SECTION IV
THEORY OF OPERATION

This section provides a block diagram oriented discussion of the functional capability and theory of operation of various configurations of the AG-440C Recorder/Reproducer. The general block diagram discussion is followed by a detailed description of the recorder/reproducer circuits.

GENERAL SYSTEM DESCRIPTION

TAPE TRANSPORT

Tape motion is controlled by the tape transport mechanism for all operation modes. The transport consists basically of a tape supply system, a tape drive system, a tape takeup system, and a control system. These systems provide smooth and positive tape motion across the magnetic heads, and maintain correct tape tension.

A separate motor drives the supply and the takeup assembly. These two motors are connected so that if power is applied with no tape threaded, the turntables will rotate in opposite directions; the supply turntable clockwise and the takeup turntable counterclockwise.

In the play or record modes of operation, the capstan controls tape speed; it pulls tape from the supply reel and delivers it to the takeup reel. The motor torque, and therefore tape tension, is adjusted by means of adjustable resistors, one for the supply and the other for takeup. Each of these resistors has two sliders to permit tape tension adjustment for any combination of large and small reels.

During fast-forward or rewind operation, the capstan is disengaged from the tape. The power of one of the motors is reduced by switching an adjustable resistor in series with the appropriate motor, while the other motor continues to operate at full power. The turntable under full power pulls the tape against the torque of the other turntable, which provides the required tape tension.

A brake controlled by two solenoids is mounted on each of the two torque motors. The main-brake solenoid on each motor is energized (brakes released) whenever tape is placed in motion in any mode. The edit-brake solenoid on each motor is energized in the stop/edit and play/edit modes to control the braking force at each turntable.

The capstan drive is provided by either a servo-controlled DC capstan motor or an AC capstan motor, depending on the tape transport selected. The capstan is at the end of the capstan motor shaft and is precision machined and hardened. AC motors have a flywheel and fan mounted on the shaft at the other end of the motor. A solenoid-controlled capstan idler presses the tape against the capstan to provide the driving friction against the tape.

The AC capstan drive motor has separate windings for each of the two tape speeds. A speed toggle switch selects the desired tape speed, and also automatically switches in the correct equalization circuit for each speed. Speed control of the servo type capstan motor is discussed in the Operation section (Section III) of this manual.

When the recorder/reproducer is in the play or record mode, the capstan idler solenoid is energized. When the capstan idler solenoid energizes, the capstan idler moves and presses the tape against the rotating capstan. The main brake solenoids are also energized, releasing the brakes, and the capstan drives the tape across the head assembly at the selected speed.

A reel idler assembly on the left side of the transport minimizes any tape motion transients caused by the supply assembly. The reel idler arm minimizes initial strain when tape motion starts (to

avoid stretching or breaking the tape) and prevents formation of a tape loop between the supply reel and the heads. The reel idler flywheel serves to dampen transients in tape speed that could result from torque motor cogging (not moving smoothly) and uneven tape pack on the supply reel.

The tape takeup tension arm has two functions; it tensions the small tape loop that is formed while the takeup reel is achieving normal speed during start, and it actuates the safety switch to stop operation if a large tape loop forms, or if the tape breaks. The tension arm also actuates the safety switch if either reel runs out of tape. The guide for the tape is similar to that on the reel idler. A tape hook holds tape on the guide during threading and when the tape becomes slack.

A solenoid-operated tape lifter assembly raises the tape from contact with the heads during fast-forward or rewind operation. When either mode starts, the tape lifter solenoid energizes and moves the tape lifter mechanism. The tape lifter is defeated as long as the edit pushbutton is pressed.

BLOCK DIAGRAM FUNCTIONAL DESCRIPTION

Figure 4-1 shows a general block diagram of the AG-440C Recorder/Reproducer. As shown in the figure, the AG-440C can be configured to record and reproduce up to four audio channels. Each audio input may come from a microphone or another audio source, such as another tape reproducer. A microphone amplifier input accessory is used when the audio input comes from a microphone.

Reproducing

With the recorder/reproducer turned on and the tape properly threaded, selecting the reproduce mode causes the control circuitry to release the main reel brakes and to enable the reel motors, the capstan motor, and the capstan idler. As a result, the recorded tape is pulled past the heads at a constant speed. The signal sensed by the record (Sel-Sync operation) or reproduce head is equalized and amplified.

Recording

In the record mode the tape is moved as in the play mode. During recording an erase signal from an internal oscillator is fed to the erase head(s), which clear(s) any previously recorded signals from the tape before it reaches the record head(s). Information to be recorded is amplified, mixed with a bias signal, and applied to the record head(s). The information is recorded on the tape as it is pulled past the record head(s).

Fast Forward/Rewind

With the recorder/reproducer turned on and the tape properly threaded, selecting the fast forward mode locally or remotely causes the control circuitry to release the main reel brakes and apply full power to the takeup reel motor and hold-back power to the supply reel motor. The control circuitry also causes the tape to be lifted away from the heads. Tape is then rapidly wound onto the takeup reel. The rewind mode is similar to the fast-forward mode except that full power is applied to the supply reel motor, and the tape is rapidly wound onto the supply reel.

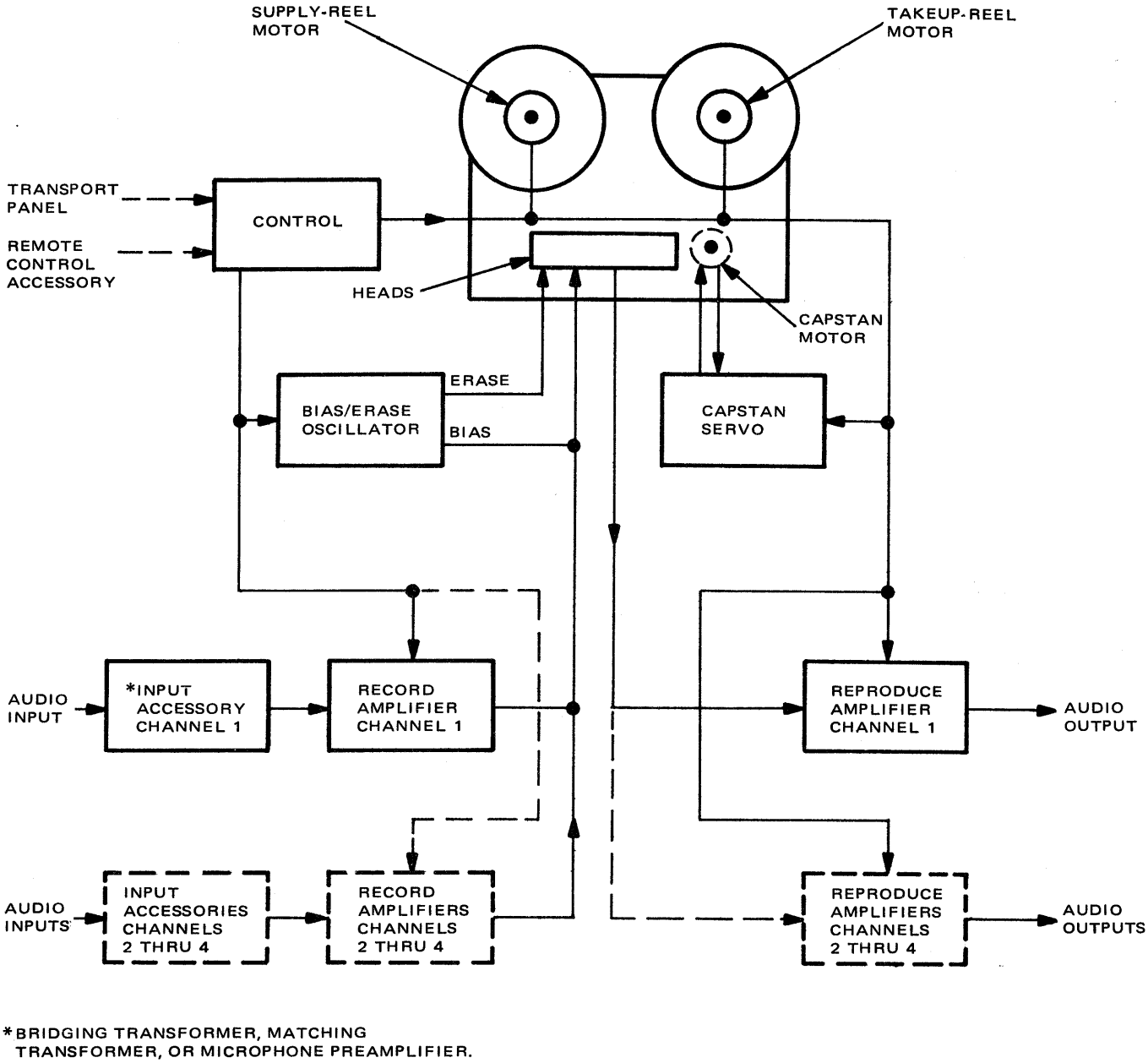
Edit

Three edit modes are selectable at the front panel of the recorder/reproducer: stop/edit, fast wind/edit, and play/edit. Selecting the stop/edit mode sets only the edit brakes of the tape-reel motors, thus facilitating manual cueing and threading of the tape. Selecting the play/edit mode causes the tape to be pulled past the heads and spilled off the right side of the transport. This mode is typically used when unwanted tape is to be cut off. The fast-wind/edit mode brings the tape into contact with the heads while the tape is being moved in the fast-forward or rewind modes, making the recorded portions audible for high speed search.

DETAILED CIRCUIT DESCRIPTION

CONTROL CIRCUITRY

The control circuitry is principally located on the tape transport and the transport control printed wiring assembly (PWA). Figures 4-2 through 4-7



*BRIDGING TRANSFORMER, MATCHING TRANSFORMER, OR MICROPHONE PREAMPLIFIER.

Figure 4-1. AG-440C Recorder/Reproducer, System Block Diagram

provide simplified functional versions of the complete schematic diagrams found in Section VI of this manual.

The transport control circuits utilize three DC power supplies: 130 Vdc (CR602 through CR605) to operate the solenoids, 24 Vdc (CR113 through CR116) to operate the relays and logic circuitry, and the 39 Vdc electronics power supply which supplies logic power when the 24V power supply is deactivated by the safety switch.

Four relays are associated with transport functions: Play (K602), Edit (K603), Fast Forward (K604), and Rewind (K601). These relays control the power to the solenoids and motors in addition

to performing logic functions. The transistor logic located on the plug-in printed wiring board coupled with the logic of the relays, control energizing of these relays.

The general functions of transistors on the logic board are described below:

Q101, Q102, Q103 — Fast wind motion sense.

Q104, Q107 — Stopping the play and edit modes (de-activation of the play and edit relays).

Q105 — Record stop delay which delays the stopping of the transport until the bias decays.

Q106 — Record detector that senses when any electronics is recording.

Q108 — Fast wind stopping, when the PLAY pushbutton is pressed.

Q109, Q110, Q111 — Play memory circuit which remembers that the PLAY button was pressed during a fast wind mode.

Play Mode

The tape transport will enter the play mode whenever the play relay (K602) is energized. Relay K602 is energized by application of a positive voltage to relay pin 14 if Q107, in the ground leg of the relay, is in a conducting state. The play mode is terminated by turning off Q107. Transistor Q107 also controls the turn off, or inhibiting, of the edit relay (K603).

Positive voltage can be applied to the play relay via three paths: PLAY pushbutton S608, remote control PLAY pushbutton, and the play memory circuit (Q109, Q110 and Q111). The play memory circuit remembers that the PLAY pushbutton was pushed during a fast wind mode and when the tape comes to a stop, the play relay is energized. Detailed operation of the play memory circuit is explained after the turn-off action of Q107 is discussed.

In the standby condition, Q107 is held in a conducting state by two means: application of +24V to the base of Q107 through CR111, R116 and CR112, or application of +39V to the base of Q107 through CR110, VR102, R116 and CR112. Q107 can be turned off or inhibited by several means. If Q104 conducts, the base drive to Q107 is shunted to ground through the collector of Q104 and R110. If the FAST FWD or REWIND pushbuttons are pressed, Q104 is turned on by application of a positive voltage through the normally open pushbutton contacts CR107 or CR106, and R109. Transistor Q104 will also conduct when the local or remote STOP pushbutton is pressed. Pressing STOP removes a ground from the junction of R113 and CR109 and turns on Q104 by delivering base drive through R113, CR109 and R109. If Q106 (the record detector explained in the *Control Circuitry/Record Mode* text) is turned on, the ability of Q104 to turn off Q107 is overridden, since Q106 applies additional positive current to the base of Q107 through R118 and CR112. Therefore, pressing FAST FWD or REWIND will not stop the play mode if the recording process is active.

Q107 will also be turned off whenever the fast motion circuit (Q101, Q102, and Q103) is active (discussed in *Control Circuitry/Fast-Forward* text). Base drive is removed from Q107 by conduction of Q103 through CR104. Operation of the play memory circuit is described in the following paragraph.

Whenever fast wind motion is present, the junction of CR121 and CR120 is held positive; either through Q108, K604-11/7 or K601-11/7 and CR117, or through R105, Q101, and CR101 (during fast-wind deceleration). However, this positive voltage will not turn on Q109, Q110 or Q111 and they will remain off until the PLAY button is pressed. At this time Q108 turns off since CR119 back-biases the emitter-base junction of Q108 and the fast forward or rewind relay de-energizes. The positive edge of the pulse created when the PLAY button is pressed passes through C109, R122 and CR122 to the base of Q111. This causes Q111 to conduct, which causes Q110 to conduct. Q110 now supplies the base drive to Q111 through R124 and CR120. Transistors Q110 and Q111 latch into the conducting state and remain latched as long as the CR120/CR121 junction is high or a charge is present on C108. When the junction of CR120 and CR121 is high, CR120 acts as a forward-biased diode to charge C108. When this junction falls to ground potential, after fast wind tape motion has

stopped, CR120 acts as a zener diode to remove most of the charge from C108.

Even though Q111 is conducting, Q109 (which supplies positive voltage to the play relay) cannot conduct because its base circuit is back-biased by CR121. When tape motion finally stops, the positive voltage is removed from the junction of CR121 and CR120. However, the Q110/Q111 latch remains conducting due to the charge on capacitor C108. The base of Q109 will now conduct through VR103, R121, Q111, CR123 and STOP button S606 to ground. Therefore, Q109 will supply a positive pulse to the play relay and the tape transport will enter the play mode, since Q107 has also returned to its normal conducting state.

Contact set K602-9/5 supplies +24 Vdc via CR609 to the coil of relay K602 to keep it energized after the positive levels from the local PLAY pushbutton, remote PLAY pushbutton, or play memory circuit are gone. In addition, the positive level supplied through contact set K602-9/5 keeps the capstan servo (if used) enabled.

Contact set K602-10/6 (Figure 4-2, Sheet 2), supplies 80 Vac to the takeup tension (R606) and holdback tension (R607) resistors. Each of these variable resistors has two movable contacts. One of the movable sliders on R606, R607 is used to adjust tape tension when using a small tape reel, and the other movable slider of R606 and R607 is used for large reel tape tension adjustment. A REEL switch for each resistor (R606 and R607) is used to select the appropriate movable contact. The output of R606 is routed through contact set K604-2/10 to the takeup motor (B602). The opposite side of the takeup motor (B602) is connected to the AC neutral line through contact set K603-4/12 of the edit relay and the safety switch (S603) of the tension arm. The output of R607 is routed through contact set K601-2/10 to the rewind motor. The opposite side of the rewind motor (B603) is connected to AC neutral through the safety switch (S603) of the tension arm. Resistor R602 and capacitor C611, resistor R605 and capacitor C613 and capacitor C610 minimize contact arcing.

Contact set K602-8/12 connects +130 Vdc to the rewind main brake solenoid (K607) and to the takeup main brake solenoid (K605) through contact set K603-3/11 of the edit relay. Capacitor C615 shunts inductive transients to ground.

Contact set K602-7/11 connects +130 Vdc to the capstan solenoid (K610). Diode CR615 dampens the inductive kick when the solenoid is de-energized.

With the reel motors energized, the main reel brakes disengaged by the main brake solenoids, the capstan servo enabled (if applicable), and the capstan pinch roller pulled in by the capstan solenoid, the tape is pulled forward at the correct speed and tension for the play mode.

Record Mode

The record mode is initiated by pressing the local or remote RECORD and PLAY pushbuttons. Pressing either PLAY pushbutton initiates the circuit action described in the *Control Circuitry/ Play Mode* text. Pressing either RECORD pushbutton connects the +24 Vdc present at pin 9 of relay K602 to the base circuit of transistor 9Q1. (See Figure 4-3.) Providing the local or remote STOP pushbutton is not depressed and the SAFE/ READY switch is set to READY, the positive level at the base of transistor 9Q1 turns on the transistor. The collector current of transistor 9Q1 is supplied to the bases of transistors 9Q2 and 9Q3. The collector current of transistor 9Q2 keeps transistor 9Q1 conducting. The emitter current of transistor 9Q2 is routed through diode 9CR1 and resistor 9R5 to the base of transistor Q106 (Figure 4-2), which turns on Q106. The current supplied to the base of transistor 9Q3 (Figure 4-3) turns it on. In turn, the collector current of transistor 9Q3 turns on transistor 9Q4 and, after a delay caused by capacitor 8C1, 9Q3 turns on the bias/erase amplifier. Turning on transistor 9Q4 causes relay 4K1 to energize and the RECORD lamp to light. In addition, turning on transistor 9Q4 provides another path for base current of transistor Q106 (Figure 4-2).

With transistor Q106 turned on, the resulting high level at its collector forward biases the base/emitter junction of transistor Q105. Transistor Q105 and capacitor C105 form a stop-memory circuit that is only active in the record mode. When either the local or remote STOP pushbutton is pressed,

capacitor C105 charges through diode CR109 and resistor R113 (Figure 4-2). Also, the emitter circuit of transistor 9Q1 is opened (Figure 4-3).

Opening the emitter circuit of 9Q1 turns off transistor 9Q1, 9Q2, and 9Q3. Transistor 9Q4 is held on by the charge on capacitor 8C1, which keeps record relay 4K1 energized and transistor Q106 conducting (via 9R6 and 9CR2). (See Figures 4-2 and 4-3.) Consequently, transistor Q107 is held on by the collector current of Q106, which keeps play relay K602 energized. As soon as 9Q3 turns off, the voltage on 8C1 starts to decay, causing the bias and erase voltage to decay.

The time constant associated with capacitor C105 (Figure 4-2) is longer than that associated with 8C1 (Figure 4-3). As a result, transistor Q104 is still conducting when the charge on 8C1 becomes low enough to turn off the bias/erase amplifier and transistor 9Q4. Turning off 9Q4 turns off the record relay 4K1, the RECORD lamp, and transistor Q106. Turning off Q106 allows Q104 to turn off Q107, which turns off play relay K602, thus causing the tape to be stopped. When C105 has discharged enough to turn off Q104, transistor Q107 is turned on again by the current flowing through R116, CR112, and the base/emitter junction of Q107 returning the circuit to the standby condition. The technique of slowly turning off the bias/erase oscillator before the tape is stopped prevents switching transients from being recorded.

Fast-Forward Mode

The fast-forward mode is initiated by pressing the local or remote FAST FWD pushbutton. In either case, a nominal +24-volt level is applied through diode CR107 (Figure 4-4) to the base circuit of transistor Q104 (Figure 4-2) and through diode CR108 (Figure 4-4) to relay K604.

If the play mode is in operation, the positive level applied to the base circuit of Q104 (Figure 4-2) immediately turns it on. Turning on Q104 turns off Q107, which de-energizes play relay K602. As a result, the play mode is terminated before fast-forward becomes active.

If the record mode is in operation when fast-forward is pressed, transistor Q106 prevents Q104 from turning off Q107 as described in the *Control Circuitry/Record Mode*. This prevents the tape transport from entering a fast mode during recording.

