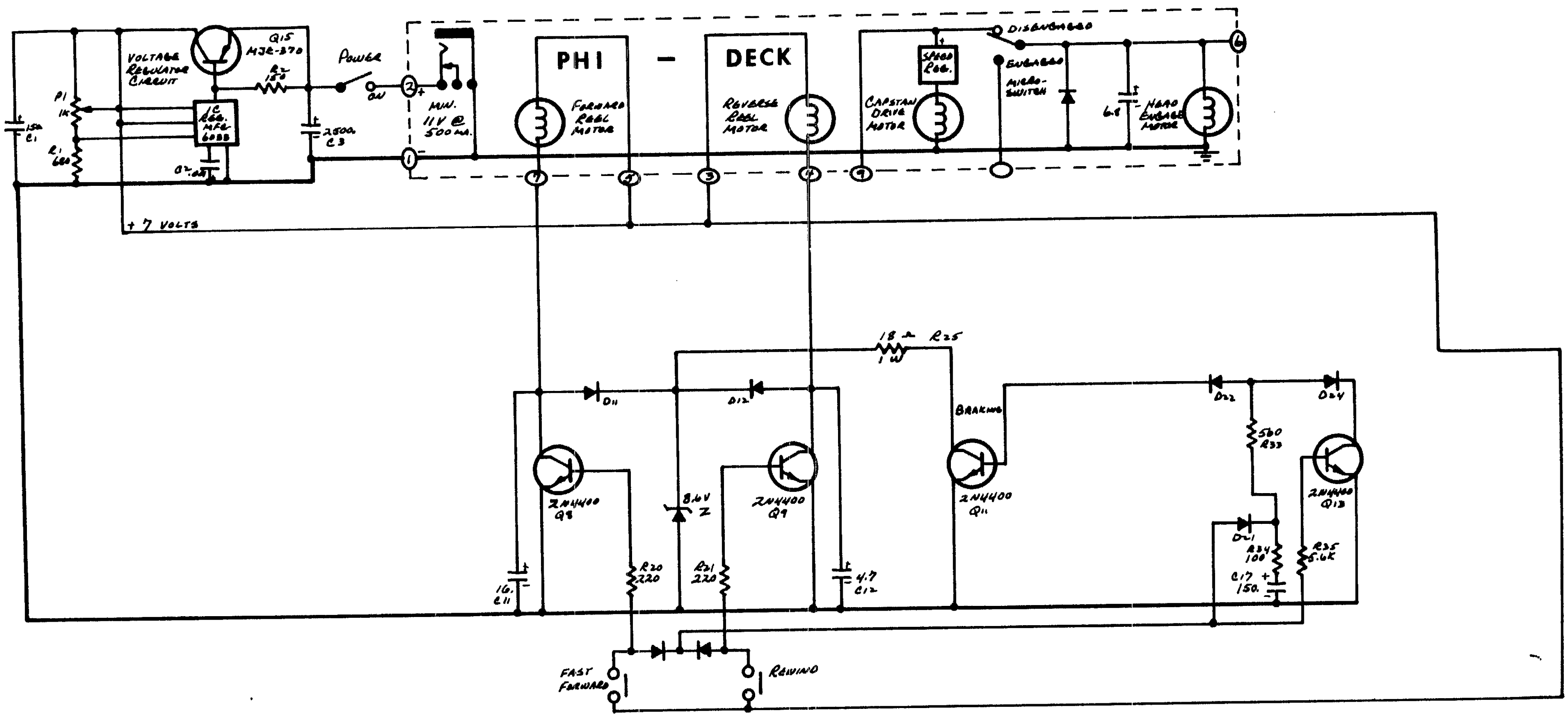


FIG. 6 TRANSISTOR REEL DRIVE

3. Tape Motion Sense

The addition of a tape motion sense circuit with minimal complexity will expand the previous circuit in Figure 6 to provide automatic end-of-tape sense, take-up failure shutdown, and latched-in rewind and fast forward functions.

This circuit makes use of a fundamental property of the reel motors. The three-segment armature results in six brush crossings per revolution. Since the brushes lose contact briefly over each crossing, a change in current results. A small resistor in series with the forward motor will accordingly develop a small voltage spike across it six times during each revolution, and the spikes will cease when the motor ceases to turn. The spikes are present also when the motor is acting as a generator. Thus, these spikes may be amplified and used to charge a capacitor to develop a DC indicating that the motor armature is turning. This DC may then be used to latch in the head engage relay. As long as the tape is moving, the head remains engaged unless disengaged by other means.

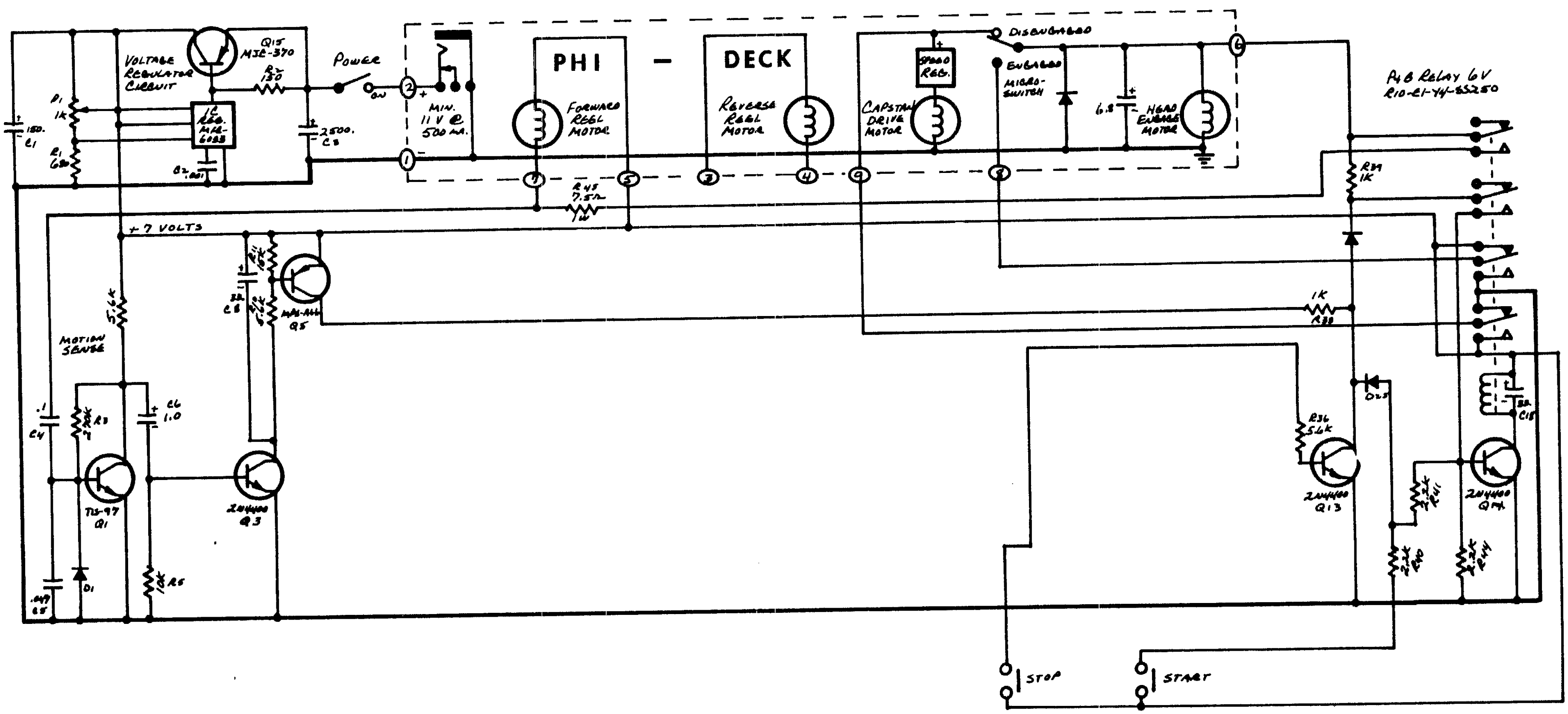


FIG. 7 TAPE MOTION SENSE

4. Latched Rewind and Fast Forward

Since the forward motor turns very slowly for the take-up function, the time constant of the circuit in Figure 7 must be long enough to accommodate the slow pulse rate. The circuit will discharge within 1 to 1.5 seconds after the motor stops.

When the circuit is functioning as an end-of-tape sense for the fast forward or rewind modes, however, the discharge time needs to be much shorter. For this reason, an additional transistor has been added to cause abrupt discharge of the circuit when the motor being pulled by the tape ceases to turn. In this manner, the DC developed from the motor spikes can be used to latch in the fast forward or rewind drives and stop immediately when end of tape is reached. Figure 8 below indicates the manner in which these drives are latched.

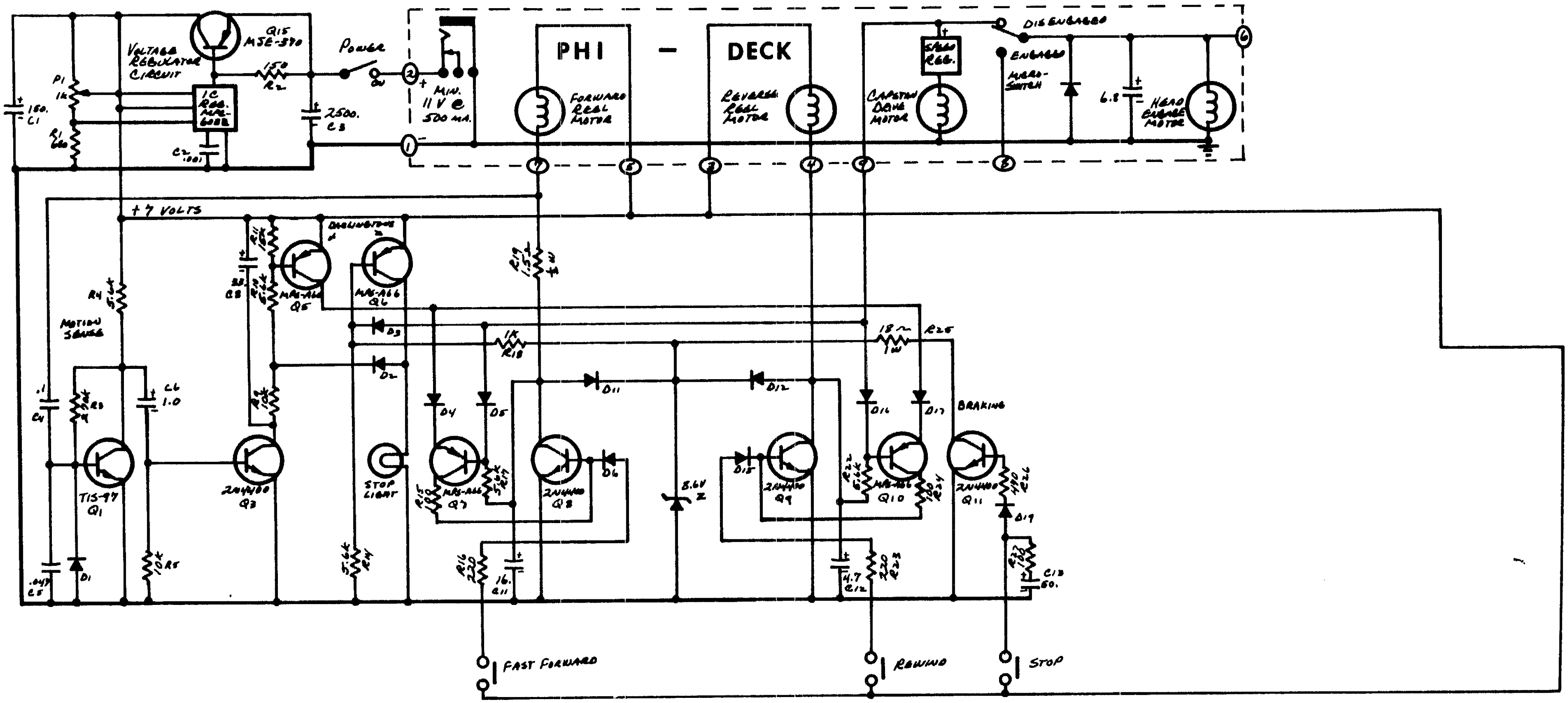


FIG. 8 LATCHED REEL DRIVE

For example, when Q8 is caused to conduct by the fast forward push button, Q7 will also conduct and couple the motion developed DC to the base of Q8, thereby maintaining Q8 in conduction until motion ceases.