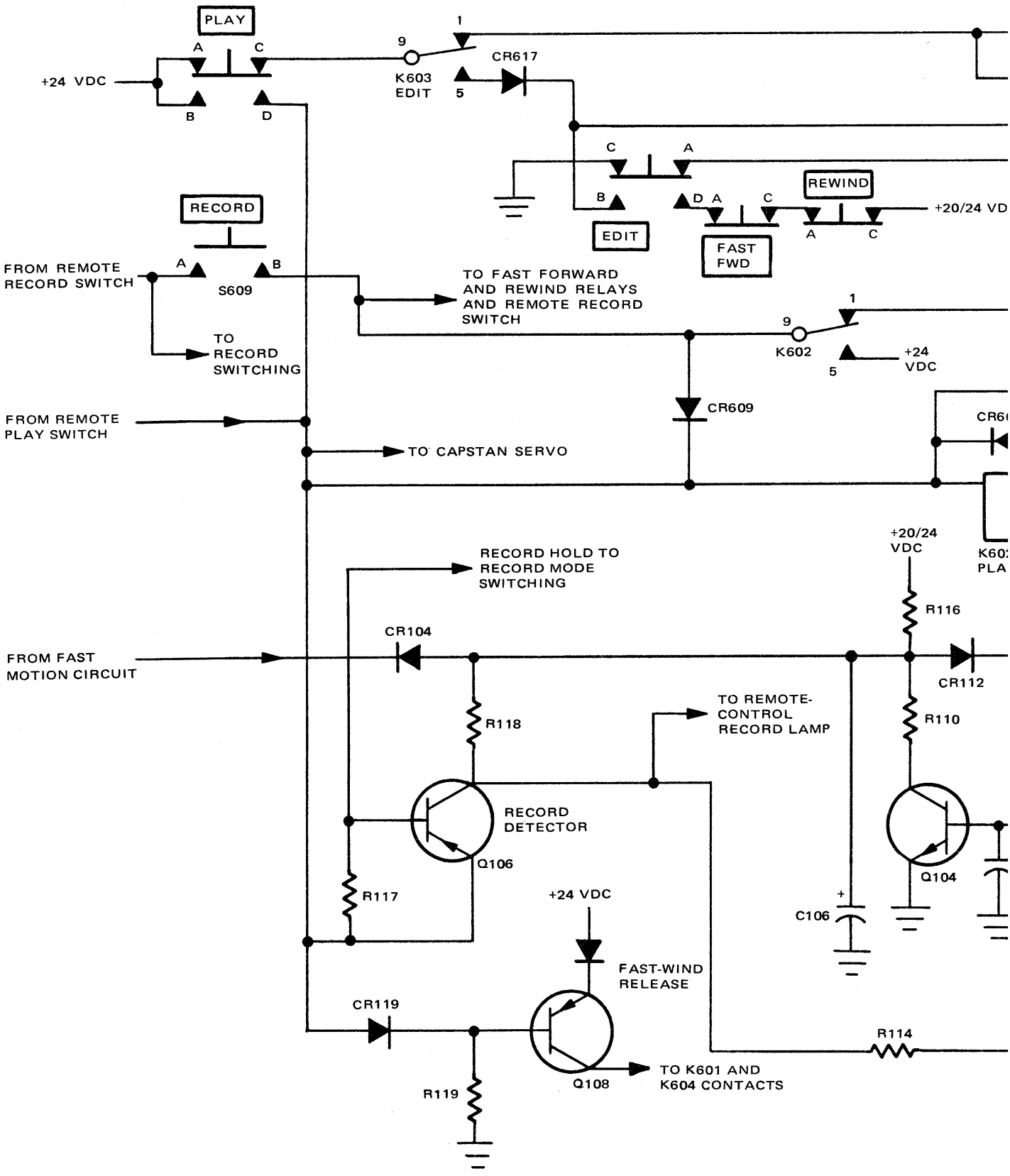
Providing the local or remote STOP pushbutton is not depressed (Figure 4-4) and play relay K602 is not energized, the coil of relay K604 is energized when the local or remote FAST FWD pushbutton is pressed. Energizing the coil of relay K604 transfers its associated contact sets, causing the circuit action described in the following paragraphs.

Contact set K604-5/9 and K601-3/11 connects a nominal +24-volt level from the collector of normally on transistor Q108 to the coil of relay K604 to keep it energized. The return path for the relay current is through play relay contacts K602-9/1, CR610 and STOP pushbutton S606 to ground. Thus, the recorder/reproducer is held in the fast-forward mode after the FAST FWD pushbutton is released.

Contact set K604-7/11 connects a nominal +24-volt level from the collector of transistor Q108 to the coil of relay K101. As a result, relay K101 is energized; and its closed contact set connects +130 Vdc to the tape-lifter solenoid (K609), which energizes the solenoid. Diodes CR102 and CR616 dampen the inductive transient produced when the coils of K101 and K609, respectively, are de-energized.

Contact set K604-6/10 connects either 80 Vac or 117 Vac (depending on setting of the REEL switch) to the takeup motor (B602) and variable resistor R603 (fast motion holdback). The output of R603 is applied to the supply motor (B603). The takeup motor is connected through contact set K603-4/12 to the safety switch (S603) on the tension arm, and the supply motor is connected directly to the safety switch. With the tape properly threaded, the safety switch is closed, and the AC circuits for the takeup and supply motors are completed. Resistor R605 and capacitor C613 and capacitor C610 minimize contact arcing.

Contact set K604-8/12 connects +130 Vdc to the supply main brake solenoid (K607) and to the takeup main brake solenoid (K605) through contact set K603-3/11 of the edit relay. Capacitor C615 suppresses inductive transients.


PLAY
A
C
B
D
+24 VDC
9
1
K603
EDIT
5
CR617
C
A
B
EDIT
D A
C
REWIND
A
C
+20/24 VD
FAST
FWD
RECORD
A
B
S609
FROM REMOTE
RECORD SWITCH
TO RECORD
SWITCHING
TO FAST FORWARD
AND REWIND RELAYS
AND REMOTE RECORD
SWITCH
9
1
K602
5
+24
VDC
CR609
FROM REMOTE
PLAY SWITCH
TO CAPSTAN SERVO
CR6
K60
PLA
+20/24
VDC
RECORD HOLD TO
RECORD MODE
SWITCHING
R116
CR104
FROM FAST
MOTION CIRCUIT
CR112
R118
TO REMOTE-
CONTROL
RECORD LAMP
R110
RECORD
DETECTOR
Q106
Q104
R117
+24 VDC
C106
+
FAST-WIND
RELEASE
CR119
R114
Q108
TO K601 AND
K604 CONTACTS
R119

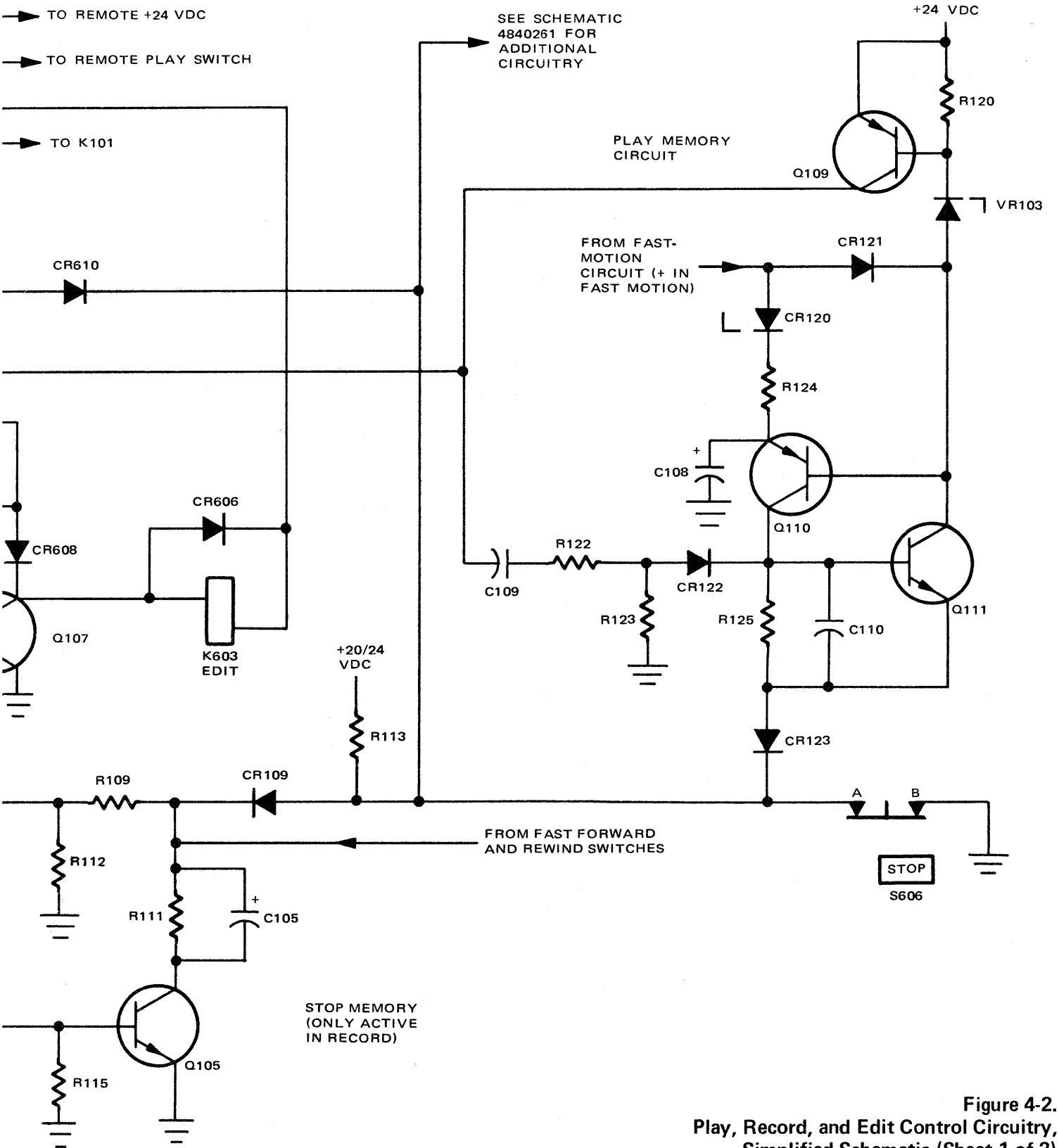
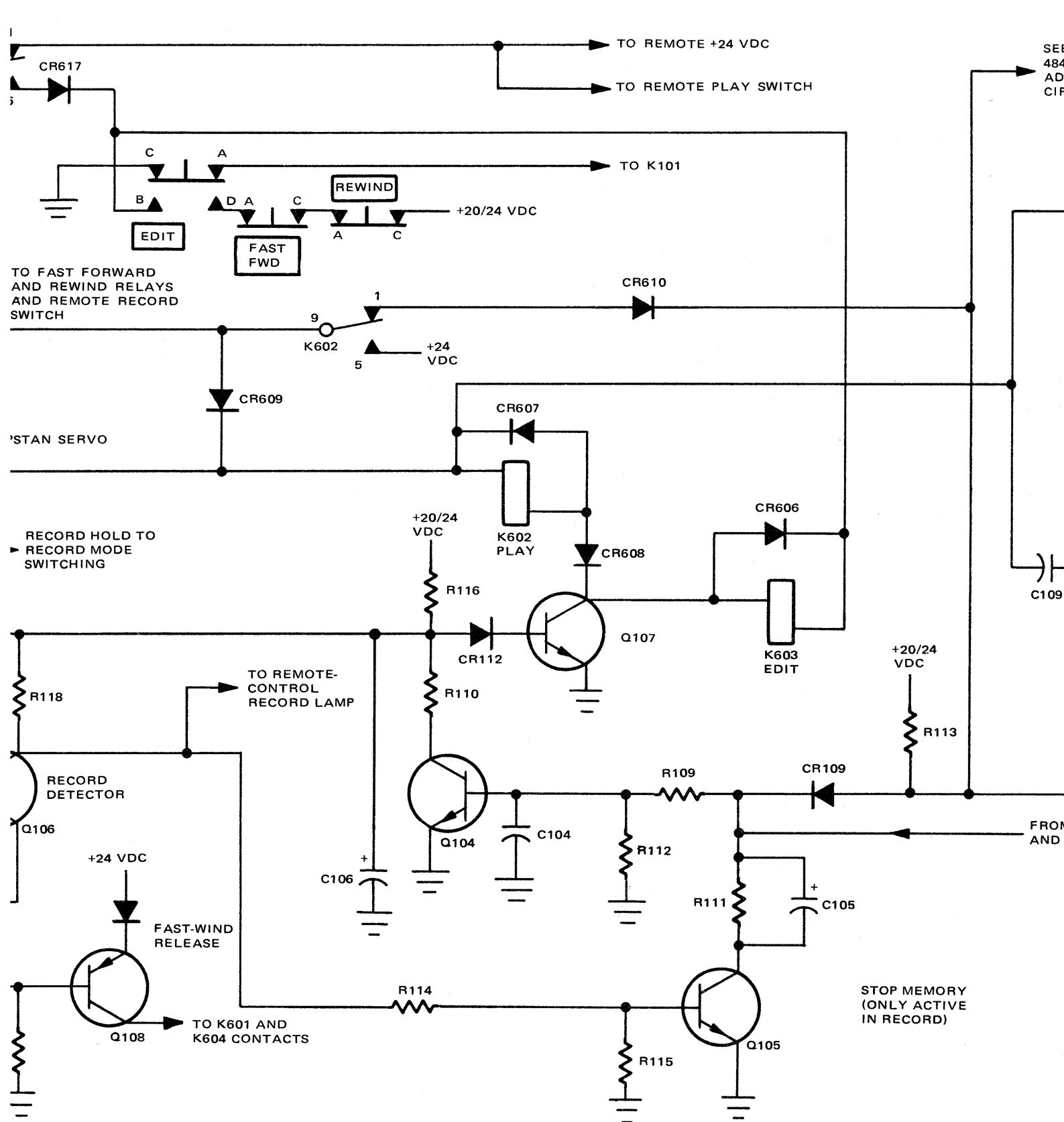
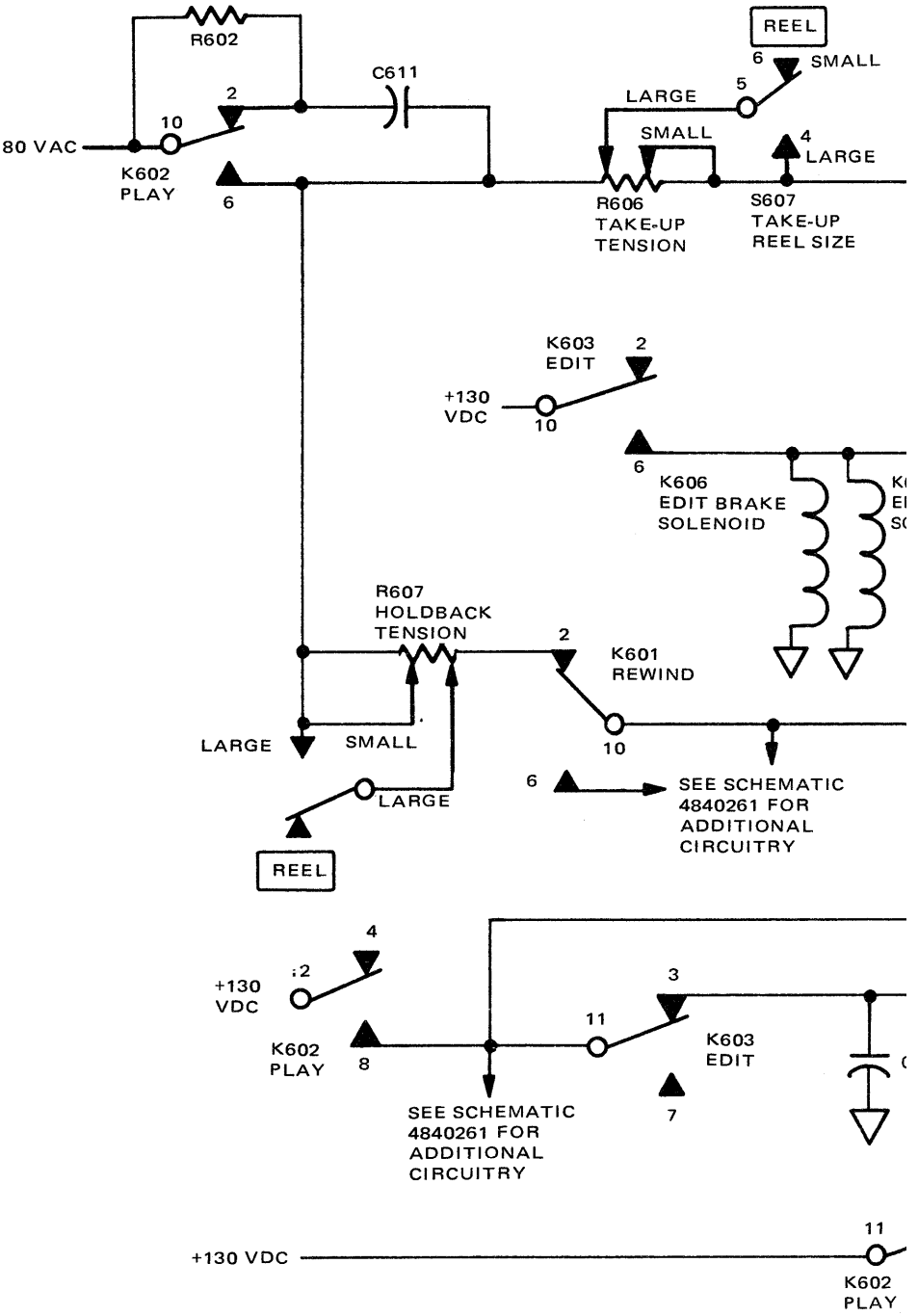


Figure 4-2.
Play, Record, and Edit Control Circuitry, Simplified Schematic (Sheet 1 of 2)


TO REMOTE +24 VDC
TO REMOTE PLAY SWITCH
CR617
C
A
TO K101
B
D
A
C
REWIND
+20/24 VDC
A
C
EDIT
FAST FWD
TO FAST FORWARD AND REWIND RELAYS AND REMOTE RECORD SWITCH
CR610
1
9
K602
5
+24 VDC
CR609
CR607
'STAN SERVO
RECORD HOLD TO RECORD MODE SWITCHING
+20/24 VDC
K602 PLAY
CR608
CR606
R116
Q107
CR112
K603 EDIT
C109
R118
TO REMOTE-CONTROL RECORD LAMP
R110
+20/24 VDC
R113
RECORD DETECTOR
Q106
Q104
C104
R109
CR109
R112
C106
R111
C105
+24 VDC
FAST-WIND RELEASE
R114
STOP MEMORY (ONLY ACTIVE IN RECORD)
Q108
TO K601 AND K604 CONTACTS
R115
Q105


R602
C611
REEL
6
SMALL
LARGE
5
2
10
80 VAC
K602
PLAY
6
SMALL
4
LARGE
R606
TAKE-UP
TENSION
S607
TAKE-UP
REEL SIZE
K603
EDIT
2
+130
VDC
10
6
K606
EDIT BRAKE
SOLENOID
R607
HOLDBACK
TENSION
2
K601
REWIND
LARGE
SMALL
10
6
SEE SCHEMATIC
4840261 FOR
ADDITIONAL
CIRCUITRY
LARGE
REEL
4
+130
VDC
2
3
11
K602
PLAY
8
K603
EDIT
7
SEE SCHEMATIC
4840261 FOR
ADDITIONAL
CIRCUITRY
11
+130 VDC
K602
PLAY