To prevent latch-up during normal play or record modes, the reel drive circuits and latches should be rendered inoperative by removing the positive voltage from the push buttons and applying a positive voltage to the bases of the latch transistors through diodes. Q6 must be similarly cut off.

It should be noted that a lamp or LED in the collector circuit of Q6 serves as an indicator that the tape is stopped in any mode, and Q6's output voltage (6 volts @ 300 MA) is available for any function desired while the tape is not in motion.

A momentary stop switch can, of course, be used in conjunction with the latched-in reel drives to stop at any time with proper braking. This feature is incorporated into the circuit presented in Figure 8.

5. Tape Position Indication

Since the motion-sense pulses are derived from the forward motor and are present whenever the motor turns in any direction, they serve as an accurate indication of the number of revolutions of the motor and hence the forward reel, as it is directly coupled to the motor (barring slippage of the belt, which can be controlled).

Therefore, if the pulses are conditioned and shaped properly, they may be counted with a digital counter. If a direction cue were taken from the forward reel drive circuit, the pulses could be counted up for forward position and down for reverse position with reasonable accuracy. If a constant factor is developed for reel diameter variation with tape, an actual footage conversion is possible. A simple system of analog up-down counting with meter readout can be suggested using a quad OP amp for pulse shaping, integrating, and compensation for reel diameter variation. Drift problems, however, are the main limitations of such a system.

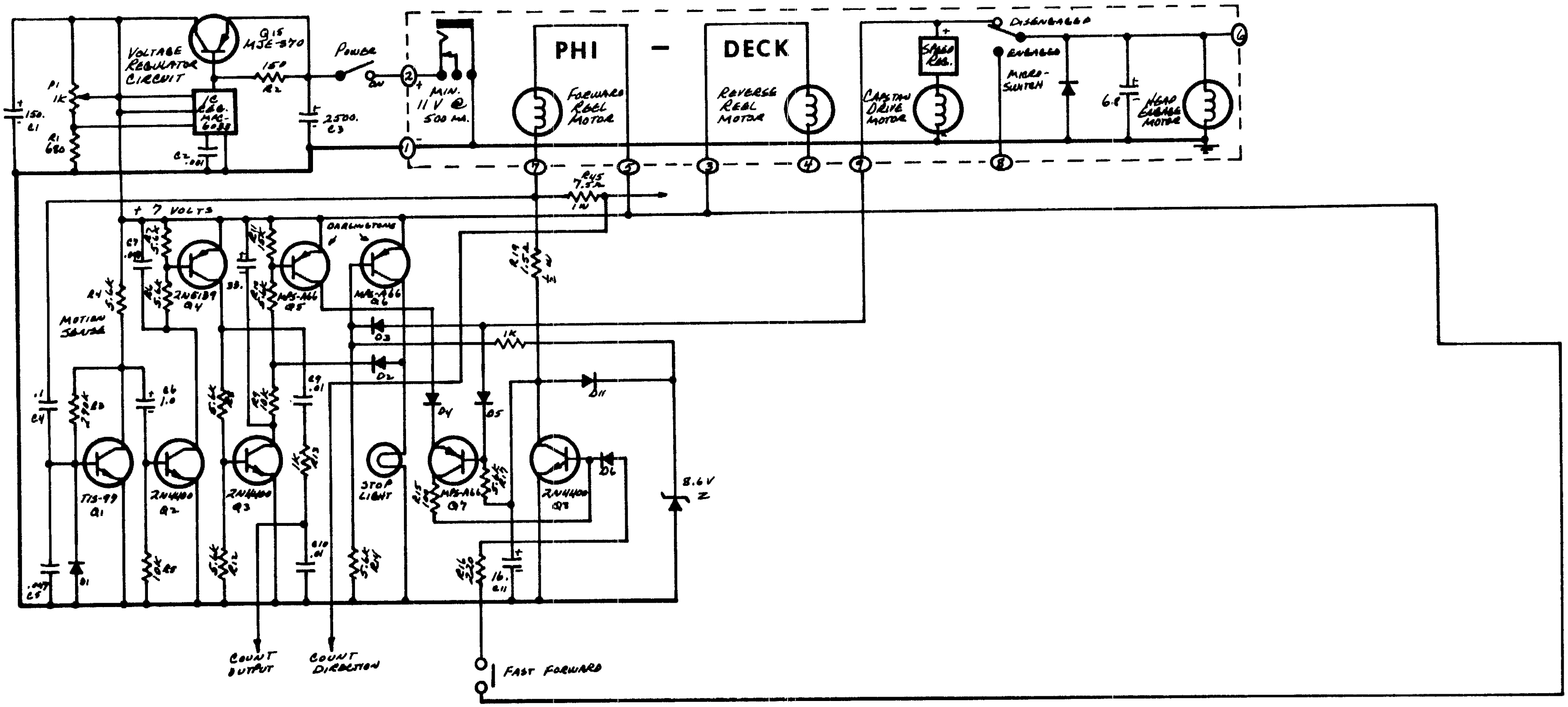


FIG. 9 UP-DOWN COUNT OUTPUTS

This circuit shows the additions necessary to provide proper outputs for digital up-down counting.

D. Optional Functions

1. Skip Forward or Skip Back

With the tape moving forward in the normal play mode, it may be desirable to repeat certain previously played sections or skip over sections and continue playing. These functions are possible with the addition of one or more push buttons for the functions desired and the circuit shown in Figure 10 below:

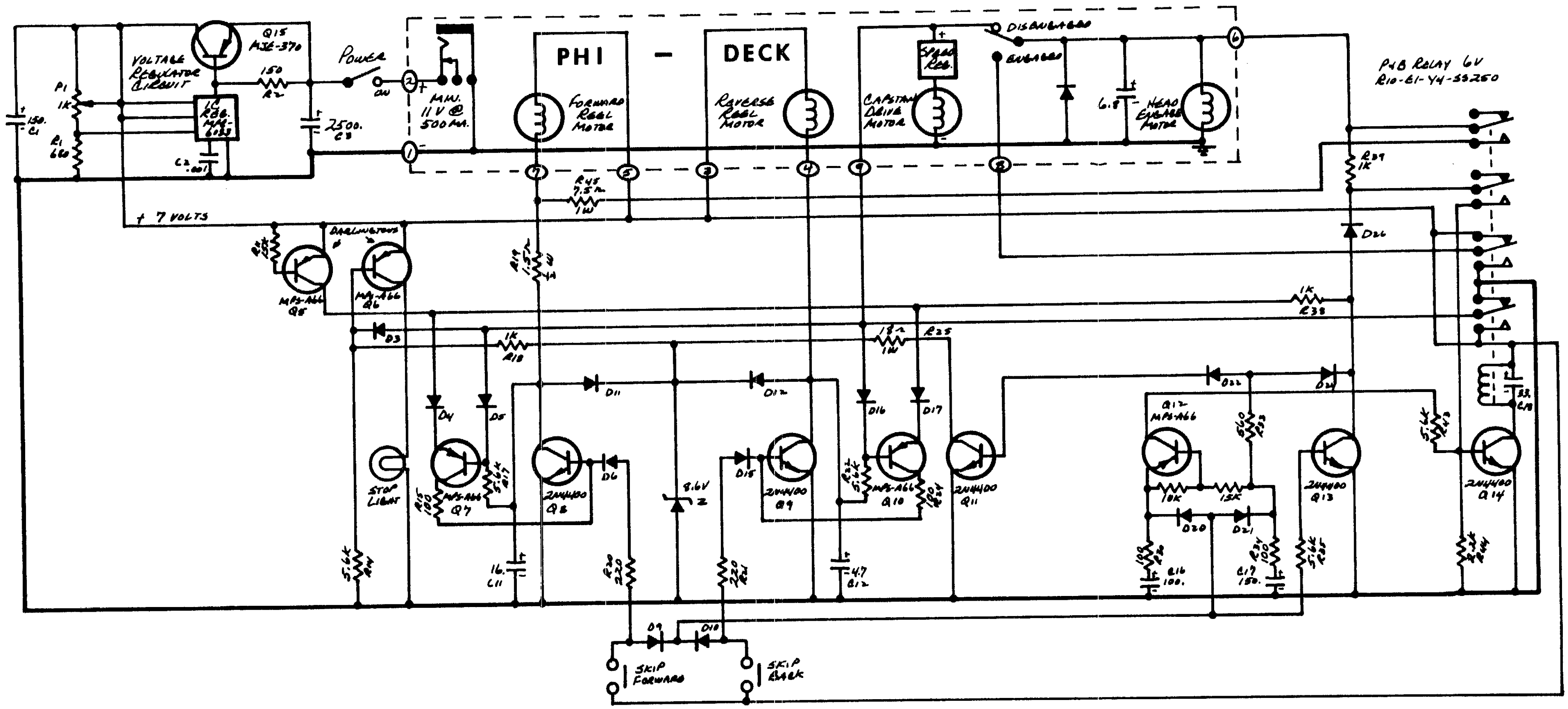


FIG. 10 SKIP FUNCTIONS

For example, if the skip-back button were pushed, Q13 would conduct and short the latching line to the head engage relay. The relay would drop open, disengaging the head. Rewind is activated because Q9 is held in conduction by the skip-back button being depressed. Capacitors C16 and C17 are also being charged through diodes D20 and D21. Diode D24 conducts through Q13 to ground, preventing C17's charge from being coupled to the braking transistor Q11. Release of the skip-back button removes conduction in Q13, allowing the charge on C17 to drive Q11 into conduction, stopping the tape. Q12 will be held cut off until C17 discharges below C16, at which time Q12 conducts and causes the head to reengage and play to resume. The skip forward function operates in this same manner. In all cases, tape is stopped briefly prior to head engagement.

2. Continuous Play

This function is accomplished by a switch that sets up the rewind function to occur whenever the head disengages and the play function to occur whenever rewind power is removed. The motion sense circuit provides the action initiation cue when it operates at either end of the tape. Thus, a tape will play through, rewind, and play again repeatedly until the switch is returned to normal position. Figure 11 below indicates the circuitry required.