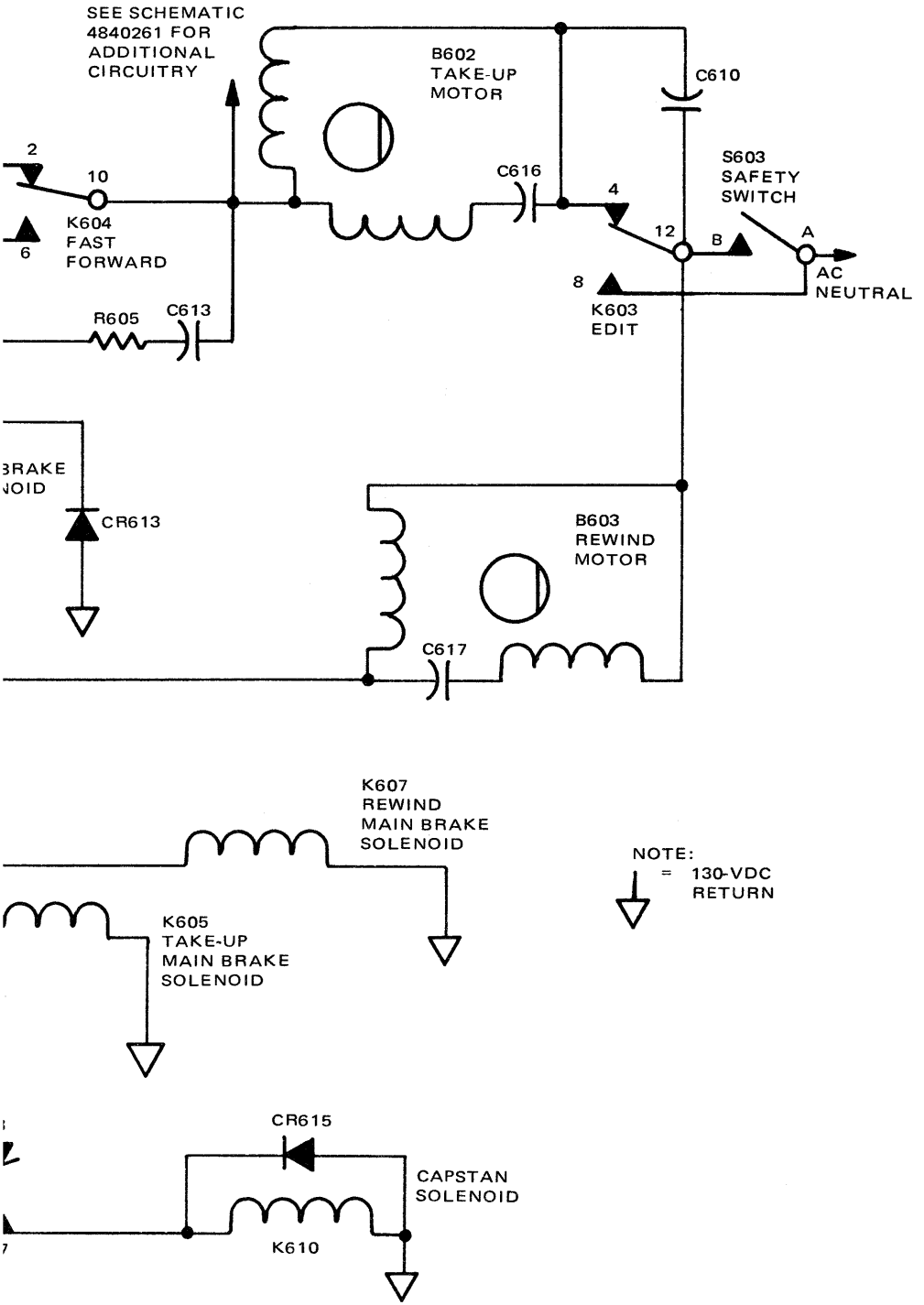
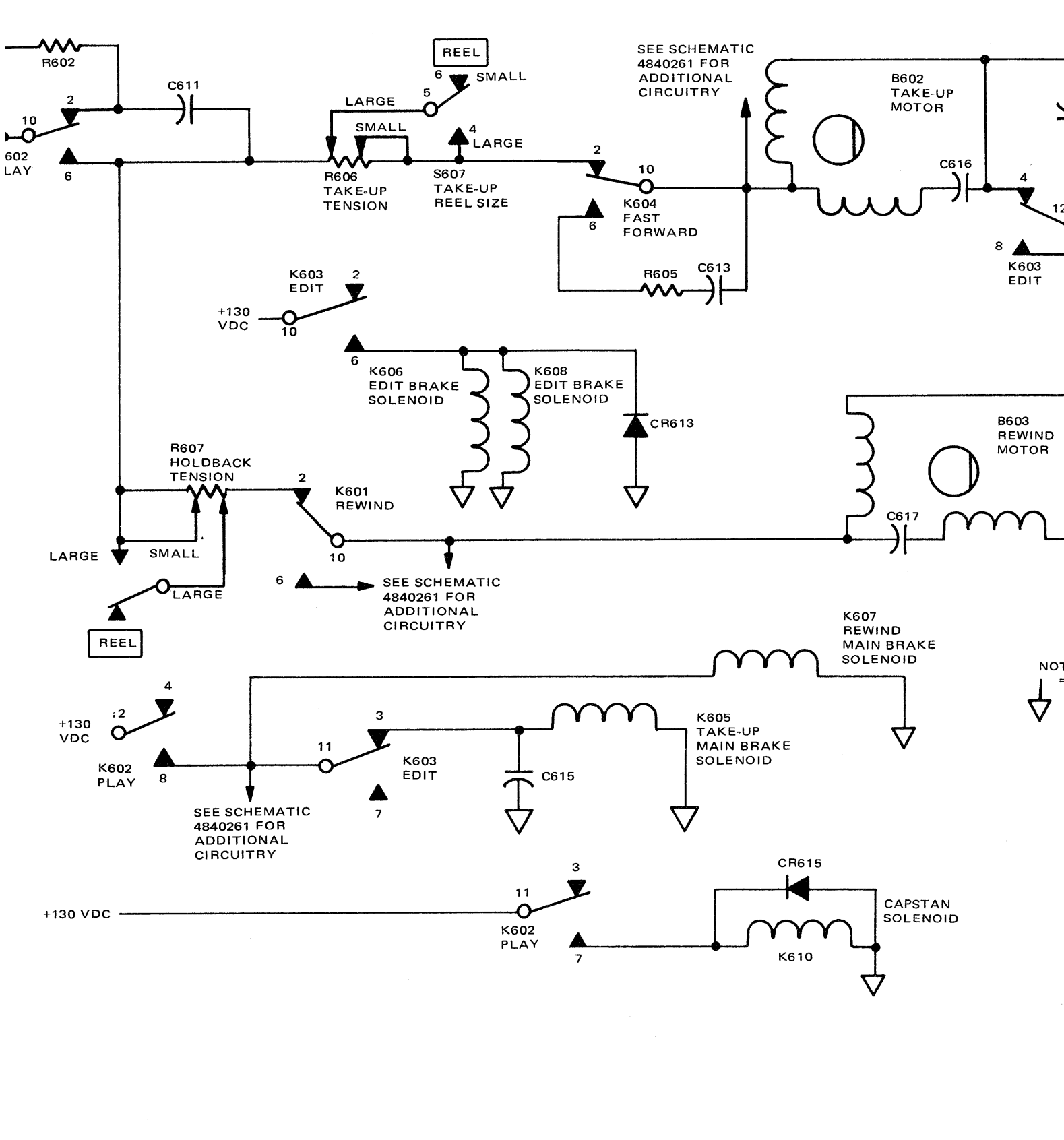
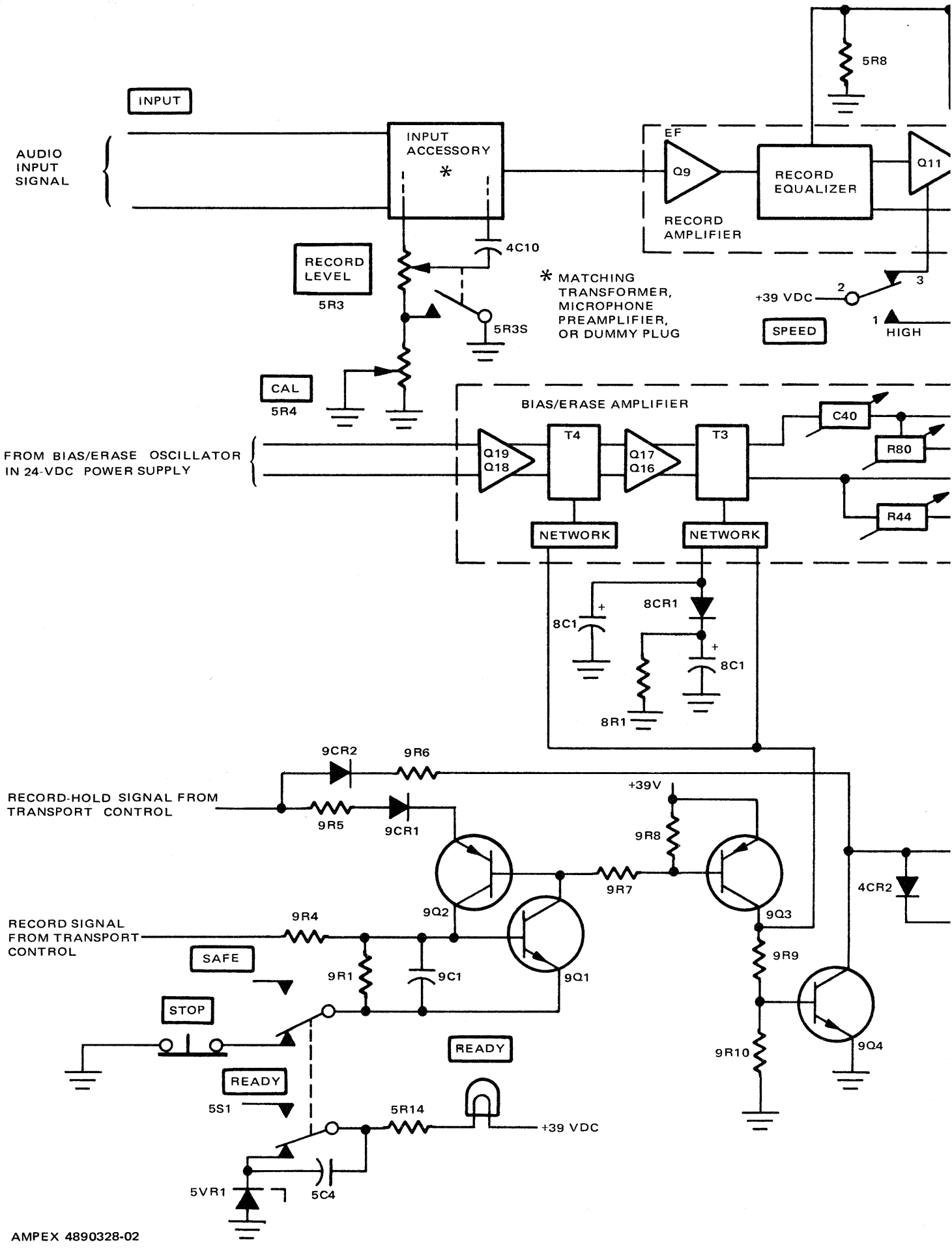


Figure 4-2.
Play, Record, and Edit Control Circuitry, Simplified Schematic (Sheet 2 of 2)


R602
C611
REEL
6
SMALL
5
LARGE
SMALL
4
LARGE
2
10
602
LAY
6
R606
TAKE-UP
TENSION
S607
TAKE-UP
REEL SIZE
SEE SCHEMATIC
4840261 FOR
ADDITIONAL
CIRCUITRY
B602
TAKE-UP
MOTOR
C616
4
8
K603
EDIT
K604
FAST
FORWARD
R605
C613
K603
EDIT
2
+130
VDC
10
6
K606
EDIT BRAKE
SOLENOID
K608
EDIT BRAKE
SOLENOID
CR613
B603
REWIND
MOTOR
C617
R607
HOLDBACK
TENSION
2
K601
REWIND
LARGE
SMALL
10
6
SEE SCHEMATIC
4840261 FOR
ADDITIONAL
CIRCUITRY
LARGE
REEL
K607
REWIND
MAIN BRAKE
SOLENOID
4
2
+130
VDC
3
11
K602
PLAY
8
K603
EDIT
7
C615
K605
TAKE-UP
MAIN BRAKE
SOLENOID
SEE SCHEMATIC
4840261 FOR
ADDITIONAL
CIRCUITRY
3
11
+130 VDC
K602
PLAY
7
CR615
CAPSTAN
SOLENOID
K610



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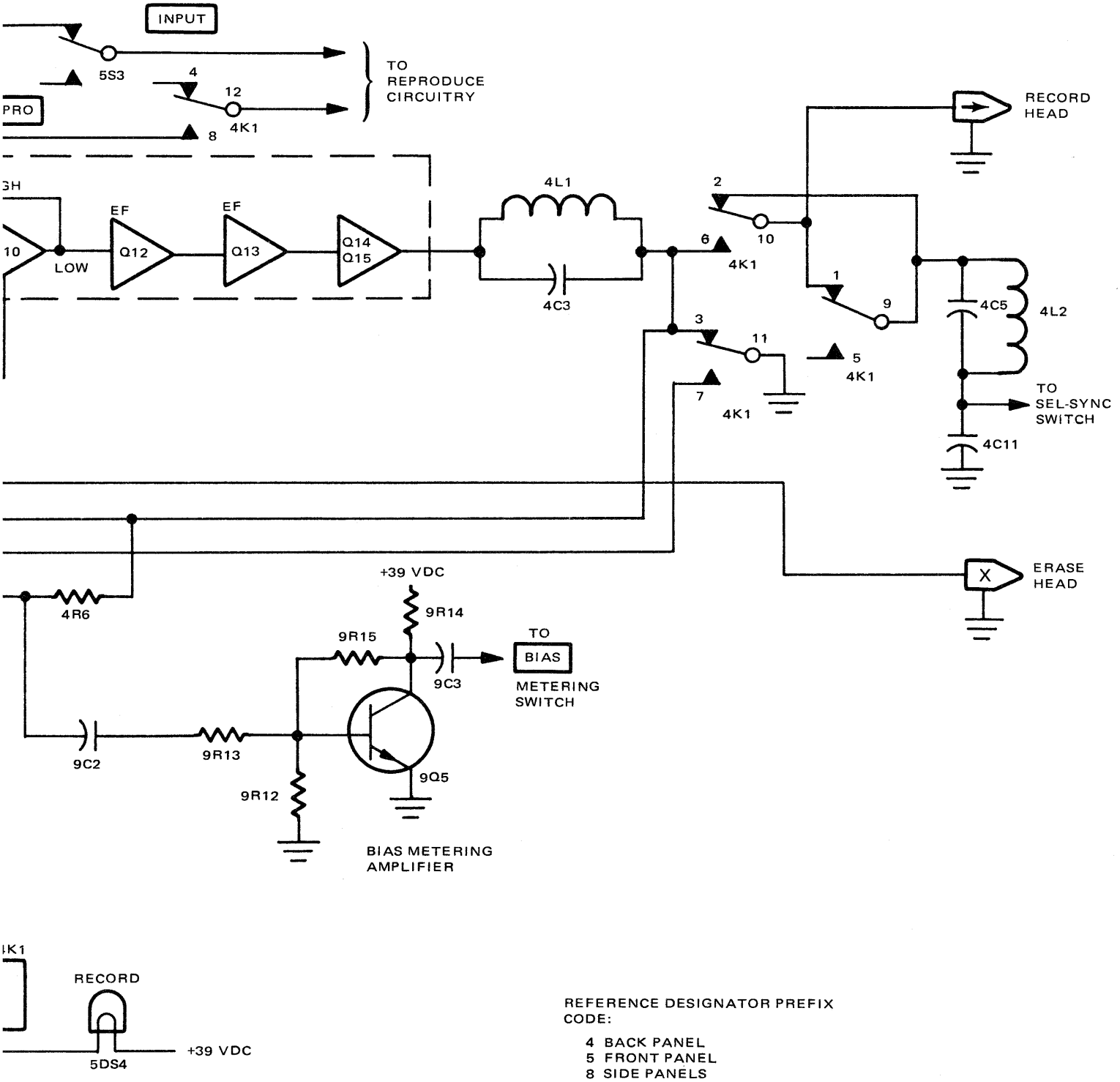
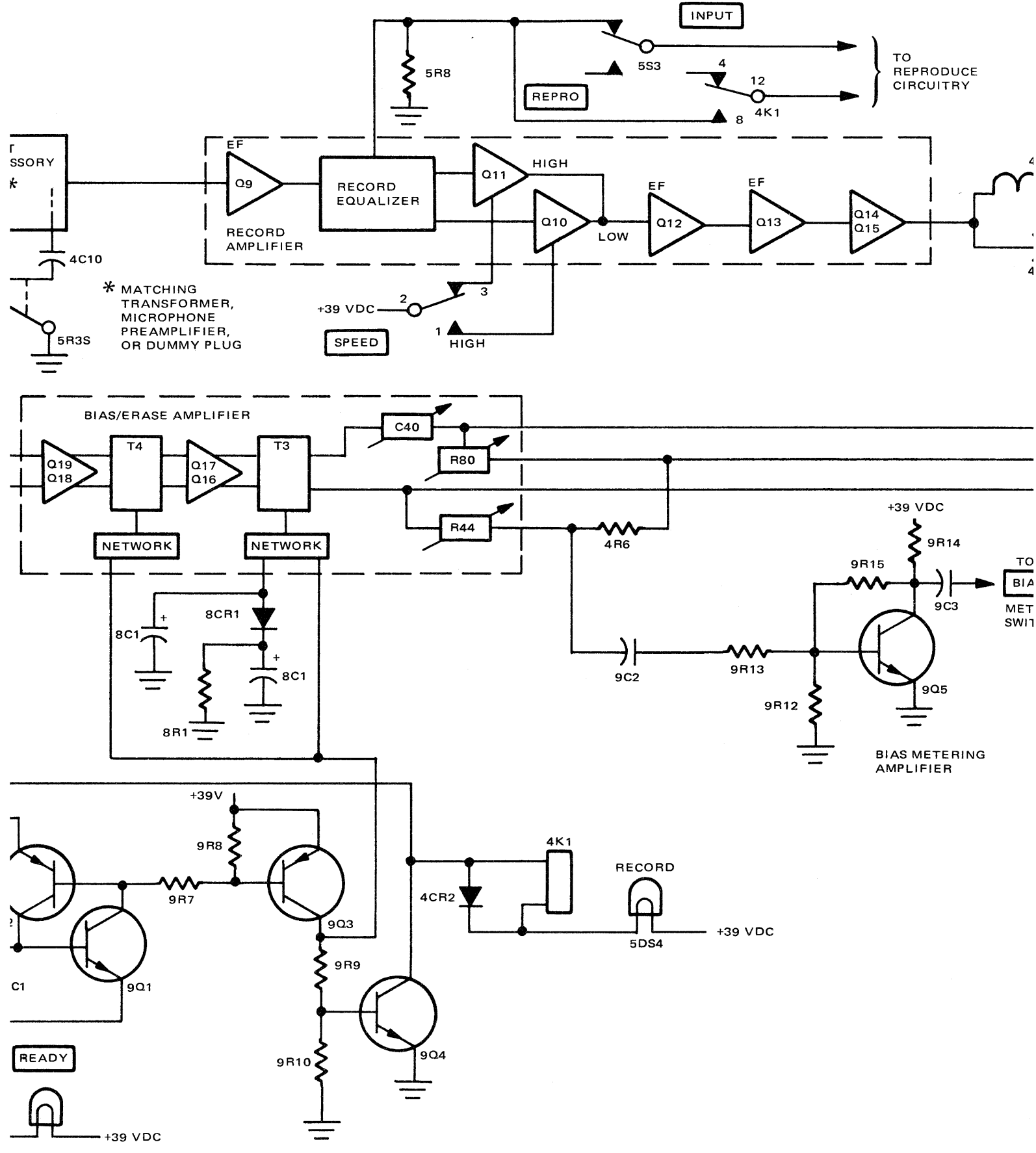
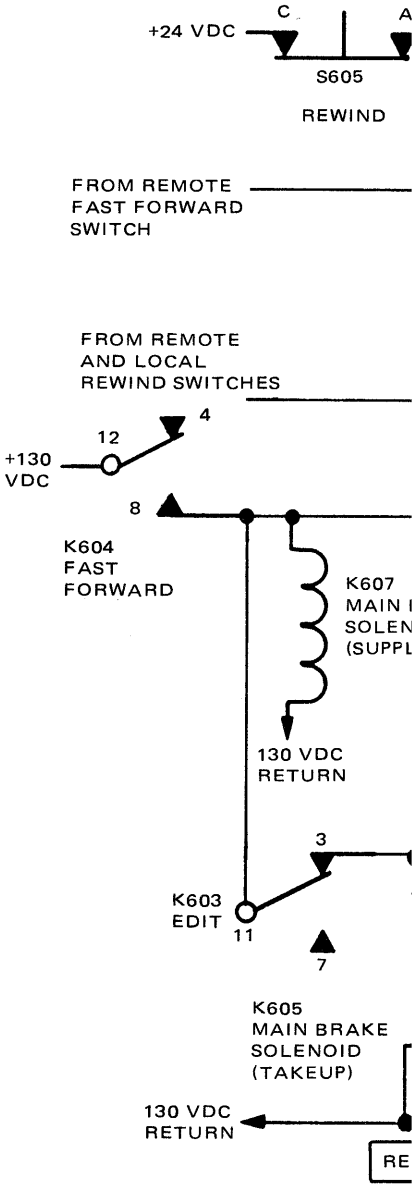