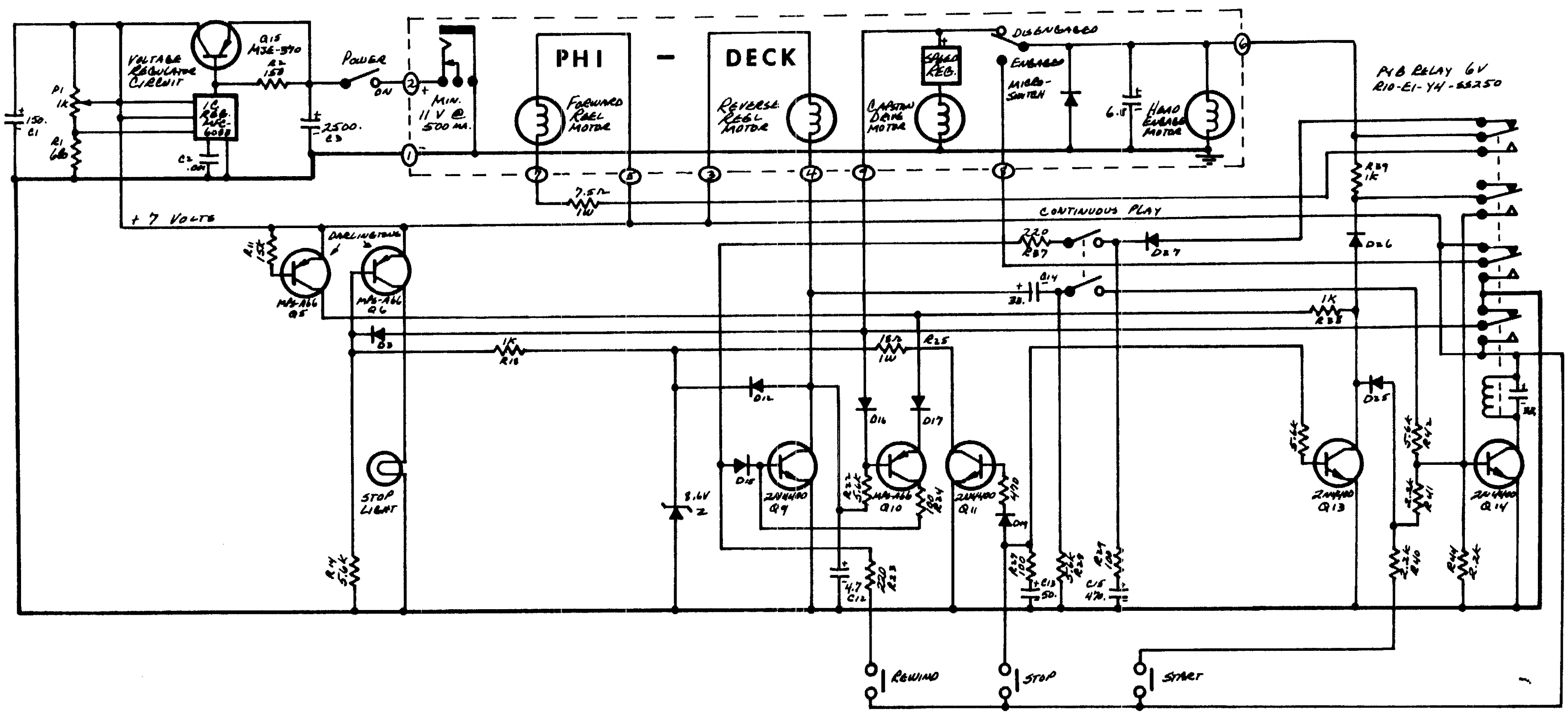


FIG. 11 CONTINUOUS PLAY

E. Overall Functions

1. Simple Manual Control

The following circuit illustrates the most simple operational circuit, providing good tape handling with minimal components. This circuit is based upon head engagement by means of a manually operated cam-actuating lever, with a microswitch sensing the engaged position.

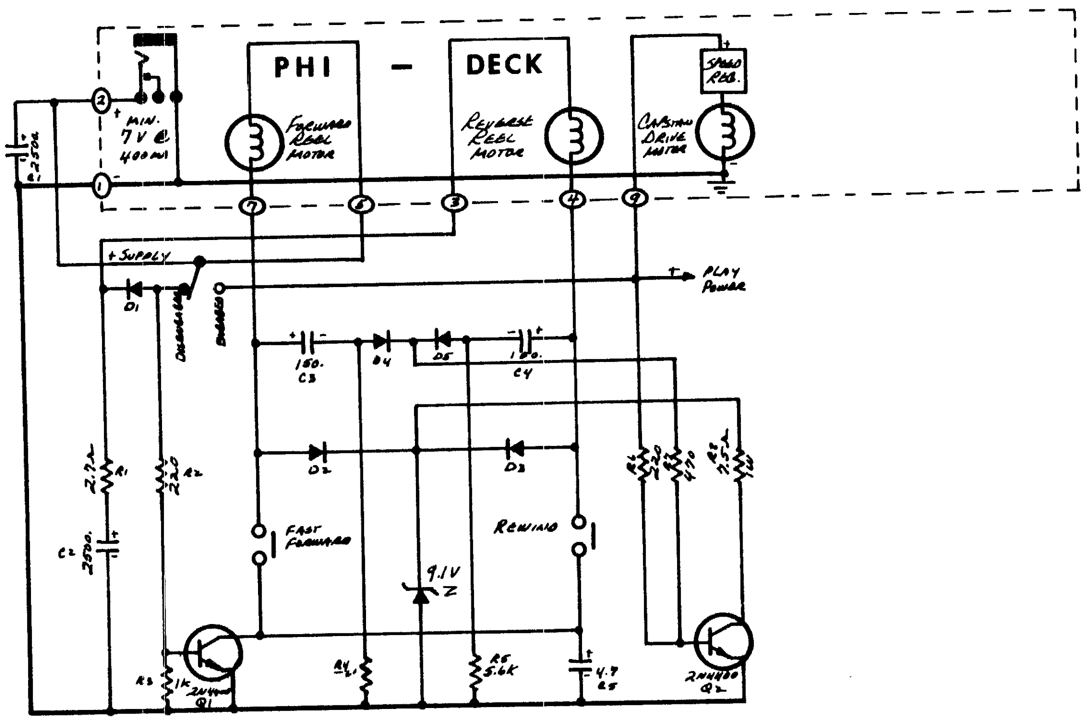


FIG. 12 COMPLETE CIRCUIT - SIMPLE CONTROL

The circuit above would not require a regulated power supply and could operate directly from an AC adaptor providing a minimum of 7 volts across the filter capacitor at 400 MA.

2. Comprehensive Control with Options

The circuit in Figure 13 combines all of the automatic features described in previous sections. Tight control of the tape is maintained for all functions with momentary touch push buttons. Since the buttons all have a common line, they may be enabled or disabled with a single switch. All control lines may be handled remotely with less than a 50 MA current for any button. With diode isolation, each line can be paralleled with any number of other units for common buss control.

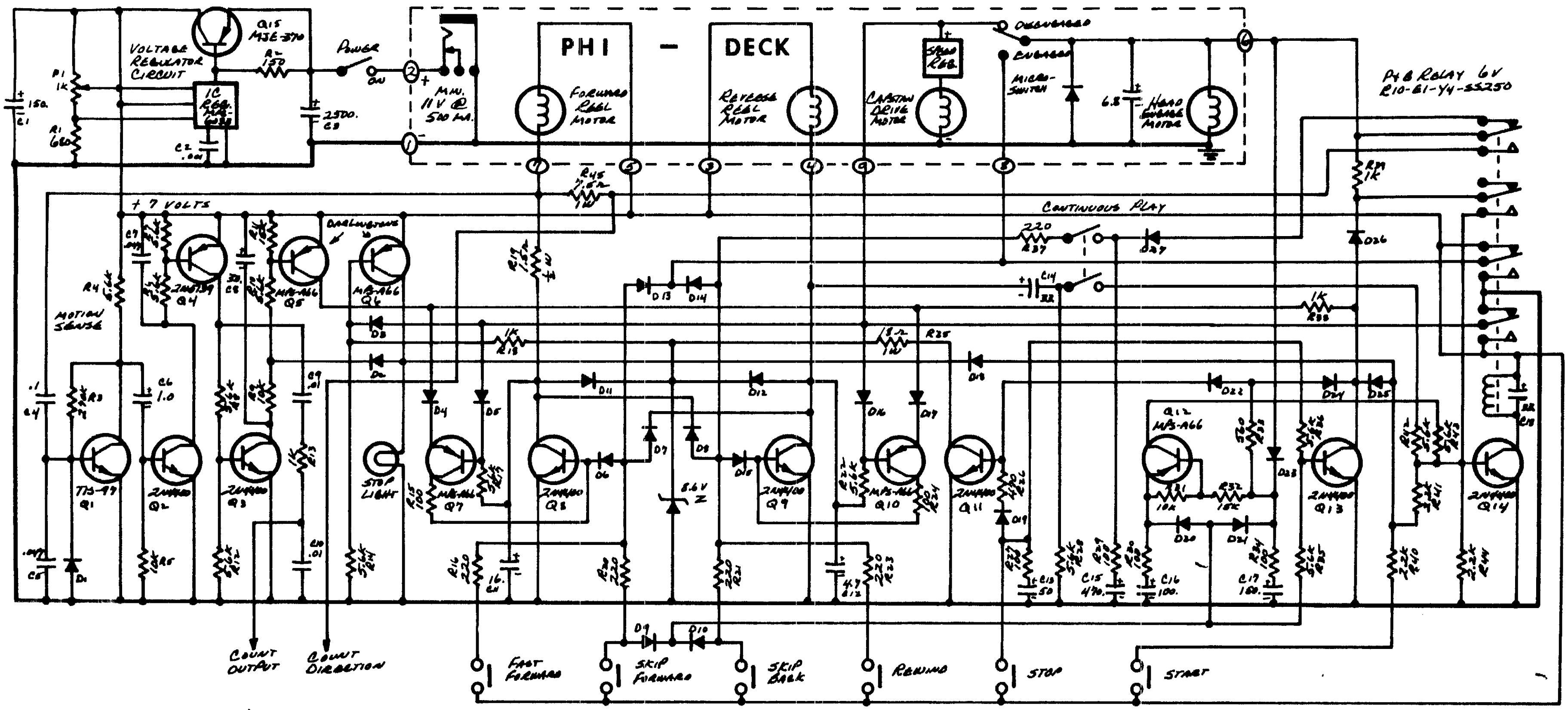


FIG. 13 COMPLETE CIRCUIT - ALL OPTIONS

This circuit allows fast starts and instant stops. The head may be disengaged in the middle of a word and reengaged at the same spot on the tape. This is possible because the tape does not move until the head is in full contact and because the forward take-up function is inhibited until the microswitch senses that the head is in position. This is accomplished by returning the forward motor drive resistor to ground through the relay and the head engage microswitch.

The button functions are interlocked so that the head cannot be engaged during rewind or fast forward functions, and vice versa. Rewind, fast forward, or play operations can only be interrupted by the stop or skip buttons. In the case of the skip buttons, the interruption of fast forward or rewind operation occurs only upon the release of the skip button.

It will be noted that the braking transistor is activated through D23 each time the head engages or disengages. Thus, power will be applied to both reels during each engage or disengage period and for a short time thereafter, determined by C17. This action is intended to provide additional cassette safety. If for some reason the forward motor cannot take up the tape slack and the tape starts to come out of the cassette and wrap around the capstan, the tape motion sense circuit will disengage the head and the tape will be pulled back into the cassette.

There are obviously many combinations of functions and different circuit configurations possible. IC's may be employed, utilizing peripheral drivers of the 75450 variety for the power functions and OP amps and power gates for others. Any IC's used should be protected from the voltage spikes and excessive current surges common with DC motor circuits.

F. Unusual Tape Speeds

The Phi-Deck is capable of good operation at speeds from ½ inch per second up to 16 inches per second. Removal of the internal speed regulator from the standard capstan drive motor is necessary for speeds other than 1⅞ inches per second. A special drive circuit has been developed for this motor to accomplish any speed within the mentioned range. No change would be necessary in the forward take-up function.

For continuous use at higher speeds, however, the capstan bearing must be changed. The bronze sleeve bearings should be replaced with Delrin bearings of the same size.

For applications requiring extensive operation at high speeds, it would be advisable to employ motors more suited to the particular speeds and life required.