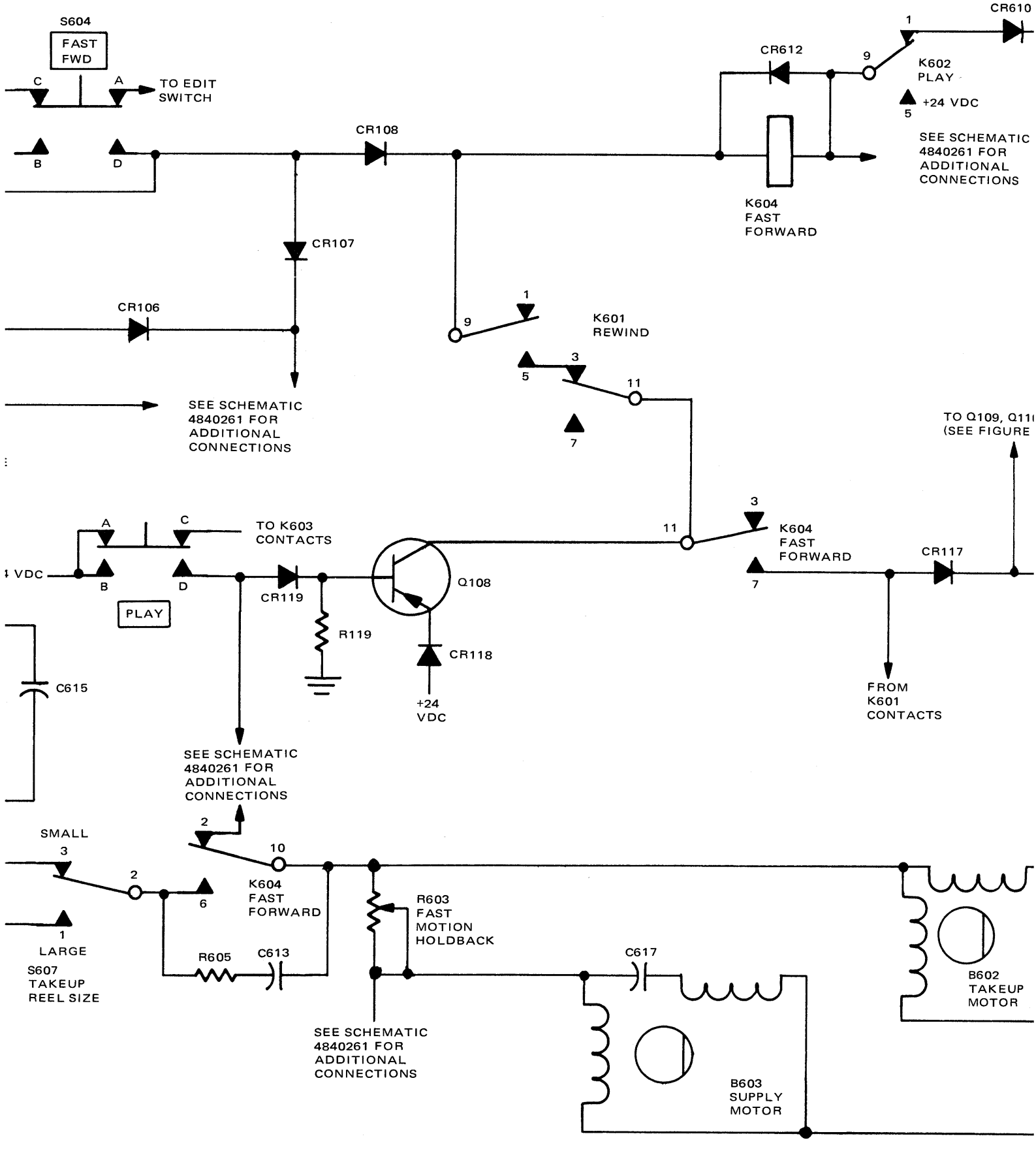
REFERENCE DESIGNATOR PREFIX CODE:

4 BACK PANEL
5 FRONT PANEL
8 SIDE PANELS
9 RECORD CONTROL BOARD

Figure 4-3.
Record Mode Signal Path and Control Circuitry, Simplified Schematic


INPUT
5S3
4
12
8
4K1
TO
REPRODUCE
CIRCUITRY
5R8
REPRO
EF
Q9
RECORD
EQUALIZER
Q11
HIGH
Q10
LOW
EF
Q12
EF
Q13
Q14
Q15
RECORD
AMPLIFIER
4C10
5R3S
* MATCHING
TRANSFORMER,
MICROPHONE
PREAMPLIFIER,
OR DUMMY PLUG
+39 VDC
2
3
1
HIGH
SPEED
BIAS/ERASE AMPLIFIER
Q19
Q18
T4
Q17
Q16
T3
C40
R80
R44
4R6
NETWORK
NETWORK
+39 VDC
9R14
9R15
9C3
8CR1
8C1
8C1
8R1
9C2
9R13
9R12
9Q5
BIAS METERING
AMPLIFIER
+39V
9R8
9R7
9Q3
9R9
9Q1
9Q4
9R10
4K1
4CR2
RECORD
5DS4
+39 VDC
READY
+39 VDC


+24 VDC
C
A
S605
REWIND
FROM REMOTE
FAST FORWARD
SWITCH
FROM REMOTE
AND LOCAL
REWIND SWITCHES
4
12
+130
VDC
8
K604
FAST
FORWARD
K607
MAIN
SOLEN
(SUPPL
130 VDC
RETURN
3
K603
EDIT
11
7
K605
MAIN BRAKE
SOLENOID
(TAKEUP)
130 VDC
RETURN
RE
80
117


S604
FAST FWD
C
A
TO EDIT SWITCH
B
D
CR108
CR610
1
CR612
9
K602 PLAY
+24 VDC
5
SEE SCHEMATIC 4840261 FOR ADDITIONAL CONNECTIONS
K604 FAST FORWARD
CR107
CR106
1
9
K601 REWIND
5
3
11
7
SEE SCHEMATIC 4840261 FOR ADDITIONAL CONNECTIONS
TO Q109, Q11
(SEE FIGURE
A
C
TO K603 CONTACTS
VDC
B
D
CR119
Q108
11
3
K604 FAST FORWARD
7
CR117
PLAY
R119
CR118
+24 VDC
C615
FROM K601 CONTACTS
SEE SCHEMATIC 4840261 FOR ADDITIONAL CONNECTIONS
SMALL
3
2
10
2
K604 FAST FORWARD
6
1
LARGE
S607 TAKEUP REEL SIZE
R605
C613
R603 FAST MOTION HOLDBACK
C617
B602 TAKEUP MOTOR
SEE SCHEMATIC 4840261 FOR ADDITIONAL CONNECTIONS
B603 SUPPLY MOTOR

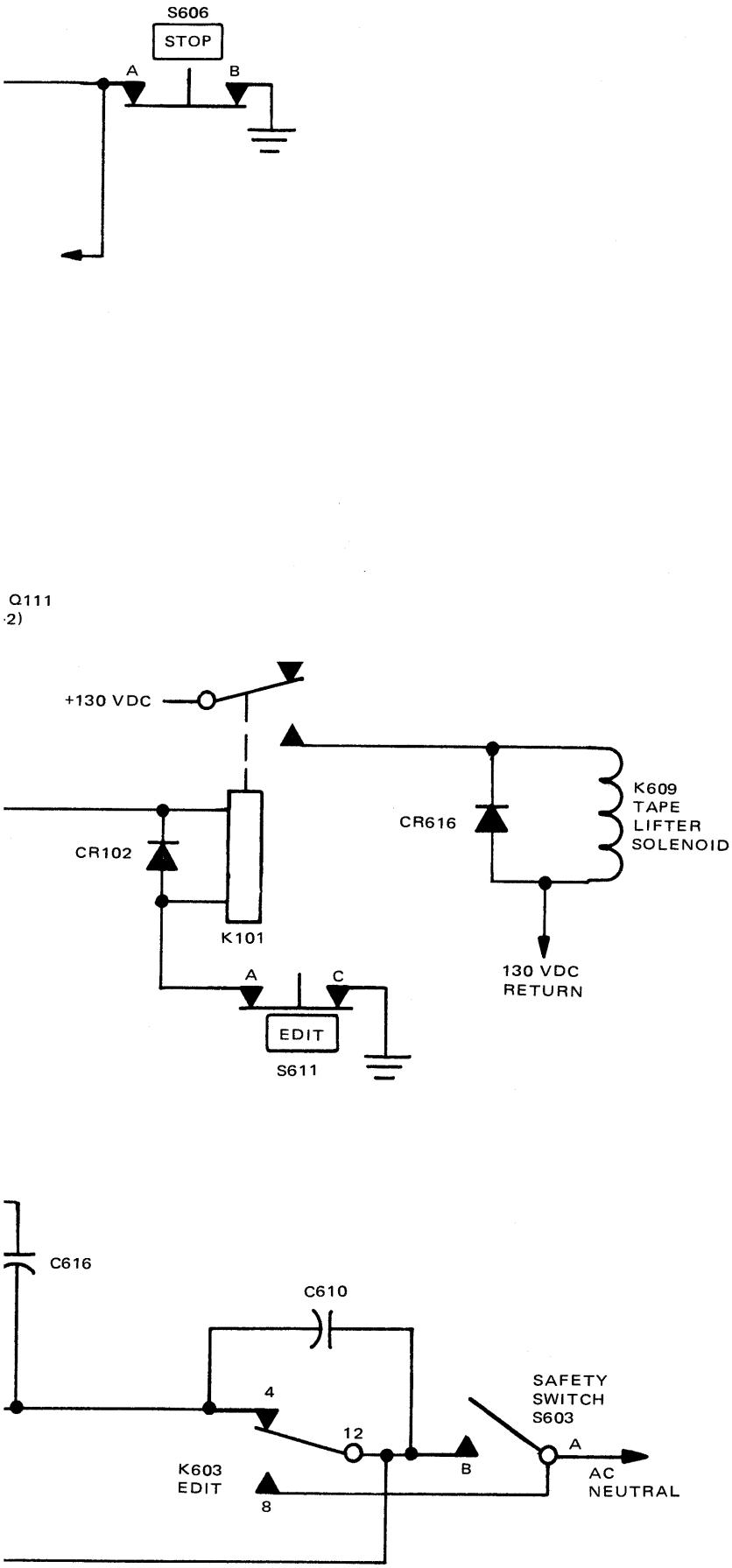
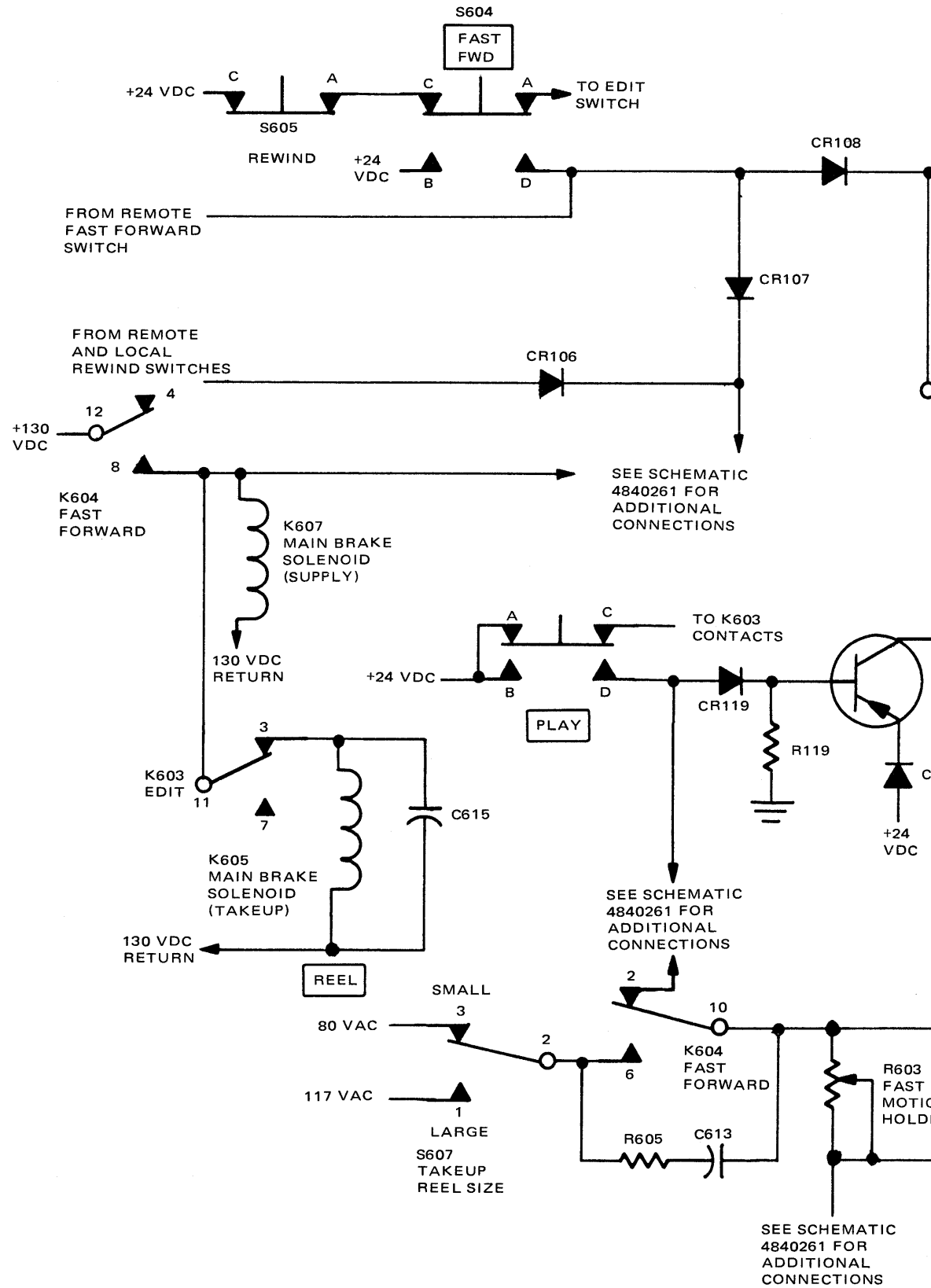
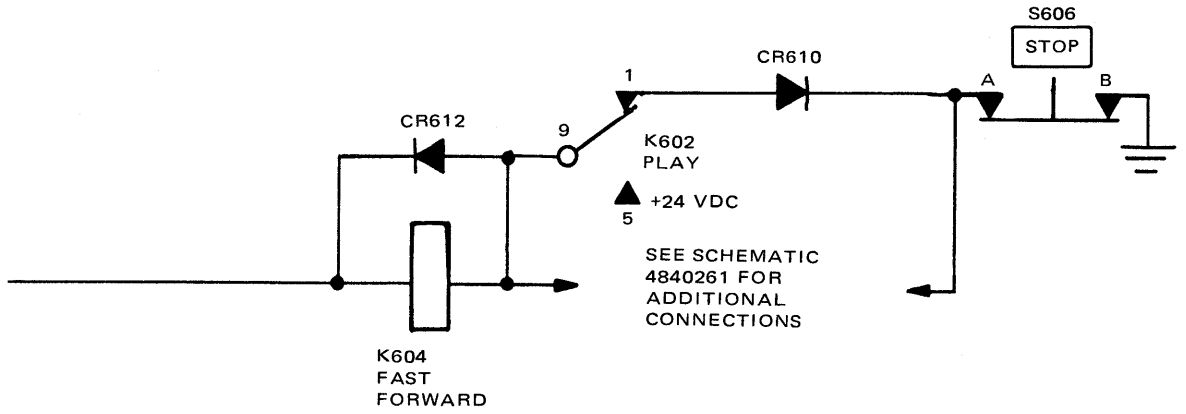
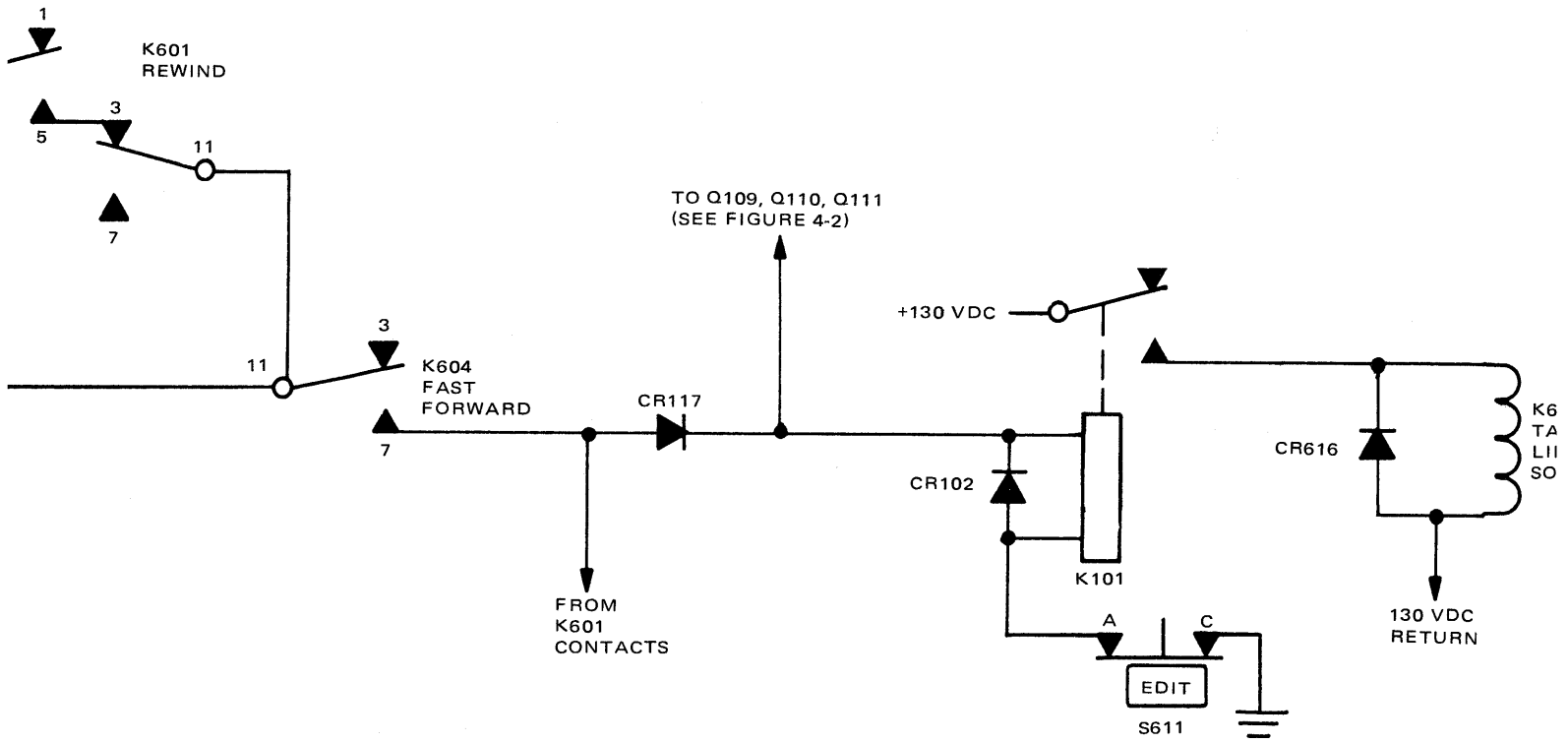
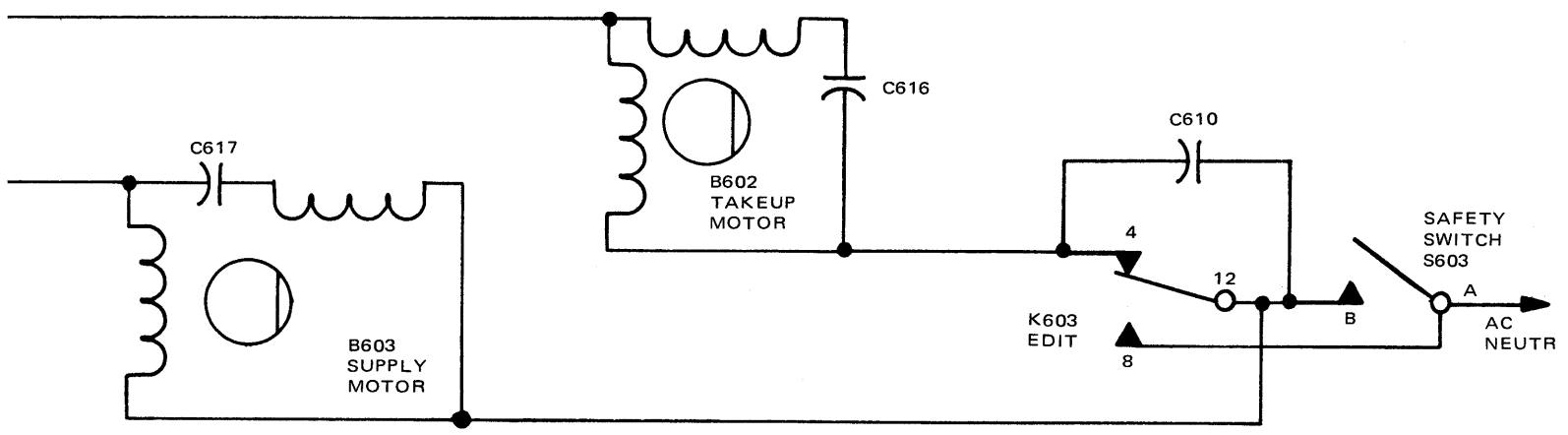


Figure 4-4.
Fast Forward Mode,
Simplified Schematic


S604
FAST FWD
+24 VDC
C
A
C
A
TO EDIT SWITCH
S605
REWIND
+24 VDC
B
D
CR108
FROM REMOTE FAST FORWARD SWITCH
CR107
FROM REMOTE AND LOCAL REWIND SWITCHES
CR106
4
12
+130 VDC
8
K604 FAST FORWARD
SEE SCHEMATIC 4840261 FOR ADDITIONAL CONNECTIONS
K607 MAIN BRAKE SOLENOID (SUPPLY)
130 VDC RETURN
A
C
TO K603 CONTACTS
+24 VDC
B
D
CR119
PLAY
R119
3
K603 EDIT
11
7
C615
K605 MAIN BRAKE SOLENOID (TAKEUP)
130 VDC RETURN
REEL
SEE SCHEMATIC 4840261 FOR ADDITIONAL CONNECTIONS
2
10
SMALL
3
80 VAC
2
6
K604 FAST FORWARD
117 VAC
1
LARGE
S607 TAKEUP REEL SIZE
R605
C613
R603 FAST MOTIO HOLD
SEE SCHEMATIC 4840261 FOR ADDITIONAL CONNECTIONS


S606
STOP
CR610
1
A
B
CR612
9
K602
PLAY
+24 VDC
5
SEE SCHEMATIC
4840261 FOR
ADDITIONAL
CONNECTIONS
K604
FAST
FORWARD


1
K601
REWIND
5
3
11
7
TO Q109, Q110, Q111
(SEE FIGURE 4-2)
+130 VDC
3
11
K604
FAST
FORWARD
7
CR117
CR102
CR616
K101
FROM
K601
CONTACTS
A
C
EDIT
S611
130 VDC
RETURN


C616
C617
C610
B602
TAKEUP
MOTOR
SAFETY
SWITCH
S603
4
12
A
B
K603
EDIT
8
B603
SUPPLY
MOTOR
AC
NEUTR

With the reel motors energized, the main reel brakes disengaged by the main brake solenoids, and the tape lifted from the heads by the tape-lifter solenoid, and tape is rapidly wound onto the takeup reel. Fast-forward is terminated by pressing the STOP pushbutton to interrupt the current in relay K604. Fast-forward is also terminated when the PLAY pushbutton is pressed. PLAY pushbutton S608 connects the nominal 24 volts through CR119 to the base of Q108. This back-biases the base-emitter junction of Q108, and the turn-off of Q108 removes the 24-volt holding voltage to K604.

Rewind Mode

The rewind mode is similar to fast-forward and is initiated by pressing the local or remote REWIND pushbutton. In either case, a nominal +24-volt level is applied through diode CR106 (Figure 4-5) to the base circuit of transistor Q104 (Figure 4-2) and through diode CR105 (Figure 4-5) to relay K601. The application of the positive level to transistor Q104 produces the same circuit action described in the fast-forward text.

Providing the local or remote STOP pushbutton is not depressed and relay K602 is not energized, the coil of relay K601 is energized when the local or remote REWIND pushbutton is pressed. Energizing the coil of relay K601 transfers its associated contact sets, causing the circuit action described in the following paragraphs.

Contact set K601-5/9 and K604-3/11 connects a nominal +24-volt level from the collector of normally on transistor Q108 to the coil of relay K601 to keep it energized. The relay current return path is the same as for the fast-forward relay. Thus, the recorder/reproducer is held in the rewind mode after the REWIND pushbutton is released.

Contact set K601-7/11 connects a nominal +24-volt level from the collector of transistor Q108 to the coil of relay K101. Consequently, relay K101 is energized; and its closed contact set connects +130 Vdc to the tape-lifter solenoid (K609), which energizes the solenoid. Diodes CR102 and CR616 dampen the inductive transient produced when the coils of K101 and K609, respectively, are de-energized.

Contact set K601-6/10 connects either 80 Vac or 117 Vac (depending on setting of the REEL switch) to the supply motor (B603) and variable resistor R603 (fast motion holdback). The output of R603 is applied to the takeup motor (B602).

Contact set K601-8/12 connects +130 Vdc to the supply main brake solenoid (K607) and to the takeup main brake solenoid (K605) through contact set K603-3/11 of the edit relay. Capacitor C615 suppresses inductive transients.

With the reel motors energized, the main reel brakes disengaged by the main brake solenoids, and the tape lifted from the heads by the tape lifter solenoid, the tape is rapidly wound onto the supply reel.

Edit Mode

In play/edit and stop/edit, the edit relay (K603) is energized, but in fast-wind/edit K603 remains de-energized. As discussed in the previous text, transistor Q107 (Figure 4-2) is turned on in the play and stop modes and turned off in the fast-wind modes (via CR104). Thus, a low level is present on one side of the edit relay coil (K603) in the play and stop modes and a nominal open circuit in the fast-wind mode.

During the stop, play, or record mode, pressing the EDIT pushbutton energizes the coil of edit relay K603, causing its associated contact sets to transfer. Only contact sets K603-5/9 and K603-6/10 of the edit relay have any effect in the stop mode. Closing contact set K603-5/9 establishes a holding circuit for the edit relay. Closing contact set K603-6/10 (Figure 4-2) energizes the edit brake solenoids (K606, K608), which release the edit brakes. Energizing the edit brake solenoid allows the tape reels to be easily moved by hand. Thus, the stop/edit mode facilitates manual cueing and tape threading. The stop/edit mode is terminated by pressing the REWIND, FAST FWD, STOP, or PLAY pushbuttons. Pressing the REWIND, FAST FWD or STOP pushbuttons causes transistor Q104 to conduct, which reverse biases transistor Q107 and de-energizes the edit relay. Pressing the PLAY pushbutton (S608) removes the positive holding voltage from edit relay K603, through the normally closed contacts of S608. Diode CR613 dampens

the inductive transient produced by the edit brake solenoids when they are de-energized.

Pressing the EDIT pushbutton after selecting the play mode places the recorder/reproducer in the play/edit mode. As in the stop/edit mode, pressing the EDIT pushbutton establishes a holding circuit for the edit relay. In addition, contact set K603-7/11 breaks the circuit to the takeup main brake solenoid, which engages the takeup reel brake. Further, contact set K603-4/8/12 breaks the takeup motor circuit and disables the safety switch (S603). Consequently, the tape is pulled forward by the capstan and spilled off the right side of the transport because the takeup reel does not move. This mode is mainly used when unwanted tape is to be cut off. The play/edit mode is terminated by pressing the STOP, PLAY, FAST FWD, or REWIND pushbuttons.

The fast-wind/edit mode is selected by first selecting the fast-forward or rewind mode and then pressing the EDIT pushbutton. During the fast-wind modes, the fast-motion circuit furnishes a low level to the anode of diode CR112, back-biasing the diode and transistor Q107. Consequently, transistor Q107 is turned off; and the edit relay (K603) cannot be energized. Thus, the edit relay cannot modify fast-wind operation. However, relay K101 is de-energized through normally closed contacts of S611, as long as the EDIT pushbutton is depressed (Figure 4-4). As a result, the tape-lifter solenoid is de-energized, the tape remains in contact with the heads, and any audio material on the tape is reproduced. This mode is primarily used for quickly reaching a desired portion of the recorded material.

Stop Mode

Pressing the STOP pushbutton deactivates any mode of operation. If the fast-forward mode is active, pressing the STOP pushbutton de-energizes fast-forward relay K604. (See Figure 4-4.) De-energizing K604 transfers its associated contact sets, which de-energizes the reel motors, applies the main reel brakes, and relaxes the tape-lifter mechanism. Similar shut-down action occurs if the STOP pushbutton is pressed during the rewind mode.

Pressing the STOP pushbutton also removes the ground from the junction of CR109 and R113 (Figure 4-2). Transistor Q104 turns on when the ground is removed and shunts current around the base/emitter circuit of Q107, which turns off Q107. Turning off Q107 turns off play relay K602 and/or edit relay K603. Consequently, the reel motors, capstan solenoid, and brake solenoids are de-energized; and the tape is brought to rest.

If the record mode is active, pressing the STOP pushbutton causes the events described in *Control Circuitry/Record Mode* text. As a result, the tape is ultimately brought to rest.

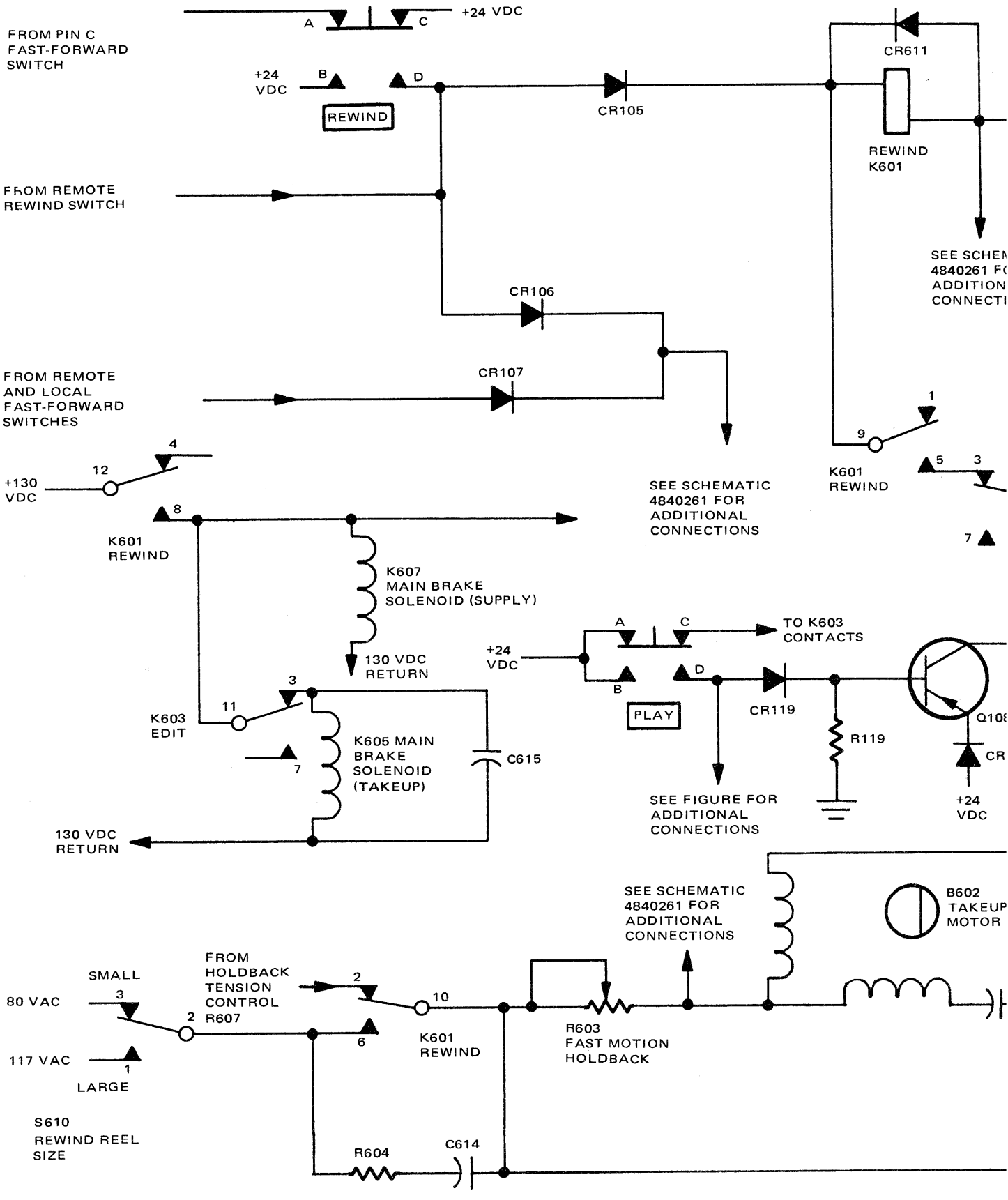
End-Of-Tape/Broken Tape

When the tape supply is exhausted or the tape breaks, the tension arm is spring-returned to its rest position, which opens the safety switch (S603). In all modes except edit, the safety switch removes AC power from the reel motors, capstan motor or capstan servo, 130 Vdc power supply, and the 24 Vdc power supply. Thus, the reel motors and capstan motor are de-energized, the capstan pinch roller is allowed to retract, and the main reel brakes are applied.

Fast-Motion Sensor

A motion-sensing device is mounted on the rewind motor. This device consists of a light-emitting diode, a phototransistor, and a perforated tachometer disk fixed to the shaft of the motor (see Figure 4-6). When the shaft is turning, the light path between the diode and phototransistor is periodically broken by the disk. The transistor conducts each time the light shines on its base and cuts off when the base is shielded from the light. Thus, an AC signal is developed that is coupled through capacitor C103 to the base of transistor Q102. Diode CR103 protects the base/emitter junction of transistor Q102 from high amplitude negative-going voltage spikes.

With either the fast-forward or rewind mode selected, either contact set K601-7/11 or K604-7/11 connects the positive collector voltage of normally on transistor Q108, to relay K101 and the base circuit of transistor Q103. Relay K101 is


FROM PIN C FAST-FORWARD SWITCH
+24 VDC
A
C
+24 VDC
B
D
REWIND
CR105
CR611
REWIND K601
FROM REMOTE REWIND SWITCH
SEE SCHEM 4840261 FO ADDITION CONNECTI
CR106
CR107
FROM REMOTE AND LOCAL FAST-FORWARD SWITCHES
1
9
5
3
4
12
+130 VDC
8
K601 REWIND
SEE SCHEMATIC 4840261 FOR ADDITIONAL CONNECTIONS
K601 REWIND
7
K607 MAIN BRAKE SOLENOID (SUPPLY)
130 VDC RETURN
A
C
TO K603 CONTACTS
+24 VDC
B
D
PLAY
CR119
R119
Q108
CR
3
11
K603 EDIT
7
K605 MAIN BRAKE SOLENOID (TAKEUP)
C615
SEE FIGURE FOR ADDITIONAL CONNECTIONS
+24 VDC
130 VDC RETURN
SEE SCHEMATIC 4840261 FOR ADDITIONAL CONNECTIONS
B602 TAKEUP MOTOR
SMALL
3
80 VAC
2
FROM HOLDBACK TENSION CONTROL R607
2
10
K601 REWIND
R603 FAST MOTION HOLDBACK
117 VAC
1
LARGE
6
S610 REWIND REEL SIZE
R604
C614

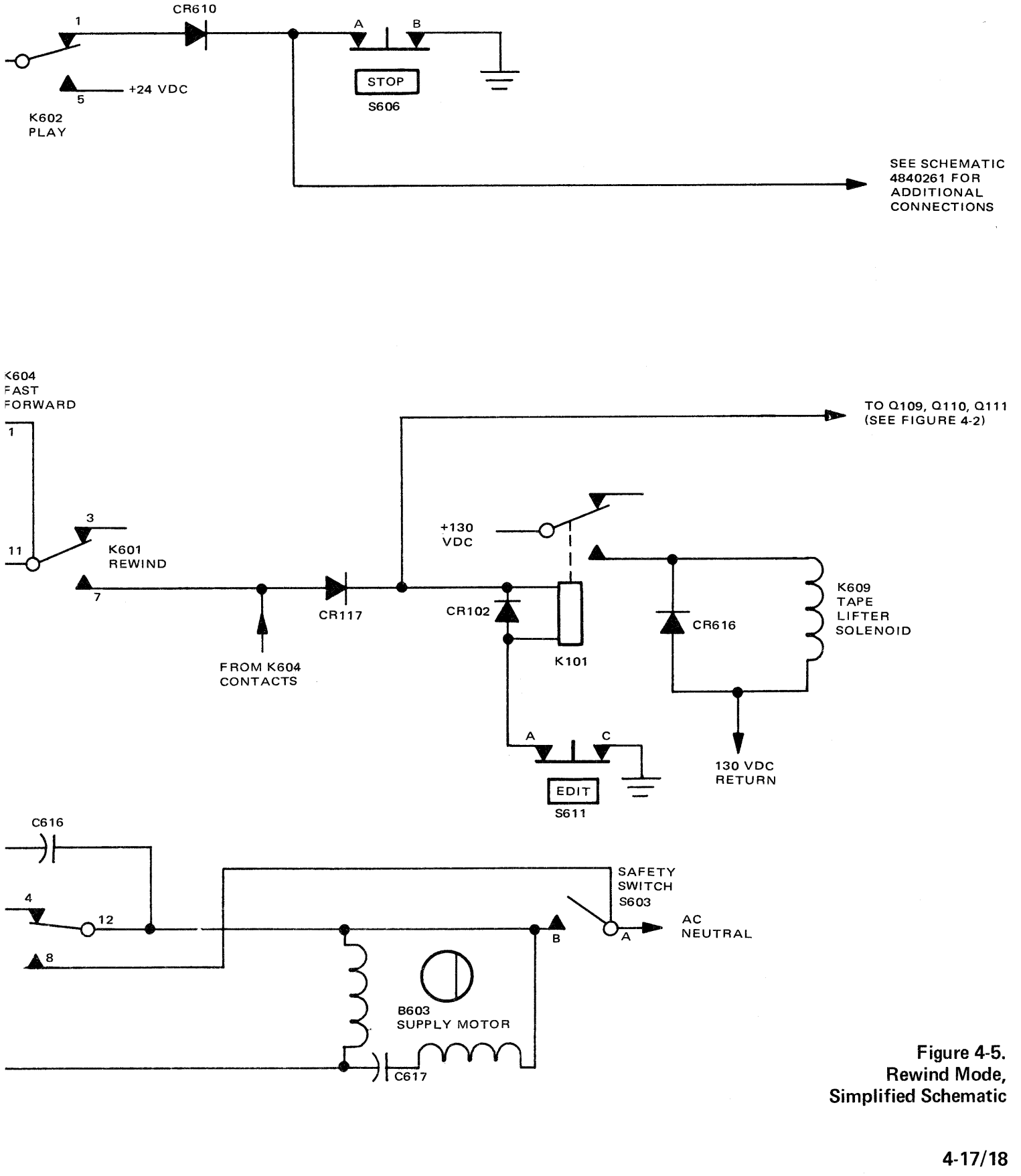
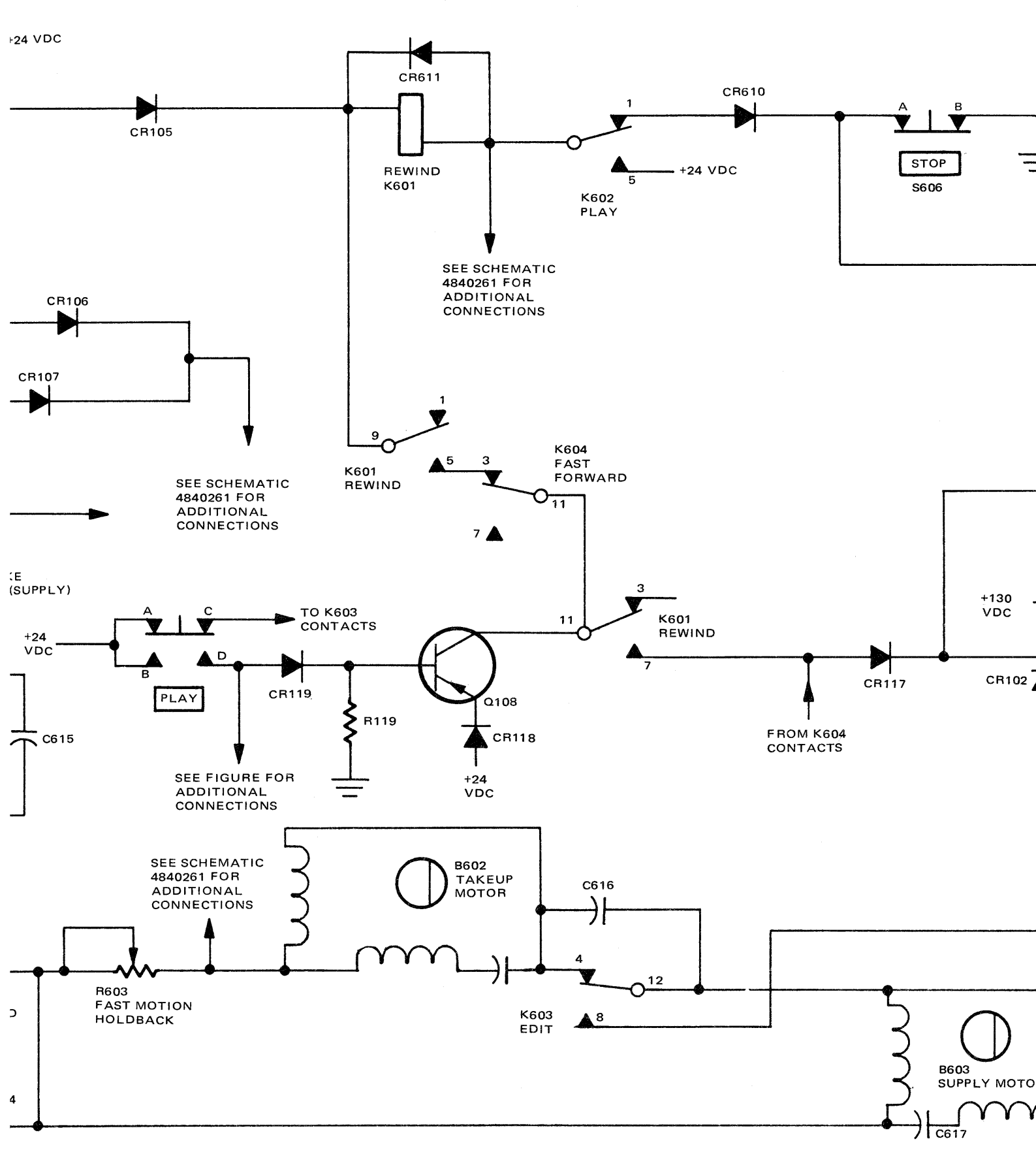