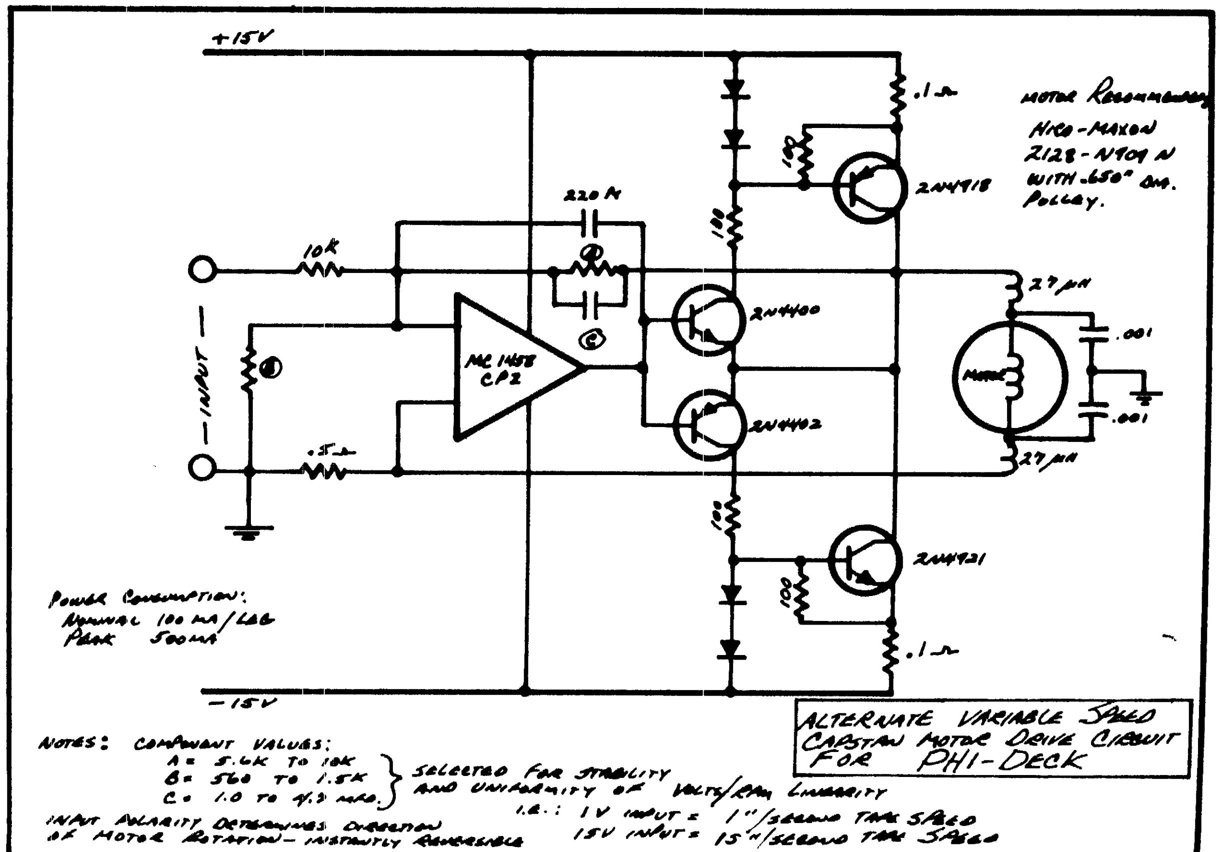


FIG. 14 ALTERNATE VARIABLE SPEED CAPSTAN MOTOR DRIVE

III. Demonstrator Instructions

A. Caution to the Operator

The power switch must be in the off position (away from operator) before electrical current is applied to the unit. When adjusting the motor speed, be sure that the device being used is insulated to prevent shorting out against the motor case.

B. Demonstrator Control Circuitry

The following procedure explains the operation of the various functions present in the control circuitry of the Phi-Deck demonstrator board. These functions were chosen by the designer to display the versatility of the Phi-Deck transport. Many other variations of this circuit are possible without compromising performance of the transport.

1. Power Switch

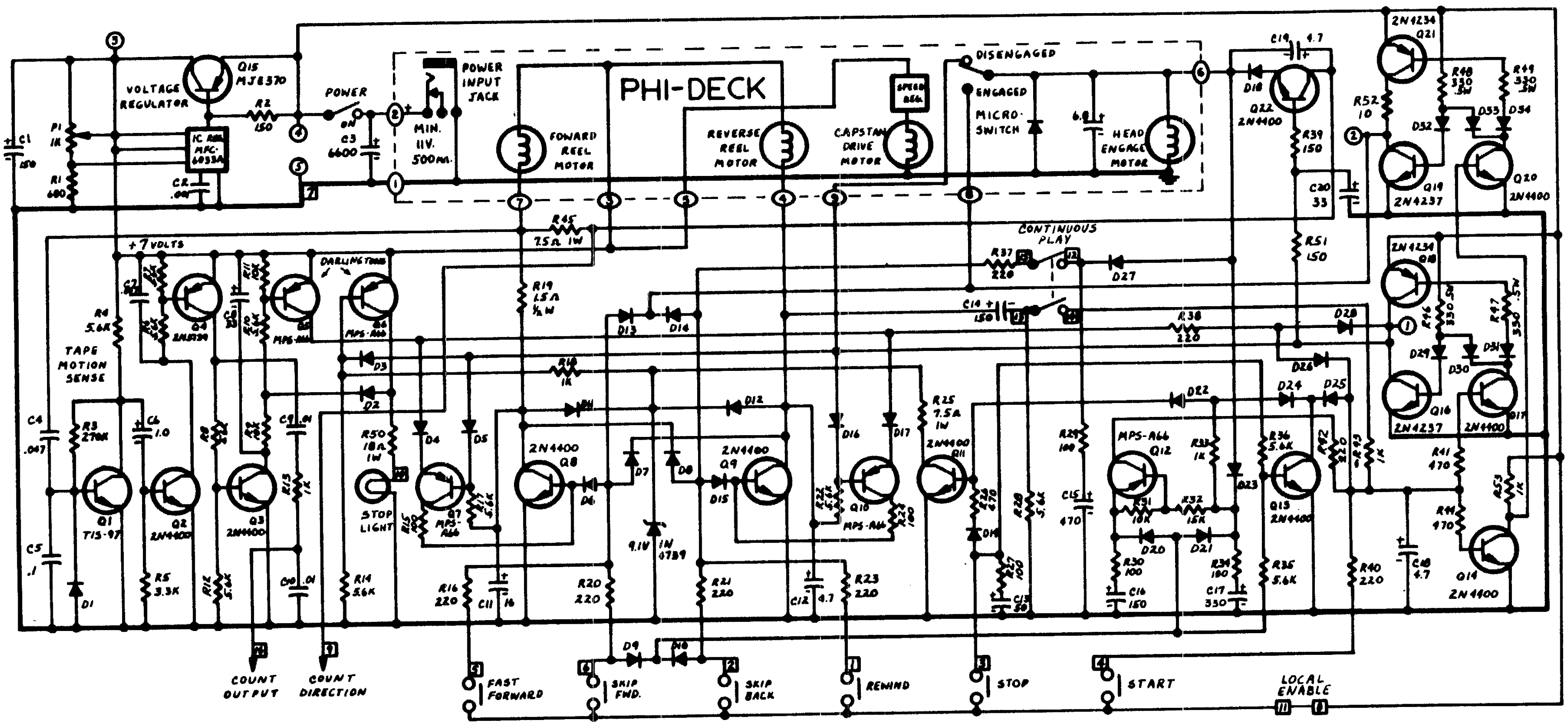
With this switch in the on position (toward the operator), power is applied to the unit.

2. Play Button

When this button is depressed, the head and the pressure roller assembly are engaged and power is applied to the forward reel motor. The unit is then in the play mode.

3. Stop Button

When this button is depressed, the head and the pressure roller assembly are retracted and power is removed from the forward reel motor. Tape movement stops. This button also stops the rewind and fast forward operations.



NOTES:

1. ▣ DENOTES CONNECTION TO DIP SOCKET FOR REMOTE OPERATION
2. D1-D34 IN4001 OR EQUIVALENT
3. FOR REMOTE OPERATION, LOCAL ENABLE JUMPER SHOULD BE REMOVED
4. ② DENOTES CONNECTION TO 5-PIN MOLEX CONNECTOR AT EDGE OF BOARD

FIG. 15 DEMONSTRATOR CONTROL CIRCUITRY

4. Rewind and Fast Forward Buttons

When either of these buttons is momentarily depressed, the unit begins the corresponding function and continues until the stop button is depressed or until the end of the tape is reached.

5. Skip Rewind and Skip Forward Buttons

While the unit is in any operating or stop mode, depressing either of these buttons causes a momentary rewind or fast forward mode. Upon release of either button, the unit proceeds to the play mode.

6. Continuous Play Switch

With this switch in the on position (toward the operator), a cassette is played and replayed until stopped by the operator. During the play mode, when the end of the tape is reached, the unit automatically begins rewinding. When the beginning of the tape is reached, the unit automatically returns to the play mode.

7. Stop Light

This lamp functions only when the power is on and the unit is in the stop mode.

8. Tape Motion Sense Circuit

If the take-up reel ceases to turn, either because the end of the tape has been reached or due to some tape movement malfunction, the unit returns to the stop mode. This circuit is sensitive to motor pulses in the take-up reel motor. There are no pulses if the motor stalls; hence, the unit stops. If the continuous play switch is on, the unit proceeds to the rewind mode and then changes to the play mode.

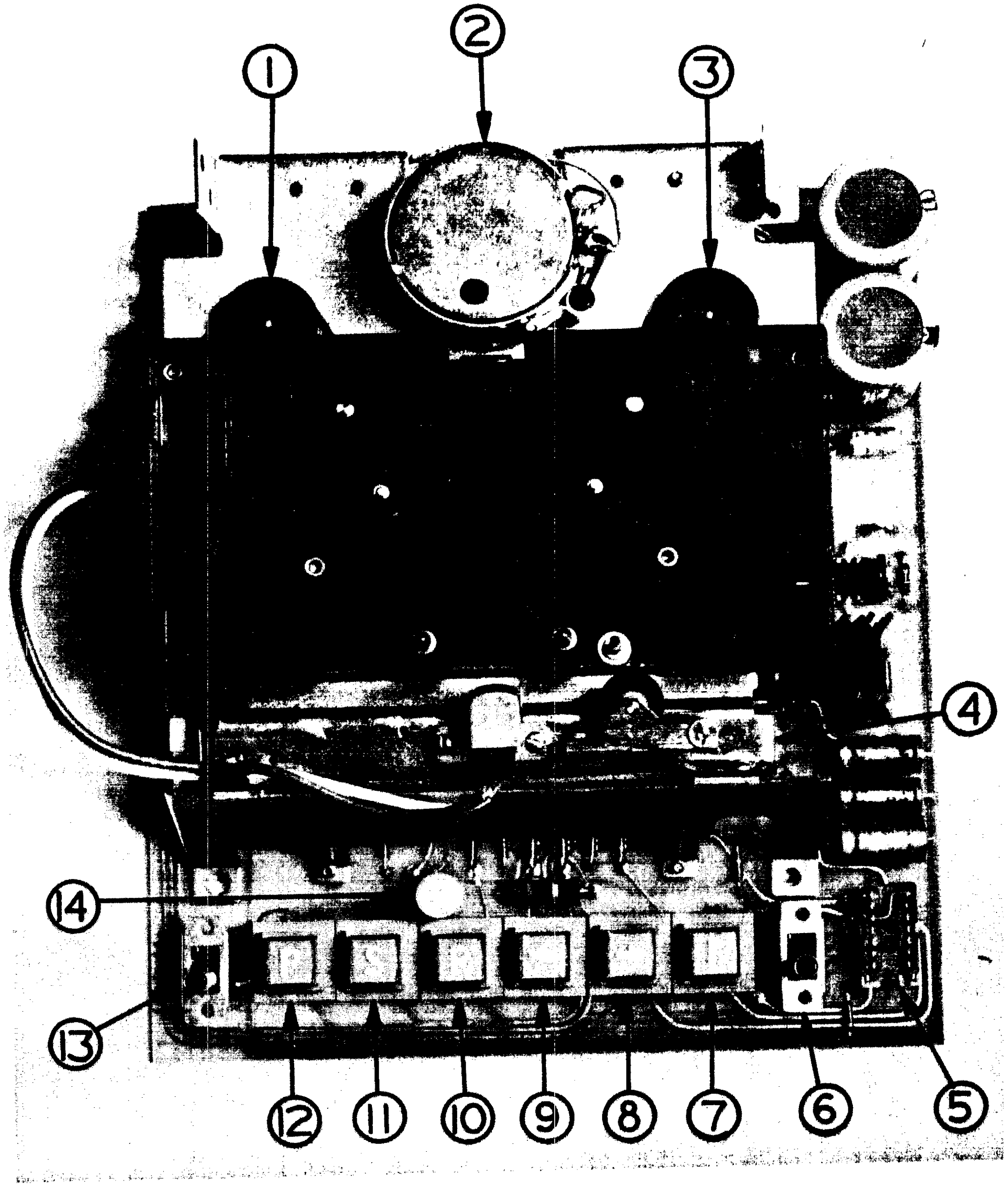


FIG. 16 DEMONSTRATOR TRANSPORT

C. Demonstrator Transport

1. Rewind Motor
2. Capstan Drive Motor
3. Forward Reel Motor
4. Head and Pressure Roller Assembly
5. Remote Socket
6. Continuous Play Switch
7. Fast Forward Button
8. Skip Forward Button
9. Skip Rewind Button
10. Rewind Button
11. Stop Button
12. Play Button
13. Power Switch
14. Stop Light

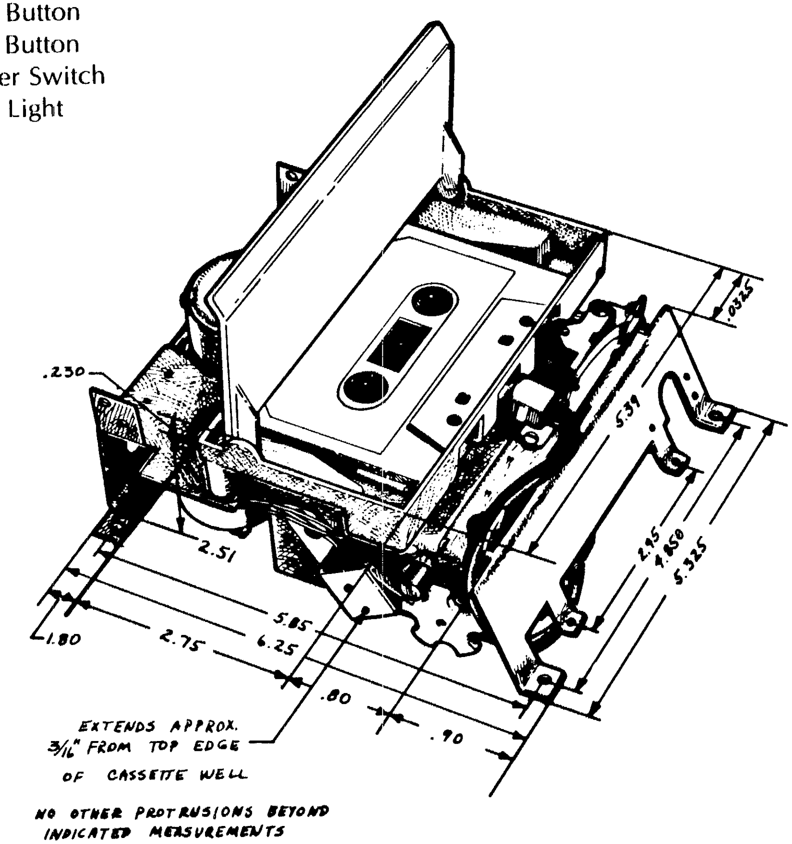


FIG. 17 DIMENSIONS OF DEMONSTRATOR TRANSPORT

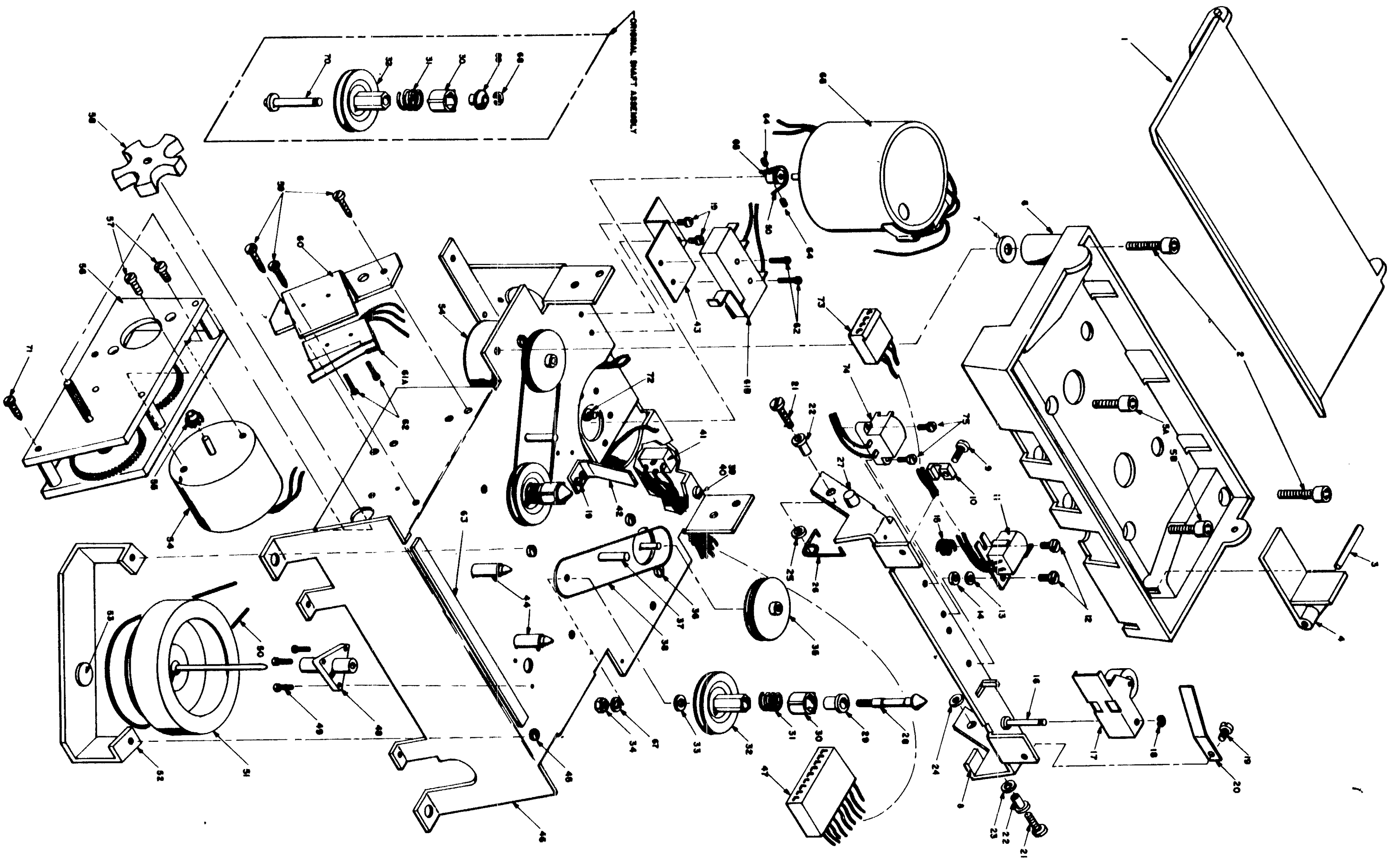


FIG. 18 BREAKDOWN OF PARTS

D. Breakdown of Parts

1. Cassette Door
2. 440x5/8" 18-8 S.S. Socket Head Cap Screw
3. Eject Lever Pin
4. Eject Lever, Cassette

5A. 440x5/16" 18-8 S.S. Socket Head Cap Screw

5B. 440x1/2" 18-8 S.S. Socket Head Cap Screw

6. Cassette Well Blue or Black
7. #4 H.H. Smith Washer
8. Head Pivot Bar 10059
9. 440x1/4" 18-8 S.S. Pan Head Slotted Screw
10. Wire Clamp 10070H
11. R747 Record/Playback Head
12. 2-56x1/4" 18-8 S.S. Pan Head Slotted Screw
13. Washer Waldom MW401
14. Spacer Head .060" 10071FA
15. Head Azmuth Spring 10074E
16. Pressure Roller Post 10071A
17. Pressure Roller Assembly 03-04-06
18. C-Ring Pressure Roller Assembly
19. 4-40x1/8" 18-8 Pan Head Slotted Screw
20. Pressure Roller Spring 10074A
21. 4-40x5/16" 18-8 S.S. Pan Head Slotted Screw
22. Head Bar Pivot Sleeves 10071B
23. Washer, 3/16" ID x 3/8" OD x .032" T
24. Washer, 3/16" ID x 3/8" OD x .062" T
25. Washer, 3/16" ID x 3/8" OD x .047" T
26. Pivot Bar Spring 10074D
27. Head Pivot Bar Activator 10071C
28. Reel Rest Post
29. Reel Rest Cap
30. Reel Rest Slider 10070B
31. Reel Rest Spring 10074C
32. Reel Rest 10070A
33. #4 Washer
34. 4-40 nut
35. Reel Pulley 10070D
36. 2.6 mm x 3 mm Slotted Pan Head Zinc Plated Screw
37. Stud, cassette support 04-14-04B
38. Red O-Ring 45-1.600
39. 440x1/4" 18-8 S.S. Pan Head Slotted Screw
40. Cable Clamp N5590
41. Power Jack 722-A
42. Cassette Tension Spring 10074B
43. Record Lockout bracket
44. Cassette Guide Pin 02-11-02
45. 440x1/4" 18-8 S.S. Pan Head Slotted Screw
46. Chassis 10054
47. Harness Connector 9 CIR 2139-092
48. Flywheel Metal Bearing 02-02-02B
49. 2-52x1/4" 18-8 S.S. Pan Head Slotted Screw
50. Drive Belt 2-3/4" ID .047 C. S. Sq. Cut.
51. Flywheel Assembly 02-02-01
52. Capstan Rest Bracket 10073
53. Flat Round Disc 3/8" x .032"
54. Gear Box Motor MHN-5LB3
55. Pitch Pinion Gear 100701
56. Gear Box Assembly
57. 3.0 mm x 5 mm Slotted Pan Head Zinc Plated Screw
58. Star Wheel 10070E
59. #4x1/2" Pan Head Screw Type A
60. Switch Bracket Head Engage 10077

61A. Snap Switch E61-00H

61B. Snap Switch E61-00H

62. 2-56x3/8" 18-8 S.S. Pan Head Slotted Screw
63. 3-1/2" long urethane roll stock 1/16" thick
64. Motor Pulley Screw
65. Motor Pulley 02-12-03
66. Capstan Drive Motor MIH-516C
67. Star Washer
68. E Washer 1.2 mm
69. Reel Rest Cap 10070C
70. Reel Rest Post
71. #4x3/8" 18-8 S.S. Round Head Slotted Screw
72. 3 mm x 3 mm Slotted Pan Head Zinc Plated Screw
73. Harness connector 4 CIR 2139-4
74. Erase Head
75. 2-56x1/4" Pan Head Slotted Screw

E. Remote Control and External Connections

Located to the right side of the control buttons is a 16-pin DIP socket. This socket provides connections to the various control switches of the board. It allows the operator to use an external, remote control set of switches that can duplicate the functions of the board-mounted controls. To prevent the operation of the six board-mounted control buttons, the local enable jumper between pins 8 and 11 may be removed.