Figure 4-5.
Rewind Mode,
Simplified Schematic


+24 VDC
CR611
CR105
CR610
REWIND
K601
1
5
+24 VDC
K602
PLAY
A
B
STOP
S606
SEE SCHEMATIC
4840261 FOR
ADDITIONAL
CONNECTIONS
CR106
CR107
1
9
5
3
K604
FAST
FORWARD
11
7
K601
REWIND
SEE SCHEMATIC
4840261 FOR
ADDITIONAL
CONNECTIONS
(SUPPLY)
A
C
TO K603
CONTACTS
+24
VDC
B
D
PLAY
CR119
R119
Q108
CR118
+24
VDC
11
3
K601
REWIND
7
+130
VDC
CR117
CR102
FROM K604
CONTACTS
C615
SEE FIGURE FOR
ADDITIONAL
CONNECTIONS
SEE SCHEMATIC
4840261 FOR
ADDITIONAL
CONNECTIONS
B602
TAKEUP
MOTOR
C616
4
12
8
K603
EDIT
R603
FAST MOTION
HOLDBACK
B603
SUPPLY MOTO
C617

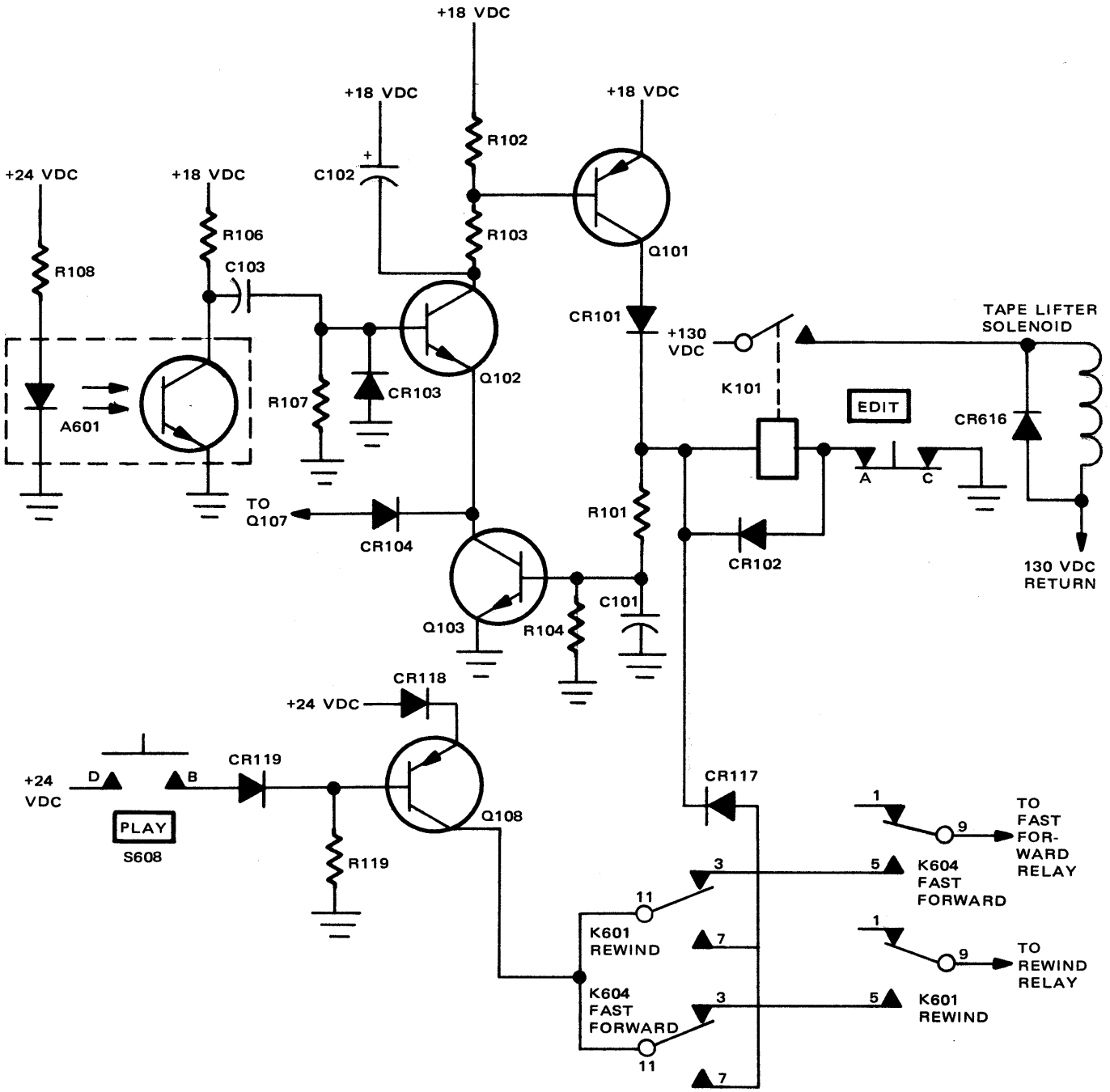


Figure 4-6. Fast Motion Circuitry, Simplified Schematic

energized by the positive voltage, which causes the tape to be lifted from the heads. In addition, transistor Q103 is turned on inhibiting Q107 through CR104. The low collector voltage of Q103 allows transistor Q102 to conduct and the time-varying signal at the base of Q102 is reproduced at the collector. Capacitor C102 filters the collector signal of Q102, and the DC voltage developed

across R102 turns on transistor Q101. Turning on Q101 establishes alternate current paths for K101 and the base circuit of Q103.

When another mode is selected, either contact set K601-3/7/11 (Figure 4-6) or K604-3/7/11 disconnects the positive voltage from K101 and the base of Q103. However, because the tape is still in motion, the circuit composed of Q101, Q102, and Q103 and associated components remains latched. That is, Q102 continues to drive Q101, which drives Q103; and, in turn, Q103 furnishes emitter current to Q102. Relay K101 is kept energized by Q101. When tape motion stops, Q102 stops conducting, causing Q101 and Q103 to stop conducting. Consequently, relay K101 is de-energized, which allows the tape to be lowered onto the heads and also allows play mode to be entered, since Q107 is no longer held off by Q103.

SIGNAL CIRCUITRY

Signal circuitry is located on the reproduce amplifier PWA, record amplifier PWA, bias/erase amplifier PWA, record control PWA, back panel, front panel, side panels, and power supply. Figure 4-3 shows a simplified schematic of the circuits involved in the record mode, and Figure 4-7 shows the signal circuits used in the reproduce mode of operation. The VU meter and its associated circuits shown in Figure 4-7 are used in both the record and reproduce modes. See schematics 4840248, 4840249, and 4840168 for details of the amplifier circuits shown in Figures 4-3 and 4-7.

Record Mode

Electronic audio signals to be recorded are applied to the back-panel INPUT connector (Figure 4-3). These signals are then coupled through the input accessory socket to the RECORD LEVEL/INPUT CAL control.

With the RECORD LEVEL control set fully counterclockwise, switch 5R3S is open; and the setting of the Input Calibration adjustment (5R4) determines the attenuation of the input signal. Turning the RECORD LEVEL control clockwise closes switch 5R3S and allows the RECORD LEVEL control to be used for input-signal attenuation.

Capacitor 4C10 couples the signal from the RECORD LEVEL control to the input accessory, and from there the signal is routed to the record amplifier assembly. (Refer to the *Circuit Description/Record Amplifier* text for a detailed discussion of the record amplifier assembly.) Emitter-follower (EF) Q9 amplifies the signal and drives the circuits of the record equalizer. The record equalizer supplies an unequalized signal to resistor 5R8, a high-speed equalized signal to amplifier Q11, and a low-speed equalized signal to amplifier Q10.

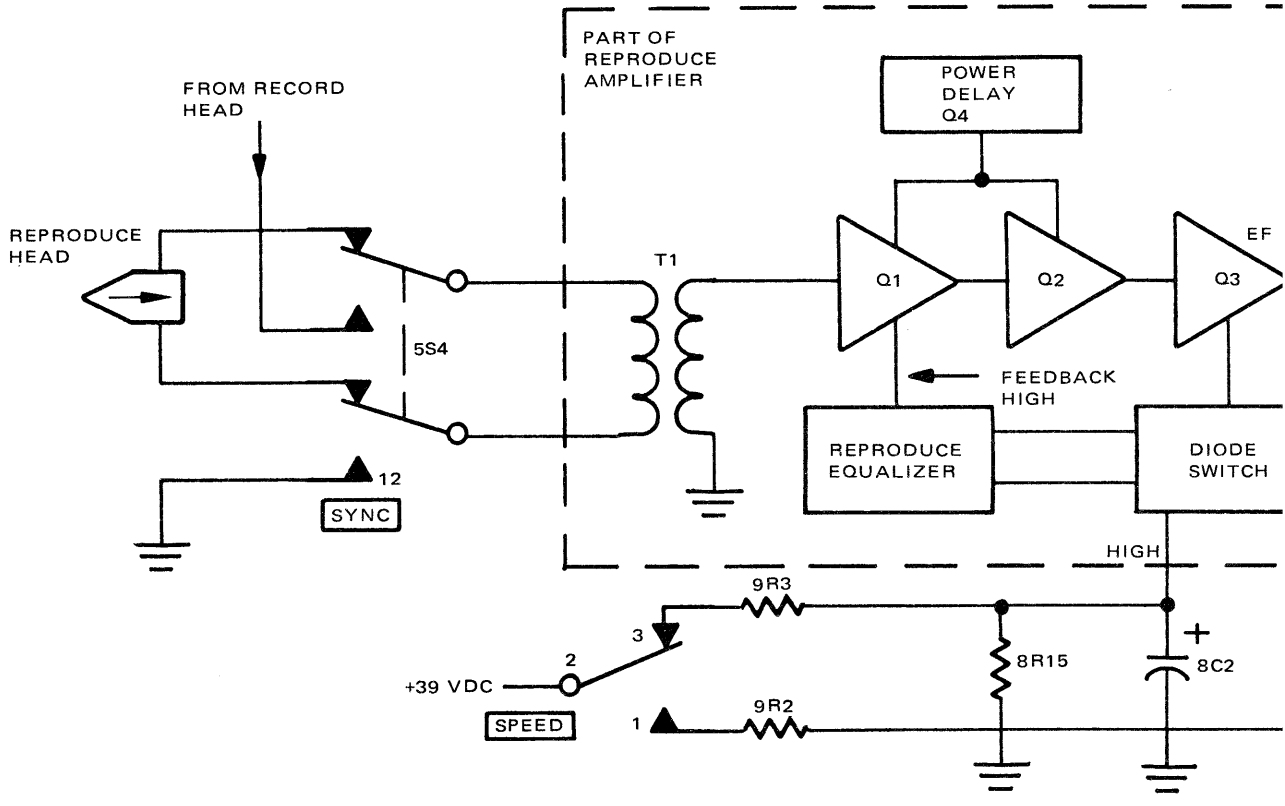
With the SPEED switch set to the low-speed position, amplifier Q11 is disabled; and amplifier Q10 is enabled. Enabling Q10 allows the low-speed equalized signal to be amplified and sent to the record head via bias trap 4L1-4C3 and contact set 4K1-6/10. Conversely, setting the SPEED switch to the high-speed position enables amplifier Q11 and disables Q10, allowing the high-speed equalized signal to be sent to the record head.

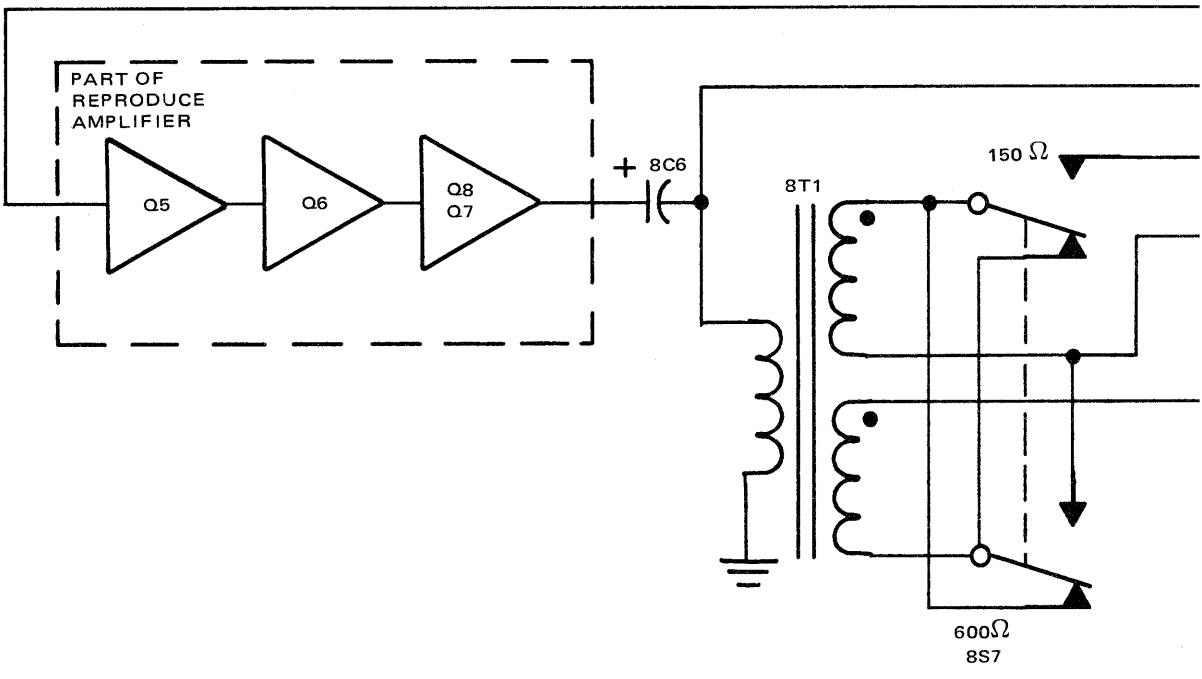
As stated in the *Control Circuitry/Record Mode* text, the bias/erase amplifier is furnished a positive voltage (referenced to ground) from the collector of transistor 9Q3 during the record mode. Reference ground is furnished to the bias/erase amplifier through contact set 4K1-7/11. The bias/erase amplifier is enabled by the applied voltage, and the 150-kHz signal from the bias/erase amplifier is delivered to the record head (via 4K1-6/10), the erase head, and the bias metering amplifier. Potentiometer R80 is used to set the level of the bias signal applied to the record head, and capacitor C40 is adjusted to resonate with the erase head to obtain maximum erase current.

Transistor 9Q5 and associated components form the bias metering amplifier. With switch 5S2 (Figure 4-7) set to BIAS, the bias signal is applied to the front panel VU meter for bias-signal monitoring. Potentiometer R44 (Figure 4-3) is used when calibrating the VU meter.

Play Mode

Recorded material can be reproduced using either the reproduce or record head. Reproduction using the record head is termed Sel-Sync operation, which is explained in the Operation section of this manual. When using the reproduce head, the audio


PART OF
REPRODUCE
AMPLIFIER
FROM RECORD
HEAD
REPRODUCE
HEAD
5S4
T1
POWER
DELAY
Q4
Q1
Q2
Q3
EF
FEEDBACK
HIGH
REPRODUCE
EQUALIZER
DIODE
SWITCH
HIGH
12
SYNC
9R3
3
2
+39 VDC
SPEED
1
9R2
8R15
+
8C2


PART OF
REPRODUCE
AMPLIFIER
Q5
Q6
Q8
Q7
+ 8C6
8T1
150 Ω
600Ω
8S7

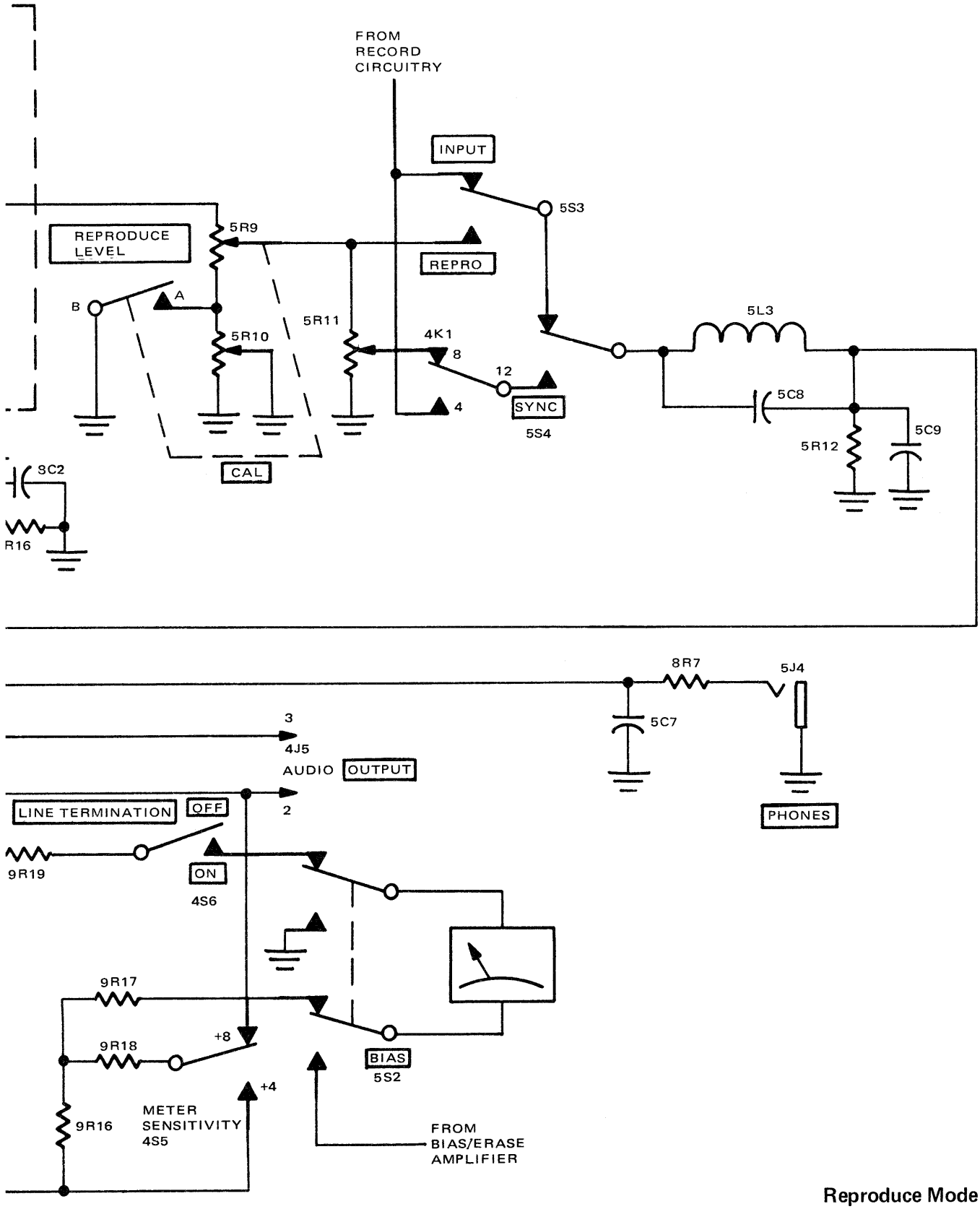
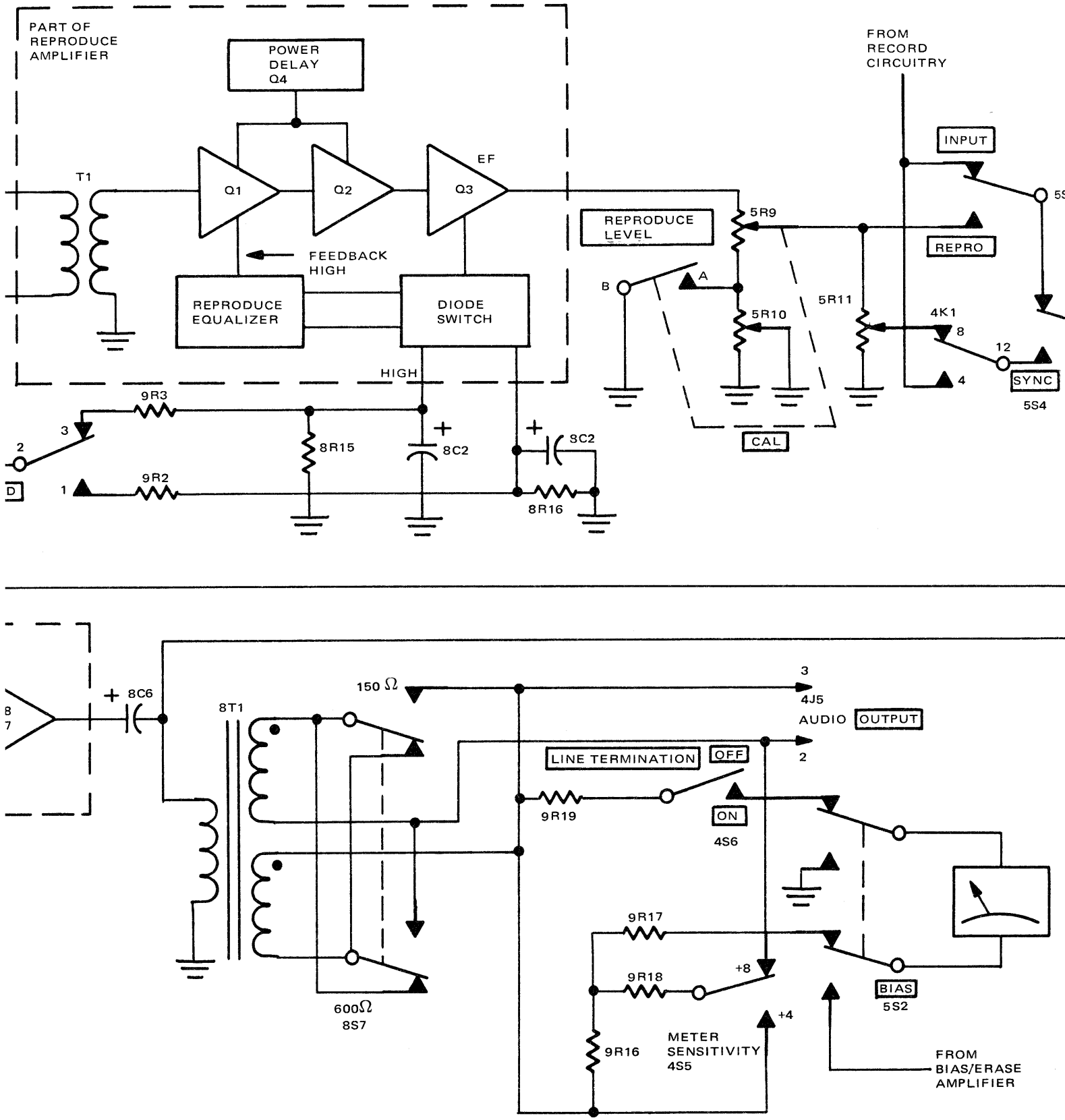


Figure 4-7.
Reproduce Mode Signal Path,
Simplified Block Diagram


PART OF
REPRODUCE
AMPLIFIER
POWER
DELAY
Q4
T1
Q1
Q2
EF
Q3
FEEDBACK
HIGH
REPRODUCE
EQUALIZER
DIODE
SWITCH
HIGH
9R3
3
2
D
1
9R2
8R15
8C2
8C2
8R16
FROM
RECORD
CIRCUITRY
INPUT
REPRODUCE
LEVEL
5R9
REPRO
B
A
5R10
5R11
4K1
8
12
4
SYNC
5S4
CAL
8
7
+ 8C6
8T1
150 Ω
3
4J5
AUDIO OUTPUT
LINE TERMINATION
OFF
2
9R19
ON
4S6
9R17
9R18
+8
9R16
METER
SENSITIVITY
4S5
+4
600Ω
8S7
BIAS
5S2
FROM
BIAS/ERASE
AMPLIFIER

signal developed across the head is connected through contacts of switch 5S4 to the primary of transformer T1 of the reproduce amplifier PWA. (See Figure 4-7.) In Sel-Sync operation, the signal developed across the record head is routed through a bias trap (4L2, 4C5, 4C11) and contacts of switch 5S4 to the primary of T1. (See Figures 4-3 and 4-7.)

Transformer T1 couples the reproduced audio signal to amplifier Q1. Amplifier Q2 further amplifies the signal and drives emitter-follower (EF) Q3. In turn, amplifier Q3 drives the REPRODUCE LEVEL control and the reproduce equalizer. The equalizer is situated in a feedback path between amplifiers Q3 and Q1. A diode switch controlled by the tape transport SPEED switch routes the feedback signal from emitter-follower Q3 to either the high-speed or low-speed section of the reproduce equalizer, depending on the setting of the SPEED switch. Therefore, the signal developed across the REPRODUCE LEVEL control is equalized in accordance with the tape speed being used.

With the REPRODUCE LEVEL control set fully counterclockwise, the switch associated with potentiometer 5R10 is open. Therefore, the setting of potentiometer 5R10 determines the attenuation of the reproduced signal. Turning this control clockwise closes the switch associated with potentiometer 5R10, which bypasses 5R10 and allows potentiometer 5R9 to be used for reproduce-signal attenuation. In either case, the signal appearing at the movable contact of potentiometer 5R9 is applied to one contact of REPRO switch 5S3 and to potentiometer 5R11.

For normal reproduction (not Sel-Sync), the INPUT/REPRO switch (5S3) is set to REPRO; and the SEL SYNC switch (5S4) is set to the normal (out) position (not SEL SYNC). Therefore, the signal appearing at the movable contact of potentiometer 5R9 is connected to the bias trap (5L3, C8, R12, C9). Alternately, in Sel-Sync operation, switch 5S4 is set to the SYNC position. This switch position forces the REPRO switch out, disconnects the movable contact 5R9 from the bias trap and connects the trap to the movable contact of potentiometer 5R11 (via contact set 4K1-8/12). Potentiometer 5R11 is used to compensate for the higher level of the signal developed across the record head compared to that developed across the reproduce head.

Contact set 4K1-8/12 of the record relay remains closed in the reproduce mode. However, in the record mode, the record relay is energized; and contact set 4K1-4/12 connects the unequalized output of the record equalizer (Figure 4-3) to the bias trap (5L3, C8, C9, R12; Figure 4-7). Thus when the SYNC pushbutton is depressed, the audio signal to be recorded is connected to the reproduce circuitry for monitoring purposes.

The output of the bias trap is amplified by stages Q5, Q6, and Q7/Q8 of the reproduce line amplifier. Capacitor 8C6 couples the output of the reproduce line amplifier to the PHONES jack (5J4) and to the primary of output transformer 8T1. The secondary of 8T1 is connected through an output-impedance switch (8S7) to the audio OUTPUT jack (4J5) and the metering circuitry.

The output signal level is indicated on the front-panel VU meter when the BIAS pushbutton is in its out position (not depressed). A meter-sensitivity switch and its associated resistive network (9R16, R17, R18) is used to calibrate the VU meter for either +4-dBm or +8-dBm output-signal levels. The output line can be terminated internally by setting the LINE TERM switch (4S6) to ON, which connects resistor 9R19 across the audio-output line.

BIAS/ERASE AMPLIFIER

Schematic 4840249 shows the circuitry of the bias/erase amplifier. This amplifier receives a 150-kHz push-pull bias/erase signal from the bias/erase oscillator whenever the recorder/reproducer is turned on.

Essentially, the bias/erase amplifier consists of two cascaded push-pull amplifiers and three adjustments. During the record mode, operating power for the amplifier is received via transistor switch 9Q3 on the record control PWA. An external network connected to pin 6 of the amplifier PWA causes a short turn-on delay of the operating power and a longer turn-off delay. These delays cause the bias and erase signals to rise and decay slowly to minimize imperfections in the recorded material

caused by turning the bias/erase amplifier on and off.

The push-pull signal from the bias/erase oscillator is applied to the bases of transistors Q18 and Q19. Each transistor drives one half of the primary winding of transformer T4. The push-pull signal taken from the center tapped secondary of T4 is used to drive a second push-pull transistor/transformer stage (Q16, Q17, T3). Both amplifier stages operate at clipping level.

The single-ended signal taken from the secondary of T3 is routed through capacitor C40 (ERASE ADJ) to the erase head (schematic 4840248) and potentiometer R80. The signal taken from potentiometer R80 is routed through contacts of external relay 4K1 to the record head and through external resistor 4R6, potentiometer R44 (BIAS CAL), and contacts of relay 4K1-7/11 to ground. Capacitor 9C2 couples the signal developed across potentiometer R44 to the bias metering amplifier.

Capacitor C40 is adjusted to resonate with the inductance of the erase-head winding to provide maximum sinusoidal current through the winding. Potentiometer R80 is used to adjust the level of bias current, and potentiometer R44 is used to calibrate the front panel VU meter for bias-signal monitoring.

Resistors R83 and R87 are biasing resistors, and capacitors C42 and C45 are tuning capacitors. Capacitors C41, C43, and C44 are signal decouplers for the input power line.

RECORD AMPLIFIER

Schematic 4840249 shows the circuitry of the record amplifier. Capacitor C24 couples the input audio signal to the base of transistor Q9. Transistor Q9 and associated components form an emitter-follower circuit that provides high input impedance for the input circuit of the record amplifier and low-impedance drive to the record-equalizer circuit. Capacitor C52 couples the signal taken from the emitter of Q9 to potentiometer R108. The signal taken from the movable contact of R108 is routed to the output stages of the reproduce amplifier in the record and input-monitoring modes of operation.

The signal from Q9 is also connected to the plug-in, high- and low-speed record equalizer PWA. As shown by schematic 4840249, there are several plug-in record equalizer circuits available to suit different record-equalization requirements. The output of the low-speed equalizer is applied to the base of transistor Q10, and the high-speed equalized signal is applied to the base of transistor Q11.

Transistors Q10 and Q11 and associated components form the low- and high-speed equalizer amplifiers, respectively. The setting of the SPEED switch determines which of these amplifiers is enabled and which is inhibited. To inhibit amplifier Q10, a high positive level is applied to pin 5 of the record amplifier PWA. Resistor R57 and capacitor C26 delay the voltage rise at the junction of resistors R55 and R56. Delaying the voltage rise causes transistor Q10 to turn off slowly and, thus, avoids switching transients. Conversely, amplifier Q10 is enabled when a low level is applied to pin 5. Amplifier Q11 is turned off and on in a similar manner.

Capacitor C25 provides low-frequency boost for amplifier Q10, and C27 provides low-frequency boost for amplifier Q11. Capacitors C55 and C56 defeat the low-frequency boost when it is not desired.

Capacitor C30 couples the output of amplifier Q10 or Q11 to the base of transistor Q12. Transistors Q12 and Q13 and associated components form two cascaded emitter-follower circuits. These circuits provide high-signal current for the output amplifier stage.

The output driver stage consists of transistors Q14 and Q15 and associated components. Transistor Q15 is an active collector resistance for Q14, thus allowing high recording current to be obtained. Capacitor C31 keeps signals at the base and emitter of Q15 in phase (i.e., bootstrapped), which causes the amplifier to have a high output impedance in the audio-frequency range. This high output impedance minimizes the effects of a variable load caused by changes in the record-head impedance over the audio spectrum.

REPRODUCE AMPLIFIER

Schematic 4840249 shows the details of the reproduce amplifier. Transformer T1 couples the audio output of the reproduce head or record head (Sel-Sync operation) to the base of transistor Q1. Transistor Q1 and associated components form a common-emitter amplifier. Base bias for Q1 is derived from the DC voltage developed across resistor R4, and capacitor C1 prevents signal degeneration. Transistor Q2 and associated components form another common-emitter amplifier. This amplifier receives its signal input from the collector of Q1 and, in turn, drives the base of transistor Q3. DC feedback is coupled from the collector of Q2 through resistors R2 and R3 to the base circuit of Q2. Capacitor C2 decouples the junction of R3 and R2 to signal ground, C4 prevents high-frequency oscillation of stage Q2, and C5 minimizes signal degeneration in the emitter circuit of Q2.

Collector voltage for Q1 and Q2 is supplied by transistor stage Q4. The turn on of Q4 is delayed by R38 and C8 when power is applied to the reproduce amplifier PWA, minimizing turn on transients.

Transistor Q3 and associated components form an emitter-follower circuit. This circuit provides the low-impedance drive for the reproduce equalizer and the base circuit of transistor Q5. The reproduce equalizer is situated in a feedback path that interconnects the emitter of Q3 with the emitter of Q1.

High-speed or low-speed equalization is selected by control voltages that are applied to diodes CR1 and CR2. These voltages are controlled by the SPEED switch. When a high voltage is applied to pin M and a low voltage to pin N, diode CR1 is forward biased and CR2 is reverse biased. Thus, the audio signal taken from the emitter of Q3 is routed through C6, CR1, C3, R104, R103, R102, C50, and R101 to the emitter of Q1. Conversely, when CR1 is turned off and CR2 is turned on, the feedback path is via C6, CR2, C17, R107, R106, C51, R105, and R101. Potentiometers R104 and R102 are used to adjust the high-speed frequency response, and R107 and R105 are adjustments for the low-speed frequency response.

The output of emitter-follower Q3 is coupled through capacitor C7, circuitry on the front and back panels, and capacitor C11 to the base of transistor Q5. Capacitor C10 attenuates unwanted high frequencies, and C12 decouples the base-bias network of Q5.

Transistor Q5 and associated components form a common-emitter amplifier. The output of stage Q5 is directly coupled to common-emitter amplifier Q6, which drives complementary-amplifier Q7-Q8. Capacitor C14 enhances the DC voltage (hence current) available to the base circuit of transistor Q8 and, therefore, allows the output signal at pin 5 to swing almost to 39 volts without clipping. Resistor R25 couples feedback from the signal output line to the emitter of Q5. Resistors R26 and R25 set the overall AC gain of the amplifier formed by transistors Q5 through Q8 and associated components.

AC CAPSTAN DRIVE MOTOR

Schematic 4840261 shows the details of the capstan motor circuit. The circuit essentially consists of a two-speed, AC-powered, capstan motor and switching circuitry. The motor (B601) has one set of field windings for high speed and another set for low speed. Switch S602 (SPEED) is used to select the desired speed by connecting 117-Vac, single-phase power to either the high-speed or low-speed field windings. Notice that one section of the SPEED switch connects a phase-shifting capacitor (C601) in series with one of the field windings for each speed. Capacitors C602 through C605 minimize contact arcing of the SPEED switch.

SERVO CAPSTAN DRIVE MOTOR

The closed-loop capstan servo system consists of the capstan servo PWA; a reference generator, a frequency/phase comparator, and a servo amplifier on the capstan servo chassis; and a high torque, tachometer-equipped, DC motor. The tape is driven directly by the shaft of the motor.

SERVO SYSTEM BLOCK DIAGRAM

Figure 4-8 shows a block diagram of the capstan servo system. During operation, tachometer pulses are provided at a rate proportional to capstan speed. These pulses are amplified and fed to one input of a digital phase comparator. The other input to the phase comparator is a reference signal. This signal is derived from a reference oscillator and divider circuit on the capstan servo PWA or an external reference-frequency source. A pulse shaper converts the input reference signal into a train of steep-sided pulses. This pulse train is then appropriately divided to obtain one pulse train for high-speed operation and one for low-speed operation. The setting of the SPEED switch determines which pulse train is applied to the overspeed limiter. In turn, the limiter drives the reference input to the phase comparator.

The phase comparator compares the tachometer signal with the selected reference signal and produces an output that is proportional to the phase difference between the two signals. The phase-comparator output can vary from a DC level for an extreme underspeed or overspeed condition to a symmetrical square wave for an on-speed condition. During the record or reproduce mode, this speed-proportional output is integrated to form an error signal, which is amplified by the capstan motor drive amplifier (MDA) and used to drive the capstan motor. If the capstan motor slows, the

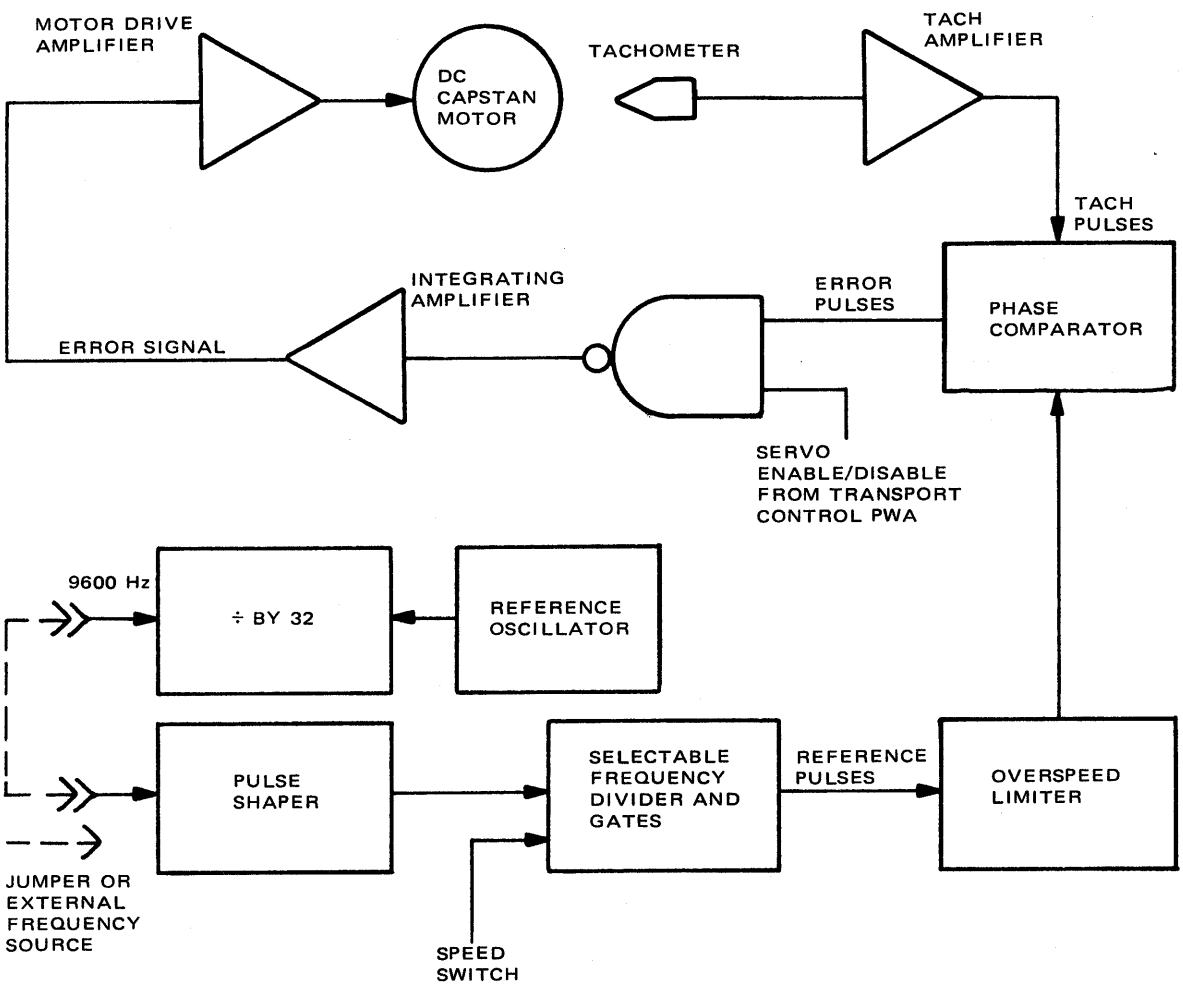


Figure 4-8. Capstan Servo Block Diagram

error signal causes the MDA to provide more current to the capstan motor to increase its speed. Conversely, if the capstan motor overspeeds, the MDA supplies less current to the motor, causing it to slow.

The overspeed limiter prevents severe overspeeding of the capstan motor if the frequency of the external reference oscillator (when used) is set too high. If the reference frequency increases to a preset limit, the output of the limiter becomes a high level. This level causes the phase comparator to produce an output that stops the capstan motor.

SERVO SYSTEM CIRCUIT DESCRIPTION

Stage A5, crystal Y1, and associated components comprise the internal reference oscillator (schematic 4840356). Crystal Y1 is situated in the feedback path of stage A5 and is series resonant at 307.2 kHz. Consequently, only a 307.2-kHz signal is fed back with minimum attenuation, causing the stage to oscillate at 307.2-kHz. This 307.2-kHz signal is fed to stage A2.

Stage A1 is an integrated circuit that is strapped to divide the oscillator signal by 16. In turn, the 19.2-kHz output of stage A1 is halved in frequency by flip-flop A3-8/9. Normally, either the 9600-Hz output of flip-flop A3-8/9 or an external 9600-Hz signal is applied to pin 9 of the capstan servo PWA.

Diode CR1 protects the base/emitter junction of transistor Q6 from large-amplitude negative-going spikes. Transistor Q6 and associated components amplify and clip the signal and drive Schmidt trigger A11. The Schmidt trigger delivers a clearly shaped pulse train to flip-flop A3-1.

Flip-flops A3 and A2 form a divider chain. This divider chain is connected to strapping points E1, E4, E3, and E6 such that division by one, two, four or eight is possible. Accordingly, certain of these strapping points are interconnected at the factory to obtain the proper frequency division for the customer-specified tape speeds.