In the corner of the board farthest from the 16-pin DIP socket is a 5-pin Molex connector. This makes the following connections available to ground: the unregulated power input, the regulated 7 volts, and the switching voltage present at the junction of Q19 and Q21 collectors and at the junction of Q16 and Q18 collectors. These connections may be used to power an external audio amplifier or similar equipment.

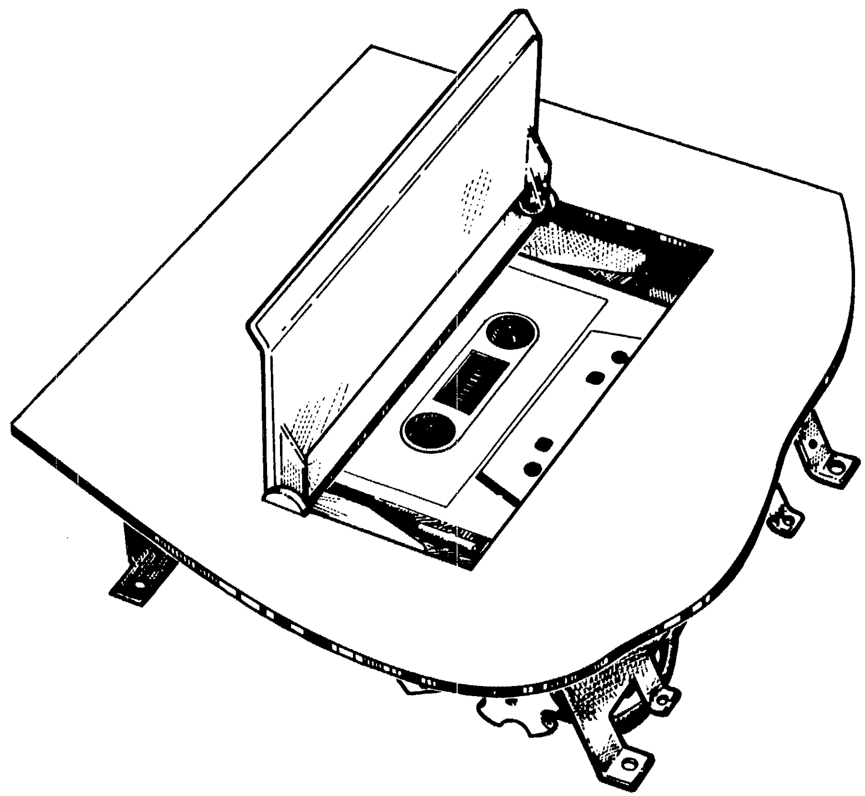


FIG. 19 SURFACE MOUNTING

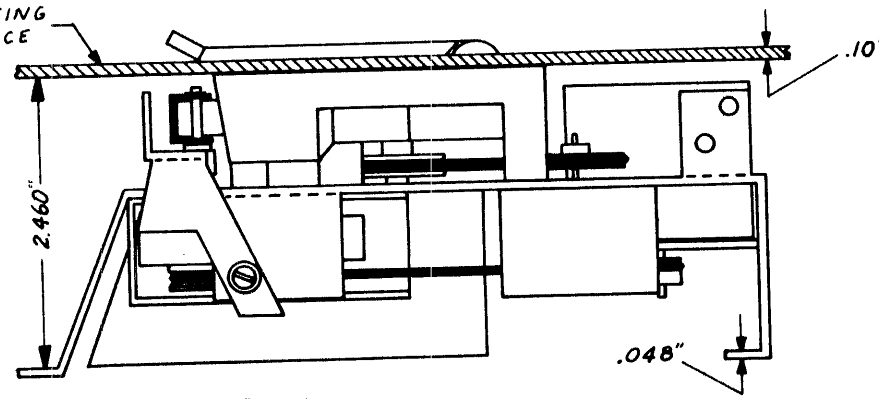
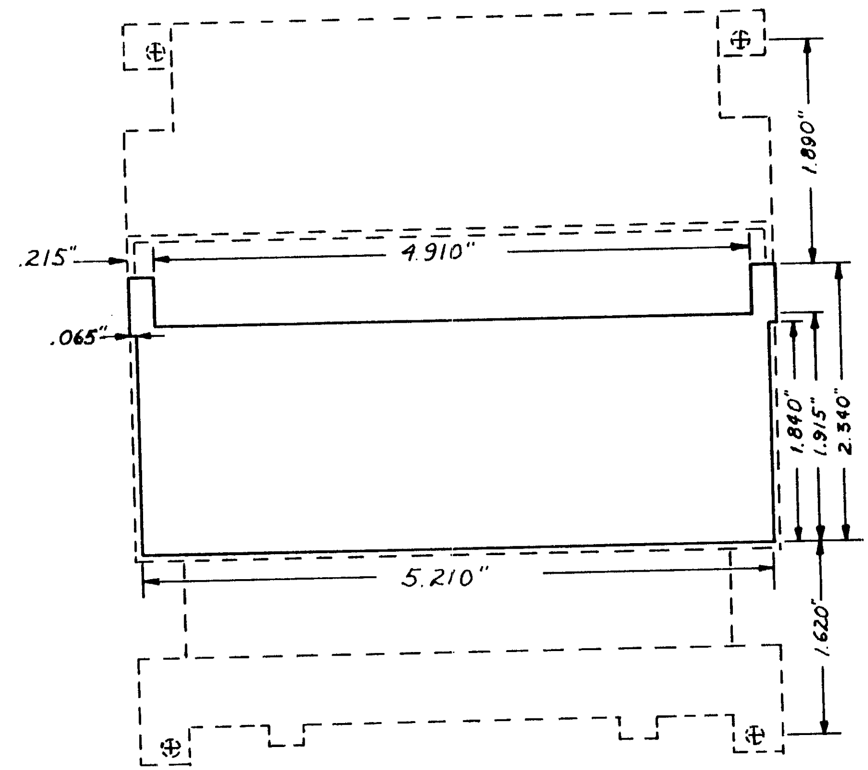


FIG. 20 SIDE VIEW OF SURFACE MOUNTING



THE AREA WITHIN THE SOLID LINE REPRESENTS THE OPENING NEEDED TO SURFACE MOUNT THE PHI-DECK

FIG. 21 DIMENSIONS OF SURFACE MOUNTING

IV. Possible Modes of Operation

Eight modes of operation are possible with a cassette tape. These modes are based on the following principles: the tape moves in one direction or the other at a regulated or unregulated speed, with or without the head engaged. With appropriately designed control circuits, each of the eight modes can be reached from any other mode by remote control.

Tape moving in the forward direction, head engaged, speed regulated: This is the normal play mode. With a standard tape recorded at one and seven-eighths inches per second, the Phi-Deck does this and does it very well. The wow and flutter characteristics are unusually low. The regulated speed, however, can be non-standard. The Phi-Deck speed can be regulated over a great range with the standard motor by altering the pulley arrangement. By substitution of another motor for the standard motor, even greater or lower speeds are obtainable. One electronic configuration even permits the tape itself to govern the speed of the tape movement.

Tape moving in the forward direction, head engaged, speed unregulated: If there is reason to move the tape at an unregulated speed, it can be done. The maximum unregulated speed is sometimes used as a search mode, but since the Phi-Deck can be regulated at very high speeds, unregulated speeds are not usually advantageous.

Tape moving in the forward direction, head unengaged, speed regulated: The Phi-Deck could probably be made to operate in this mode if there were a need for it.

Tape moving in the forward direction, head unengaged, speed unregulated: This is the typical fast forward mode. With standard motors, fast forward on the Phi-Deck takes less than 30 seconds when using a C-60 tape. At these high speeds a tape would break at the end if an electronic end-of-tape sensing circuit were not used. The recommended circuits are not dependent upon specially prepared tapes. Using the tape protection circuits, even tape as fragile as the C-180 can endure the very fast wind and rewind speeds of the Phi-Deck.

Tape moving in the rewind direction, head engaged, speed regulated: Because the Phi-Deck has individual reel drives, it is possible to have reverse play function by electronically reversing the capstan drive and activating the rewind motor instead of the forward motor for the take-up function. The rewind drive current in this instance should be adjusted to accommodate the friction between the head and the pressure pad. An optimized system will result in only a slight increase in typical wow and flutter, approaching the maximum specified. This feature makes the Phi-Deck uniquely simple compared to other systems which use dual capstans and slip clutch change-over mechanisms.

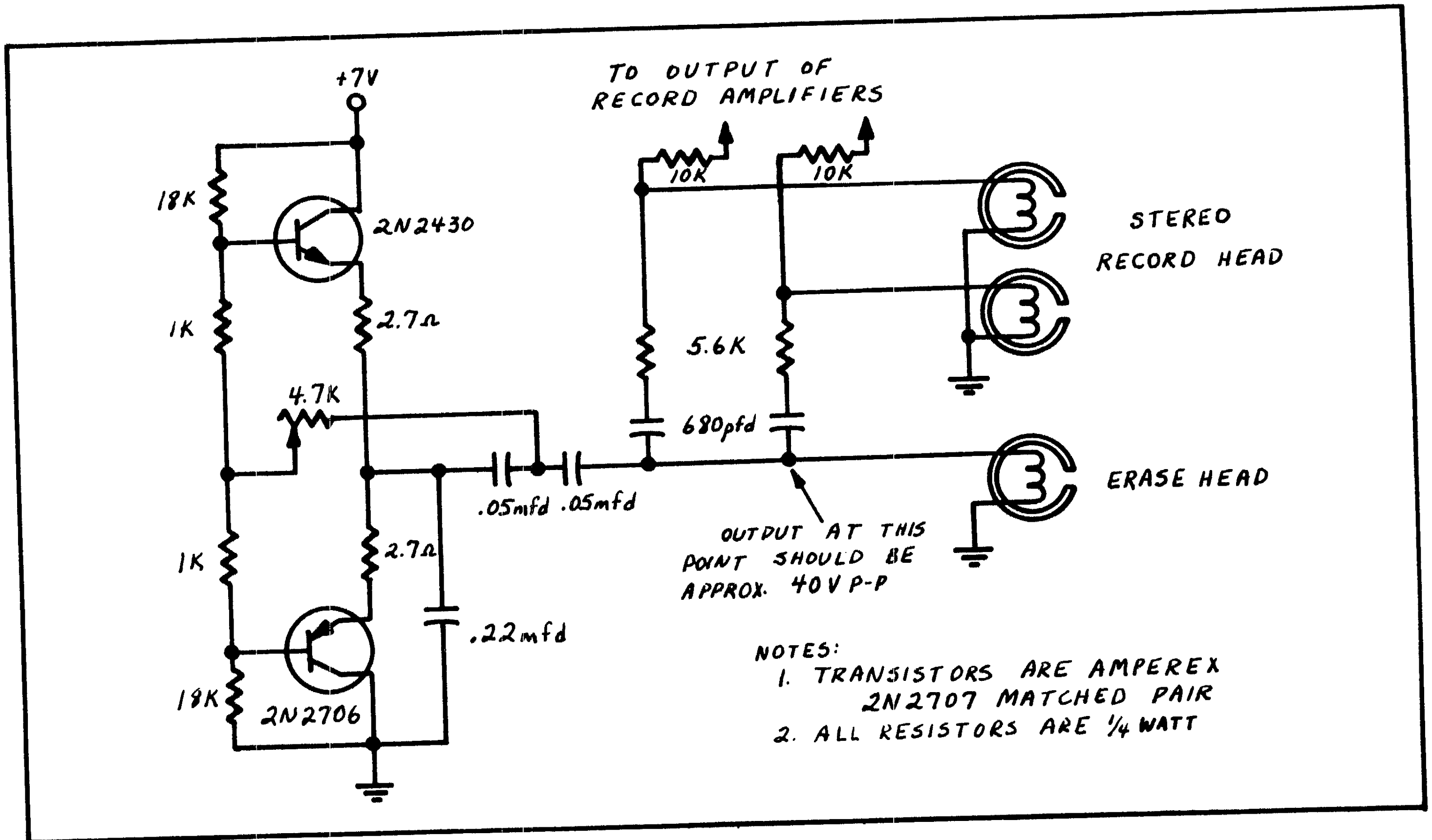


FIG. 22 RECOMMENDED 60 KHZ BIAS OSCILLATOR CIRCUIT

Tape moving in the rewind direction, head engaged, speed unregulated: This may have application for signal searching in the reverse direction and may be of value in some applications.