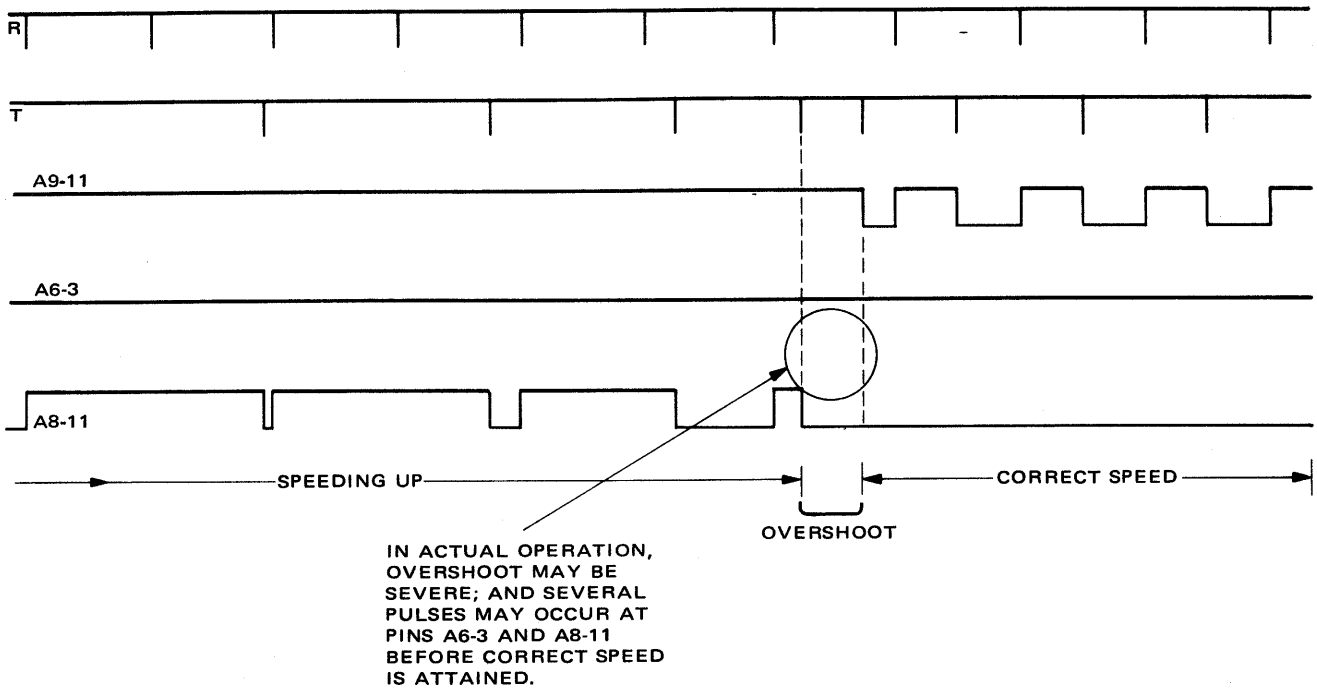
Strapping point E2 is connected to pin 13 of NAND gate A7 and E5 is connected to pin 10 of NAND gate A7. Both NAND gates are also connected to the SPEED switch. Setting the SPEED switch to the low-speed position enables gate A7-11 and disables gate A7-8. Conversely, setting the SPEED switch to the high-speed position enables gate A7-8 and disables gate A7-11. Therefore, the appropriate pulse train is delivered to pin 1 of retriggerable one-shot A10 (overspeed limiter).

In normal operation, one-shot A10 delivers a train of negative-going pulses to pin 6 of flip-flops A8, A9, and A6 (phase comparator). If the repetition rate of the pulse train applied to pin 1 of retriggerable one-shot A10 exceeds approximately 12,000 pps, the output of A10 becomes a high level. This high level will cause the phase comparator to stop the capstan motor, thus preventing the motor from overspeeding.

Tach pulses from the capstan-motor tachometer are applied to the base of transistor Q8. Transistors Q8 and Q7 form a high-gain, non-inverting amplifier. Resistors R29, R32, R35, R36, R38 and R39 are biasing resistors; and resistor R37 provides a DC feedback path. The amplified tach signal taken from the collector of Q7 is shaped by Schmidt trigger A11-6, inverted at A7-6 and applied to pin 5 of flip-flops A8, A9, and A6 (phase comparator).

Figure 4-9 shows a typical set of waveforms for the capstan phase comparator while increasing speed to synchronous speed and a table listing the signal conditions at pins A8-11, A9-11, and A6-3 for each motor-speed condition. The waveforms of this figure depict a situation similar to the time when the capstan motor is accelerating to operating speed after starting. Notice that when the tach-signal (T) frequency reaches and then exceeds the reference-signal (R) frequency, two T pulses occur between adjacent R pulses. At this point, flip-flop A9-3/11 begins changing state; and a square wave that contains phase information appears at pin A9-11.

When the capstan motor reaches the correct speed (synchronized operation), the R and T pulses alternate; and a rectangular wave is produced at pin A9-11. Notice that while the motor is increasing speed and when it is synchronized, pin 3 of flip-flop A6-3/11 is low. Further notice that during the same time interval, each T pulse causes the signal at pin A8-11 to go low, but the following R pulse returns the signal to a high level. After the



MOTOR SPEED	A8-11	A9-11	A6-3
INCREASING	PULSES	HIGH*	LOW*
SYNCHRONIZED	LOW*	SYNCHRONIZED SQUARE WAVES	LOW*
DECREASING	LOW*	LOW*	PULSES

*THERE MAY BE A BURST OF PULSES PRESENT AT THE INSTANT MOTOR ENTERS BY SYNCHRONISM DUE TO OVERSHOOT OR UNDERSHOOT.

Figure 4-9. Capstan Phase Comparator, Typical Operation

instant that the tach-signal frequency exceeds the reference-signal frequency (termed overshoot), flip-flop A8-3/11 stops changing state; and the signal at pin A8-11 stays low during synchronized operation. In actual operation, although Figure 4-9 does not show it, the overshoot may be enough to cause a burst of pulses at pins A6-3 and A8-11.

When the motor is slowing, pin A9-11 remains low until the capstan is turning (for an instant) below the correct speed (undershoot). During the undershoot interval, two T pulses occur between adjacent R pulses. Subsequently, a rectangular wave at the correct frequency is again produced at pin A9-11.

(The motor-slowing sequence is not shown in Figure 4-9.) The signal at pin A6-3 is normally high and is forced low by each R pulse when the motor is slowing. At the instant of undershoot, the signal at pin A6-3 goes low and stays low. Further, the signal at pin A8-11 remains low (as the signal at pin A6-3 does when the motor is coming up to speed). However, a few pulses may appear at pin A8-11 at the instant of undershoot because of inertia.

The output of the phase comparator is applied to NAND gate A7-2. During the record or reproduce mode, this gate is enabled by a high level coupled through resistor R27 when the coil of relay K1 of the capstan servo is energized. The coil of relay K1 is energized when transistor Q8 of the capstan-servo chassis (schematic 4840279) is turned on by the play signal from the transport-control circuitry or by a high level from the capstan-stop circuitry. (The capstan-stop circuitry is discussed in a subsequent paragraph.) Enabling NAND gate A7-3 allows the phase-comparator output to be applied to the base of transistor Q1.

The signal developed at the collector of Q1 is coupled to the base of transistor Q2. Transistor Q2 and associated components form a double-integrating active filter. Resistors R16 and R17 and capacitors C10 and C11 form the integrating network, and transistor Q2 multiplies the effect of the network. The output signal taken from the emitter of Q2 is again integrated by another double-integrating active filter (A3 and associated components). The signal taken from the emitter of Q3 is routed through a lead/lag network (R21, R22, R23, C14) to pin 5 of integrated circuit A4. The lead/lag network supplies required phase shift to keep the capstan servo system from oscillating.

Integrated circuit A4 is a differential amplifier that compares the output of the lead/lag network with the feedback signal from the capstan motor drive amplifier. The difference signal developed at the output of A4 is coupled through an attenuator (R25, R26) to the base of Q4.

Transistor Q4 supplies the base-drive current for the capstan motor drive amplifier (Q6, R28) located on the capstan-servo chassis. The capstan-motor circuit forms the collector load for transistor Q6. Potentiometer R19 on the capstan servo PWA is used to adjust the gain for best DC stability.

The capstan-servo circuitry is shown in schematic 4840279. With the CAPSTAN STOP switch set to BOTH SPEED, the junction of resistors R29 and R30 is grounded holding Q8 off and K1 de-energized. During the play or record modes, a high level from the play circuitry is applied to the base of transistor Q8, turning transistor Q8 on, and energizing the coil (K1A) of relay K1. Transferring contact sets K1B-1/9 and K1B-2/10 removes a shunt from the capstan motor, which enables the motor. Transferring contact set K1C-4/12 enables NAND gate A7-3 of the capstan servo (schematic 4840356), which enables the servo. Consequently, the capstan motor starts turning and is servo controlled.

With the CAPSTAN STOP switch set to HIGH SPEED and the tape SPEED switch set to the low-speed position, the junction of R29 and R30 is connected to an open circuit. As a result, the +5 Vdc level at pin J3-4 causes transistor Q8 to be turned on in all modes. Thus, the capstan motor is turning and under servo control in all modes.

With the CAPSTAN STOP switch set to HIGH SPEED and the tape-speed switch set to the high-speed position, the junction of R29 and R30 is connected to ground through the tape transport speed switch. Thus, the capstan servo and motor only operate in the play and record modes as previously described. This arrangement is used to start the tape at a 30-in/s speed when the play or record mode is selected.

BIAS/ERASE OSCILLATOR

The bias/erase oscillator is mounted on the 39-Vdc regulator PWA and supplies a 150-kHz push-pull signal to the bias/erase amplifier of the audio electronics. Schematic 4840168 shows the details of the oscillator.

Transistors Q701 and Q702 and associated components comprise the circuitry of the oscillator, which is a variation of a standard stable multivibrator. Capacitors C702 and C703 and resistors R703 and R704 are the basic timing elements of

the multivibrator. Capacitor C701 prevents the bases of Q701 and Q702 from swinging excessively negative and removes unwanted transients. The collectors of Q701 and Q702 are connected to opposite ends of the center-tapped primary of transformer T701. This primary and capacitor C704 form a tuned circuit that is shock excited by the push-pull drive from the collectors of Q701 and Q702. With the slug of T701 appropriately set, a 150-kHz, push-pull sine wave signal is obtained across the center-tapped secondary of T701. This signal is routed to the bias/erase amplifier.

Operating power for the oscillator is taken from the 39-Vdc regulator. Resistor R705 and voltage regulator VR701 reduce the 39 Vdc to 13 Vdc. Capacitor C705 prevents AC signals from the oscillator from entering the 39 Vdc power line via resistor R705.

POWER SUPPLIES

There are four power supplies in the tape machine. The +5/12/20 Vdc power supply (capstan servo chassis), a 24 Vdc supply, and a 130 Vdc supply are located in the tape transport control box and a 39 Vdc supply is contained in the bias/erase oscillator and power supply chassis. Each of these power supplies is described in detail in the following paragraphs.

+5/12/20 Vdc Power Supply

The +5/12/20 Vdc power supply (schematic 4840279) receives 117 Vac power from the AC power-distribution circuitry of the recorder/reproducer. Transformer T1 steps down the 117 Vac power and drives bridge-rectifier CR1. The 20-volt level developed across filter capacitor C17 is applied to the capstan-motor circuit and to a series-regulator circuit. The series regulator is composed of transistor Q7, capacitor C16, resistor R27, and voltage-regulator diode VR1. Diode CR1, resistor R27, and capacitor C16 function together to hold the base of Q7 at about 13 Vdc. The regulated 12-volt level appearing at the emitter of Q7 is applied to stages Q1, Q2, Q3, and Q4 and to a +5 volt regulator, which are located on the capstan servo PWA (schematic 4840356).

The +5 volt regulator consists of filter capacitors C4 and C5, resistor R6, voltage-regulator diode VR1, and transistor Q5. Resistor R6 and diode VR1 function together to hold the emitter voltage of Q5 at +5 Vdc.

24 Vdc Power Supply

Schematic 4840261 shows the details of the 24 Vdc power supply. This supply receives 117 Vac power supply from the AC power-distribution circuitry of the recorder/reproducer. Transformer T601 steps down the 117 Vac power and drives a bridge rectifier composed of diodes CR113 through CR116. The 24-volt level developed across filter capacitor C107 is then distributed to the transport-control circuitry.

130 Vdc Power Supply

Schematic 4840261 shows the details of the 130 Vdc power supply. This supply receives a nominal 117 Vac power from the AC power-distribution circuitry of the recorder/reproducer. A bridge rectifier (CR602, CR603, CR604, CR605) and filter capacitor (C609) convert the input AC power into an unregulated 130 volt level that is applied to the circuitry of the tape transport. Bleeder resistor R601 dissipates the charge on capacitor C609 when the power is turned off.

39 Vdc Power Supply

Schematic 4840168 shows the details of the 39 Vdc power supply. This supply receives 117 Vac power from the power-distribution circuitry of the recorder/reproducer. Transformer T702 steps down the 117 Vac power and drives a bridge rectifier composed of diodes CR701 through CR704. Fuse F701 protects the primary of T702 from excessive current. The voltage level developed across filter capacitor C707 is applied to the regulator circuitry of the power supply. Bleeder resistor R706 dissipates the charge on capacitor C707 when the power is turned off.

Transistors Q703 through Q706 and associated circuitry form a conventional series regulator equipped with an overcurrent protection circuit. The divider network composed of resistor R707 and diodes CR705 and CR706 maintain transistor Q703 base/emitter voltage constant. Consequently, during normal operation, the collector current of transistor Q703 is constant. This current is shared

by the base/emitter circuits of transistors Q704 and Q705 and the collector/emitter circuit of transistor Q706.

Transistor Q705 is the series pass transistor of the regulator and operates in a Darlington configuration with driver transistor Q704. Transistor Q706, voltage-regulator diode VR702, and resistor R710 form a voltage-comparator stage. This stage compares a sample of the output voltage of the regulator with the voltage drop across diode VR702 and conducts in proportion to the voltage difference. For example, if the output voltage tends to become more positive, Q706 conducts more heavily, which shunts a portion of the current available to the base circuit of Q704. Therefore, Q704 and Q705 conduct less, causing the output voltage to be restored to the desired level (nominally +39 Vdc). Conversely, if the output voltage tends to become more negative, Q706 conducts less, which allows more of the constant collector current of Q703 to flow in the base circuits of Q704 and Q705. As a result, Q704 and Q705 conduct more to restore the output voltage to the desired level. The output voltage can be adjusted slightly to compensate for circuit variations using potentiometer R712, which is part of the output-voltage sensing network (R711, R712, R713).

Current furnished to the load is sensed by resistor R709. The value of this resistor is chosen such that if the current load tends to become excessive, the voltage drop across R709 turns on diode CR707. Turning on CR707 allows a low level to be applied to the emitter of transistor Q703, which turns off Q703. Turning off Q703 cuts off the base current of transistors Q704 and Q705, which causes them to stop conducting. Therefore, the power supply is protected until the current overload is removed.

POWER DISTRIBUTION

AC Distribution

Input 117 Vac power is routed through fuses F601 and F602 (Figure 4-10) to POWER switch S601. With safety switch S603 (on tension arm) open, closing switch S601 applies 117 Vac power to the power ON indicator (DS601), the contacts of relay K603, the 39 Vdc power supply, and safety switch S603. Thus, power is available to operate the stop/edit mode so that tape can be threaded and/or manually cued. Once the tape is properly threaded, safety switch S603 is closed and power is available for all modes of operation.

Capacitor C608 minimizes contact arcing when switch S603 is opened and closed. Any high-frequency noise present in the input AC power is shunted to ground by capacitors C606 and C607. Fuses F601 and F602 protect the entire AC distribution from damaging currents, and fuse F603 does the same for the 130 Vdc power supply.

DC Distribution

Except for a portion of the 24 Vdc and 39 Vdc power distribution, DC power distribution is straightforward. As mentioned previously, DC power is available to operate the stop/edit mode even when the safety switch (S603) is open. This DC power comes from the 39 Vdc power supply through CR110 and CR102. When the safety switch is closed, the 24 Vdc power supply is enabled. Enabling the 24 Vdc supply turns off diode VR102 on the transport-control PWA, which disconnects the 39 Vdc supply from certain circuits. These circuits are then powered by the 24 Vdc supply.

Diode CR111 disconnects the 24 Vdc supply from the 39 Vdc supply when the 24 Vdc supply is not active (schematic 4840261). Diode CR110 disconnects the 39 Vdc supply from the 24 Vdc supply if the 39 Vdc supply should fail while the 24 Vdc supply is active.

The 39 volt power supply ground is connected to the 24 volt power supply ground via the electronics (schematic 4840248). Ground is carried by the playback cable outer shield to 4J1 (electronics chassis), to 4J11-5, and then back to the 39 volt power supply. If the electronics is disconnected, the edit functions will not operate when the safety switch is open.

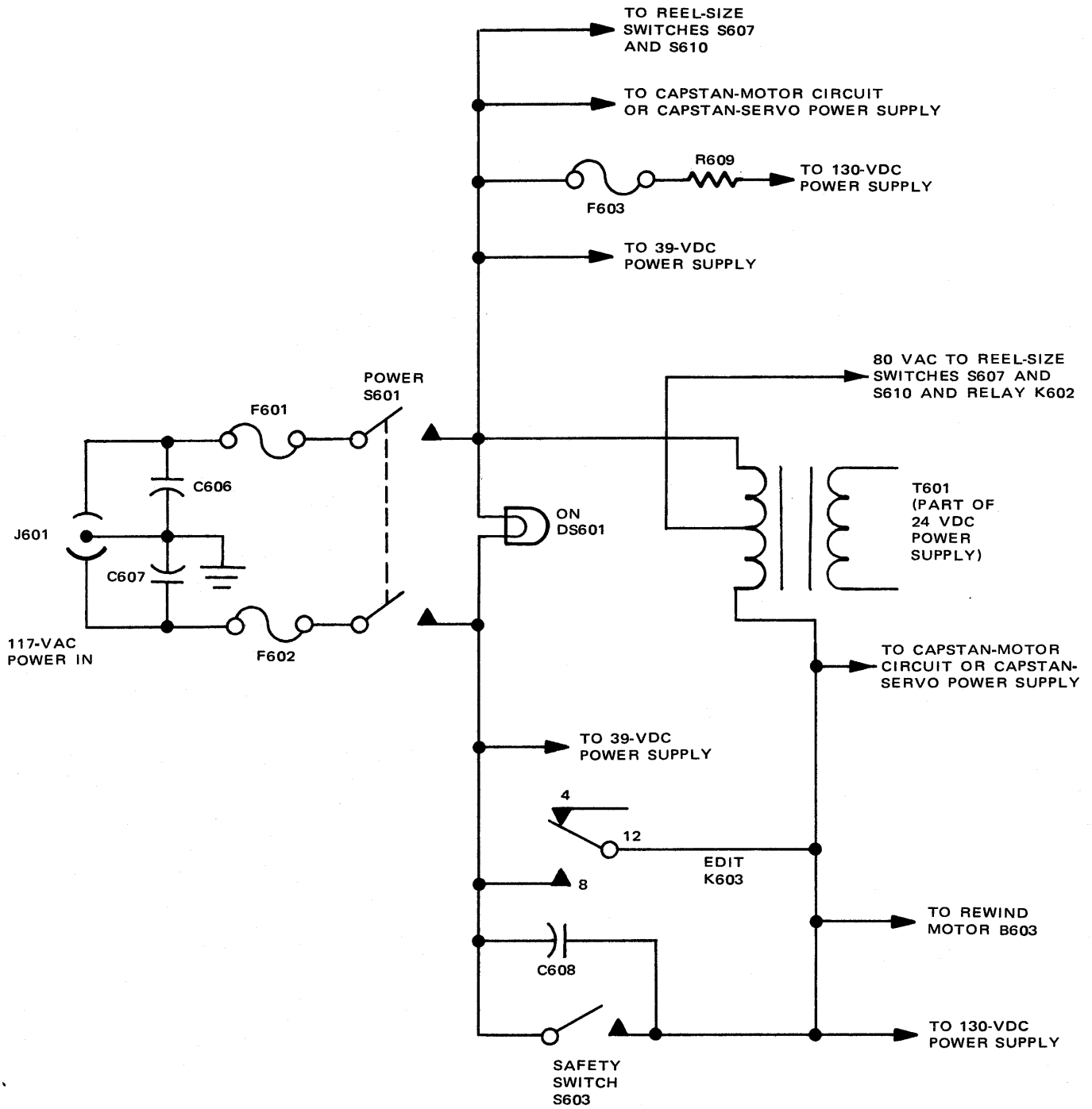


Figure 4-10. AC Power Distribution, Simplified Schematic