Tape moving in the rewind direction, head unengaged, speed regulated: This can probably be done if there is a need for it.

Tape moving in the rewind direction, head unengaged, speed unregulated: This is the typical rewind mode. The Phi-Deck operates at an unusually fast speed, rewinding a C-60 tape in less than 30 seconds. When rewinding at these high speeds, it is advisable to use the same tape protection circuitry for rewind that is used to protect tape in the fast forward mode.

V. Alternate Uses

A. Fidelity

Cassette tapes are most commonly used for audio recording. The Phi-Deck has exceptionally good wow and flutter characteristics. It is guaranteed below .25% weighted RMS. The typical machine is .15%. The deck is controlled entirely by electrical switching rather than by mechanical levers, linkages, and cams. The result is that in hi-fi applications, either as a component or as an integral part of a large console, the switches for deck control need not be close to the deck. Unless very high fidelity or remote control justifies the price, offshore decks are recommended.

B. Non-Audio Analog Recording

The Phi-Deck can move tape at any of a large variety of speeds. Since the deck does not use solenoids, it is suitable for remote, unattended locations. It can operate on car battery voltages and amperages. It is possible, with the proper electronic configuration, to get as much as 24 hours of data on one cassette. By using C-180 tape at one-half inch per second, it is necessary to interrupt the tape only three times for less than two minutes at each interruption. C-180 cassettes are difficult to find and very delicate, but can be handled comfortably by the Phi-Deck. The Phi-Deck can record voices with acceptable quality at this low speed. Some applications require intermittent data collection over longer periods of time. With the proper electronic configuration, it is feasible to record bursts of data at either scheduled or unscheduled times. Tape speeds in excess of 5 inches per second may be obtained by simply altering the pulley size on the standard motor. Using a special motor, it is practical to electronically select any speed within a 20 to 1 range.

C. Digital Applications

The Phi-Deck is suitable for a great many digital applications and is similar to analog for isolated data gathering, EPA monitoring, or process monitoring. The standard motors are limited to tape speeds of 5 inches per second with special pulleys. With the use of a special capstan motor, the Phi-Deck moves tape under capstan regulation at a maximum of 15 inches per second. Head engagement time is 180 milliseconds and disengagement is 120 milliseconds in normal production, but the deck can be comfortably operated and is used in our own products at 100 milliseconds and 60 milliseconds respectively. This means that the time from the decision to stop to the actual tape stop is 60 milliseconds. The speed of the tape then determines how much tape is unused in stopping. Though the head engagement takes 100 milliseconds, no appreciable tape loss occurs.

The tape does not move during the time between the decision to engage and the actual engagement. With a slight increase in wow and flutter, the tape can be played in the reverse direction. When a single capstan drive is used, the tape cannot move past the head without capstan regulation.

D. Telephone Answering Devices

The Phi-Deck is a remote controlled cassette tape deck designed originally for audio purposes. These factors make it ideal for use with a telephone answering system. By placing more than one deck in an answering device, it becomes possible to devise an extremely sophisticated telephone answering system including message recording and delivery, message changing, and message retrieval via telephone.

E. Dictation

The fast start, stop, wind, and rewind remote control capabilities of the Phi-Deck make it extremely useful for dictation equipment. The very fast rewind and remote control greatly simplify tape editing. The non-standard speeds make it practical to do high speed searching with the head engaged. With the use of a special motor, searching for coded signals can be done at speeds up to 15 inches per second. Dictation equipment can easily use a non-standard speed if compatability with conventional tape recorders is not critical. The usable voice quality at speeds as low as one-half inch per second greatly increases cassette capacity. For example, a C-60 tape at one-half inch per second has approximately 2 hours of recording time on each side.

F. Automotive

Theft of tape decks from automobiles has been a problem. Since the Phi-Deck is remote controlled, the deck itself can easily be placed out of sight in the dashboard, glove compartment, or even under the seat. The control panel can be mounted on the dashboard. This arrangement makes the deck itself difficult to locate.

G. Programmed Instruction

The Phi-Deck was originally developed for use in a programmed instruction system. When presenting information via tape recorder and asking for a response from the learner, it is important that the learner's thought process not be interrupted by asking him to turn the machine off. To bypass this problem, The Economy Company publishes its instructional programs for children with a coded signal on the tape that signals the machine to turn itself off. It is important that the head disengage and the system be dynamically braked, rather than coast to a stop. With the proper electronic configuration, the Phi-Deck does this. If the machine is allowed to coast to a stop with the head engaged, the tape spools become irregularly stacked, causing the apparent thickness, rather than diameter, of the tape spool to exceed the space allowed inside the cassette. After a great many stops, the take-up reel stalls out, thereby spilling tape out of the cassette due to the constant feeding from the capstan. In other decks this results in the destruction of the tape. With the proper electronic configuration, the Phi-Deck senses that the take-up motor is not turning and that either the end of the tape has been reached or something is wrong. In either case it is time to turn the machine off. The head, therefore, disengages, and the tape slack is automatically taken up, thus saving the tape.

H. Branching Programmed Instruction

Using the proper electronic configuration, it is possible with the Phi-Deck to quickly select any of a reasonable number of messages. Only a few hundred milliseconds occur between the decision point and the commencement of the audio message. This branching audio instruction is part of a computer-based instructional system. For further information, please phone or write Individualized Instruction Incorporated, an affiliate of The Economy Company.

I. Automatic Warning Systems

Recent developments in emergency alarm systems for large buildings require sophisticated audio systems. A system must be capable of directing building occupants to places of safety during an emergency. For example, if a fire breaks out on the fifth floor of a building, at least three distinct sets of instructions will be needed to direct occupants on the fifth floor, occupants below the fifth floor, and occupants on floors above the fifth floor. Elevators may be programmed to go to certain floors, but without the appropriate instructions to direct building occupants, elevator programming may be hazardous. Under the panic or near panic conditions of an emergency, an extremely lengthy list of instructions, only part of which applies to each listener, is highly undesirable. Storm warnings, bomb scares, and other potential disasters can also be handled effectively through the use of an audio system. A small computer coupled with a bank of Phi-Decks containing appropriate messages could automatically deliver the proper message to the proper location in any of a fairly large number of circumstances.

VI. Operation at Other than Normal Speeds

The standard tape cassette is designed for use with a small diameter capstan and a belt-coupled DC motor drive system to yield optimum performance and minimal wow and flutter at a tape speed of one and seven-eighths inches per second.

The following specifications apply to the Phi-Deck capstan drive system and the standard cassette:

Cassette opening for capstan shaft	.175"
Capstan shaft diameter	.07874"
Flywheel pulley diameter (bottom of V groove)	1.250"
Motor pulley diameter (bottom of V groove)	.258"
Motor shaft diameter	.07874"
Pulley ratio	4.837
Tape movement per capstan revolution	.247368"
Capstan RPS @ 1.875 tape IPS	7.5798
Motor RPS @ 1.875 tape IPS	36.6666
Capstan RPM @ 1.875 tape IPS	454.788
Motor RPM @ 1.875 tape IPS	2200
Motor voltage @ 1.875 tape IPS	2.8V DC
Pinch roller pressure	250 to 300 grams
Drive belt dimensions	.047" sq. × 2.75" ID
Capstan bearings	Bronze sleeve type
Motor bearings	Bronze sleeve type

When operating the deck at any speed other than 1.875 inches per second, any or all of the following parameters may be changed:

1. Speed of motor
2. Diameter of capstan
3. Pulley ratio

For optimum performance and longevity the following parameters must be considered:

1. Type of motor
2. Type of belt
3. Type of bearings
4. Limits of motor speed
5. Limits of capstan diameter
6. Limits of pulley ratio

VII. Operation at Lower than Normal Speeds

Since the capstan diameter in cassette drive mechanisms is unusually small, a smaller diameter would be impractical because of the required pressure of the pinch roller.

The pulley ratio may be altered only slightly without resorting to two stages or drastic revision of the flywheel. Since the motor pulley is already quite small, its diameter may only be reduced to approximately .150". This reduction will still allow a decent ratio of the motor shaft diameter to the V-groove bottom. This results in a pulley ratio of 8.3333 and a tape speed of 1.0884 inches per second.

The motor speed may be altered only slightly without resorting to a different drive circuit. The standard adjustment available on the motor may be set to the minimum of approximately 32 revolutions per second. In combination with the pulley change described above, this will reduce the tape speed to approximately .949 inches per second.

Any further reduction in speed is accomplished by changing the motor and/or the drive circuit. Since the standard motor is already operated at a low voltage (2.8V), the voltage cannot be reduced substantially and still allow the motor to start reliably and with adequate torque. The standard motor can be used, however, by removing the internal regulator circuit and utilizing a circuit such as that recommended for the Phi-Deck alternate motor drive. This type of circuit uses feedback from the motor in a way that allows adequate torque with unusually low voltage across the motor terminals. A minimum tape speed of one-half inch per second can be achieved in this manner.

For low speeds the bronze or Delrin sleeve bearings and square-cut belt are optimum; the wow and flutter will increase in approximate proportion to the speed reduction.

VIII. Operation at Higher than Normal Speeds

With all other parameters remaining unchanged, tape speeds up to 5 inches per second may be realized by a directly proportional increase in the size of the motor pulley. This approach will not result in any significant change in the wow and flutter or life of the bearing.

Another way to increase tape speed is by increasing the motor drive voltage. This results in an approximately proportional decrease in wow and flutter. An IC regulator such as the SGS-ATES type TCA-910 may be employed with the standard motor if the internal motor regulator circuit is removed. Minimal wow and flutter will occur at a speed of approximately 5 inches per second. Other types of belts, bearings, and motors should be considered for use with speeds in excess of 5 inches per second.

A wide speed range can be attained by using a round belt of good quality, Delrin capstan bearings, a .650" diameter motor pulley, and a Hico-Maxon motor type 2128-N909, in combination with the recommended alternate motor drive circuit. The wow and flutter with this system is above normal at 1 inch per second, normal at 2 inches per second, below normal at 4 to 6 inches per second, and holds steady or shows a slight increase between 6 and 15 inches per second. Tape speed regulation is affected by many factors, such as belt slippage and capstan slippage. However, for most practical purposes, the tape speed will be consistant if the motor speed is constant. The speed regulation of a hysteresis synchronous motor may be approximated with the use of a DC motor if a proper feedback scheme is employed. The alternate motor drive circuit provides this type of motor feedback, and the regulation may approach that of the power source if good quality resistors and lo-drift components are used. Since DC drift is the main problem, precision resistors and a well-regulated power supply are mandatory for good results.

A higher supply voltage will allow drive speeds higher than 15 inches per second; however, the motor voltage should not exceed 24 volts.

At speeds above 8 inches per second, square-cut belts will flutter badly. A round belt is preferable. However, at certain discrete speeds between 8 and 15 inches per second, even round belts will visibly "sing" in resonance with vibrations of the flywheel and as a result of pulley imperfections. At these speeds this resonance is noticed as an increase in the flutter measurement.

Ball bearings should be used to minimize capstan wear in sustained operation above speeds of 8 inches per second. The 2 mm. capstan diameter will not fit standard U.S. size bearings made for .078 shafts. However, the capstan shaft may be pressed out of the flywheel and replaced with standard .0781" precision stainless ground shafting. Although a friction fit cannot be realized, a drop of rapid bonding or Eastman adhesive will maintain the shaft in the flywheel. A special housing that will accommodate the chassis with only a small increase in the size of the chassis hole is available for PIC E3-1 ball bearings.

Tape speeds up to 25 inches per second may be achieved with the described .0781" diameter capstan and ball bearing arrangement, although some noticeable but insignificant overall vibration will occur. A reduction in vibration can be achieved with properly installed PIC E3-3 ball bearings and an .0934" capstan. A greater diameter capstan shaft is not recommended due to the size of the cassette opening and the limited space available for mounting the bearing housing.

Pulley ratios lower than 2 to 1 and/or motor voltages higher than 24 volts on the 2128-N909 Hico-Maxon motor are not recommended because of excessive vibration.

In general, speeds between 1 and 15 inches per second may be readily achieved with good results and minimal sacrifice in the life and quality of performance.

IX. Tape Position Indication by Use of Digital Counter

If tape position is determined by counting the motion sense pulses with an up-down counter, accuracy is limited primarily by slippage of the belt-coupling between the forward reel and motor. This causes a greater count in the play and fast forward modes than in the rewind mode. If the reel is locked to the motor, accuracy is limited only by spurious pulses or other interference phenomena.

Because the belt-coupling between the reels and motors significantly increases the reel friction, a tight coupling robs power from the reel drive motors and severely limits the ability of the system to perform with tight cassettes and with cassettes of maximum tape reel diameter. Since the friction of the inactive reel presents a load to the driven reel, a balanced system is necessary for equal performance in either direction. Relatively small belts are used which cause minimal friction and optimum reel performance. The standard belts thus strike a compromise between friction and slippage.

It is possible, however, to improve the coupling between the forward reel and motor by knurling the V groove of both pulleys and using a larger belt. This reduces the rewind power somewhat, but results in a substantial improvement in the counting accuracy for tape position indication. An accuracy of plus or minus 1% (or total 2%) is possible unless the cassette has unusual friction.

The play mode will have greater inaccuracy than either the forward mode or the rewind mode. This is due to the greater load on the forward reel motor. Also, since the Phi-Deck demonstrator circuit causes reel braking action during each engage-disengage period, spurious counts will result unless the pulse output line is muted. A 2N4400 transistor may be installed with the emitter to ground, the collector to the count output line (pin 16 of remote connector), and the base connected through a 3.3K resistor to the head engage motor (pin 16 of the deck connector). This arrangement will effectively prevent transient counts during engage-disengage periods.

X. Common Remote Control of Multiple Decks

For language lab and other applications, console control of numerous decks can be accomplished, providing certain precautions are taken. For a single deck with the standard control circuit, the current required for each push-button operation is approximately 50 MA at 12 V nominal supply voltage. Thus, if 10 decks were ganged for common control, the master push button must supply 500 MA or 1 Amp for 20 decks. Therefore, the master switches, control cables, and master power source must all be capable of delivering the power required for the number of decks involved.

The control lines to each deck unit must have individual series diodes to provide isolation between units for local control. This is necessary to prevent all units from operating when any local control function is initiated.

XI. Cassette Type Magnetic Heads

Audio Type Heads

Nortronics
- R/P 4T-4CH: P-W4J
- Language Lab R/P 2T-2CH: W-2P
- Erase 2T-2CH: W2 ER

Michigan Magnetics
Language Lab R/T 2T-2CH: AKS-22
Erase 2T-2CH: EKS-19
Alps
R/P 4T-4CH
Lipps
R/P 4T-4CH: Special

Digital Type Heads

Nortronics
Read After Write
2T-1CH: DC-12P
2T-2CH: DC-22P
Read/Write
Metal Face 2T-2CH: DC-21P
Plastic Face 2T-2CH: DCA-21P
4T-4CH: DC-41J
Combination Read/Write/Erase
2T-1CH: DC1ZR
2T-2CH: DC2ZR
Michigan Magnetics
Read/Write
2T-1CH: DKS-1
2T-2CH: DKS-2
American Magnetics
Read/Write/Erase
2T-1CH: ANCH-11RWE
2T-2CH: ANCH-21RWE

We do not stock any of these heads. Please contact the following firms for prices and specifications on these and other heads. We will, however, deliver decks with special heads as specified by the customer at an appropriate price when quantities exceed 50 decks per order.

Nortronics Company, Inc.
8101 Tenth Avenue North
Minneapolis, Minnesota 55427

FIXED SPEED PHI-DECK SPECIFICATIONS

TAPE:	PHILIPS TYPE CASSETTE
SPEEDS:	FIXED: 1-7/8 STANDARD 2, 3-3/4, 4, 5 OR 6 IPS OPTIONAL
WOW AND FLUTTER:	LESS THAN .25% WRMS AT 1-7/8 IPS
FAST FORWARD OR REWIND TIME:	LESS THAN 30 SECONDS FOR C-60 CASSETTE
DRIVE SYSTEM:	CAPSTAN DRIVE, WITH PINCH ROLLER, UNIDIRECTIONAL, PRECISION GROUND SHAFT, DC MOTOR, BELT AND FLYWHEEL
REEL SYSTEM:	DC MOTOR FOR EACH REEL
HEAD AND PINCH ROLLER ENGAGE/DISENGAGE SYSTEM:	DC MOTOR DRIVEN
OPERATING POSITION:	HORIZONTAL STANDARD -- MULTI-PLANE ON REQUEST
DIMENSIONS:	HEIGHTH - 2.6" WIDTH - 5.4" DEPTH - 6.3"
WEIGHT:	2.2 LBS
START TIME:	LESS THAN 100 MSEC
STOP TIME:	LESS THAN 100 MSEC
POWER REQUIREMENTS:	+12 VDC AT 900 MA

VARIABLE SPEED PHI-DECK SPECIFICATIONS

TRANSPORT

TAPE:	PHILIPS TYPE OR ANSI SPECIFIED CASSETTE
SPEEDS:	VARIABLE: 1 TO 10 IPS STANDARD .4 TO 3 IPS OPTIONAL .6 TO 5.5 IPS OPTIONAL .85 TO 8.5 IPS OPTIONAL
DRIVE SYSTEM:	CAPSTAN DRIVE WITH PINCH ROLLER, .0934" DIAMETER PRECISION GROUND CARBIDE SHAFT, DC MOTOR, BELT AND FLYWHEEL. BIDIRECTIONAL
REEL SYSTEM:	DC MOTOR FOR EACH REEL
HEAD AND PINCH ROLLER ENGAGE/DISENGAGE SYSTEM:	DC MOTOR DRIVEN THROUGH GEARBOX
OPERATING POSITION:	ANY POSITION
SIZE:	HEIGHT: 2.6" WIDTH: 5.4" DEPTH: 6.3"
WEIGHT:	2.2 LBS

TRANSPORT WITH CONTROL BOARD

WOW AND FLUTTER:	LESS THAN .25% WRMS AT 1 7/8 IPS
BIT TO BIT JITTER:	LESS THAN ± 2% AT 4 IPS
SPEED ACCURACY:	± 3%
FAST FORWARD OR REWIND TIME:	LESS THAN 30 SECONDS FOR A C-60 (282 FT) CASSETTE
START TIME:	LESS THAN 100 MSEC
STOP TIME:	LESS THAN 100 MSEC
POWER REQUIREMENTS:	+12 VDC AT 900 MA
SIZE:	HEIGHT: 2.8" WIDTH: 6.2" DEPTH: 6.4"

SUPER DECK SPECIFICATIONS

TRANSPORT

TAPE:	PHILIPS OR ANSI SPECIFIED CASSETTE
SPEEDS:	VARIABLE FROM .4 TO 20 IPS
DRIVE SYSTEM:	CAPSTAN WITH PINCH ROLLER, .0934" PRECISION GROUND CARBIDE SHAFT, DC MOTOR, BELT AND FLYWHEEL, BIDIRECTIONAL
REEL SYSTEM:	DC MOTOR FOR EACH REEL
HEAD AND PINCH ROLLER ENGAGE/DISENGAGE SYSTEM:	DC MOTOR DRIVEN THROUGH GEARBOX
OPERATING POSITION:	ANY POSITION
SIZE:	HEIGHTH - 3.0" WIDTH - 5.5" DEPTH - 6.2"
WEIGHT:	2.8 LBS

TRANSPORT WITH CONTROL BOARD

SPEED ACCURACY:	± 3%
BIT TO BIT JITTER:	± 2%
FAST FORWARD OR REWIND SPEED:	112 IPS AVERAGE
START TIME:	LESS THAN 100 MSEC
STOP TIME:	LESS THAN 100 MSEC
POWER REQUIREMENTS:	+ 18 VDC - 18 VDC + 11 VDC + 7 VDC + 5 VDC

OPTIONS

The options described below are available for all three models of the Phi-Deck except as noted. Consult the individual price sheets for prices.

BOT/EOT SENSOR - The beginning-of-tape, end-of-tape (BOT/EOT) sensor option consists of a light source and light detector arranged to "look" through the tape. The option is designed to work with ANSI specified digital grade tapes. These tapes have a clear leader and trailer preceding and following the oxide portion of the tape. In addition, they have a .024" diameter punched hole located 18 inches from the beginning of tape oxide at both ends of the tape. The sensor will detect both the clear leader and the punched hole in digital grade tapes. The performance of this option with audio grade tapes is not specified since they usually have much more light transmittance than that specified for digital tapes. In addition audio grade tapes do not always have a clear leader or trailer.

When this option is used with the Phi-Deck control boards, tape motion will immediately be halted upon detection of either the BOT/EOT hole or clear leader. This applies to the Run, Rewind or Fast Forward mode.

TAPE POSITION PULSE GENERATOR - For use in locating to a given position on a cassette tape, the Phi-Deck has an optional pulse generating feature. This consists of a slotted disk attached directly to the take-up reel, a light source and a detector. For each revolution of the take-up reel a fixed number of pulses are generated. Since the amount of tape moved for one revolution of the take-up reel varies with the diameter of tape packed on the reel, the number of pulses is not linearly related to tape displacement. However, for a given cassette, the number of pulses can be counted and totalized for locating sections of the tape. The slotted disk is available with 2 pulses per revolution or 18 pulses per revolution. Using the 18 pulse disk allows tape to be positioned to within two inches of a known location.

TAB SENSING - When it is desired to protect a recorded cassette from being erased or written over, there are tabs on the back of the cassette tape case that can be removed. There is one tab for each side of the tape. This option consists of a switch that detects the presence or absence of these tabs. These switches can be installed for either side of the cassette or both sides at once, if desired.

CASSETTE IN PLACE - This option consists of a switch mechanism that will detect when a cassette tape is present in a deck. The switch mechanism is located such that the cassette must be properly seated on the deck to activate the switch. When used with the Phi-Deck control boards, the system will be inhibited from entering the Run, Rewind or Fast Forward modes unless a tape is properly installed and seated on the deck.

CAPSTAN MOTOR PULLEY - The fixed speed Phi-Deck is available with any one of six discrete speeds as listed in the specification sheet. For any speed other than the standard 1-7/8 speed, an optional pulley must be installed in accordance with the speed selected.

The variable speed deck is available in four different speed ranges. A pulley is installed in accordance with the speed range selected.

The Super Deck covers its entire speed range with only one pulley. Therefore, no optional pulleys are required.