A BIG thanks to

Ken McKim

who provided the Maintenance Section scan

GENERAL

Maintenance is of prime importance for reliability and useful life of all magnetic tape systems. Maintenance consists of: preventive maintenance, to help prevent breakdowns; and corrective maintenance, to correct the malfunction when a breakdown occurs.

FIELD SERVICE

Regularly scheduled maintenance service is available from the Mincom Sales and Service Office on a contract basis, or service may be obtained on an emergency basis through the same office. In either case, every effort is made to provide the needed service in the minimum amount of time.

TEST EQUIPMENT

Test equipment recommended for alignment and troubleshooting of the Series 500 tape recorders is listed in table 4 which follows.

PREVENTIVE MAINTENANCE

Perform the following inspections at intervals considered necessary, based upon the operation and environment in which the recorder is operated.

1. Watch for excessive wear of moving surfaces, such as capstan, capstan idlers, reversing idler, tape guides, etc.

Table 4. Test Equipment

Equipment	Function
Flutter Meter, D & R Ltd, or equivalent	Measure percentage of flutter in reproduced output.
Wave Analyzer, HP 302A or equivalent	Measure percentage of harmonic distortion.
Oscilloscope, Tektronix RM504 or equivalent	Measure phase and observe test signals.
VTVM, HP 400LR or equivalent	Measure voltages and continuity.
Audio Oscillator, HP 200CDR or equivalent	Provide test and alignment signals.
Frequency Counter, HP5233L or equivalent	Measure bias frequency.
7 1/2 ips (1 inch) NAB calibration tape, Ampex catalog number 46-90007-01	To provide standard NAB reproduce alignment signals.
15 ips (1 inch) NAB calibration tape, Ampex catalog number 46-90006-01	To provide standard NAB reproduce alignment signals.
15 ips (2 inch) NAB calibration tape, Ampex catalog number 46-90024-01	To provide standard NAB reproduce alignment signals.

2. Observe that the two cooling fans mounted below the transport are operating and that there is no obstruction to keep air from circulating.

3. Check all connectors for security and tight fit, and tighten if necessary.

4. Inspect input and output cables for broken or frayed leads, and repair if necessary.

5. Inspect printed circuit logic board at the rear of transport for broken leads, burnt or damaged components, broken or shorted conductor tracks and pads. Check that all relays on this board are mounted securely in their sockets and the retaining clamps are positioned over each relay.

6. Check that all circuit boards in the signal electronics assembly are engaged properly. Also, check that the A/B and SYNC transistors, and their associated relays are well seated in their sockets. The RECORD relays should also be checked for proper seating in their sockets.

CAUTION

Should any of the SYNC relays be removed from their sockets, care should be used when replacing these relays due to the fragile nature of the contact pins. Hold the relay at an angle so that one lower bank of pins start to engage their proper contacts in the relay socket; then, carefully pivot the relay about its lower edge so that the remaining pins progressively engage their contacts in the socket.

7. The brushes on each reel drive motor should be checked for length. Any brush less than 1/4 inch should be replaced.

8. The capstan speed should be checked by using a neon or fluorescent light. With the light projected on the marked capstan, the marks should appear to stand still if the capstan is rotating at the proper speed. The belt tension adjustment in this section should be performed if the capstan speed is not constant or appears to be slow.

NOTE

Reel motor bearings are sealed and have been lubricated to last the useful life of the motor.

Cleaning

The tape handling surfaces should be cleaned periodically. The time between cleaning will depend on the amount of use and the environment, since increased temperature, dust and humidity will cause the tape handling surfaces to become dirty more quickly. The best precaution is to clean the surfaces just prior to a recording session.

To clean the guides, capstan, and reversing idler use a cotton swab dipped in a Freonxylene cleaner (Mincom catalog number 83-9830-0075), or equivalent. Caution must be used when applying this solvent because it damages plastic and rubber surfaces, and excessive amounts that could get into the bearing surfaces can dissolve the lubricants, causing bearing problems.

To clean the capstan idlers, use a dry cotton swab on the rubber idlers lightly pressing while the transport is in the RUN mode. If an extra amount of cleaning is necessary, use a swab lightly dipped in Freon TF, but do not apply the swab while the transport is in the RUN mode because some of the fluid may be splashed on other surfaces and may cause damage. After cleaning with Freon TF, allow the idlers to dry and then use a dry swab on the rubber idlers with the tape transport in the PLAY mode. This process will clean the surfaces of fingerprints that may accumulate.

CORRECTIVE MAINTENANCE

Corrective maintenance involves procedures for the correction of malfunctions and possible adjustments that are required when assemblies are changed or replaced because of wear or damage.

The Series 500 recorder has been factory adjusted for peak performance. With use, it will occasionally be necessary to make certain adjustments to maintain optimum performance. The following information provides a procedure for a thorough performance check and adjustment of the recorder system.

Tape Transport Adjustments

Before attempting mechanical or circuit adjustments on the tape transport, a thorough understanding of the transport operation is necessary. Review the equipment specifications, mechanical and electrical descriptions, and the circuit diagrams in the Schematics Section. Location of the transport adjustments is shown in figures 12 and 13.

Power Supply Check

Before performing any adjustments on the transport the following power supply voltage and regulation checks should be made.

1. Connect the input power cord to the output of a 7-1/2 amp Variac. Set the Variac for zero volts output.
2. Connect the positive test lead of a dc voltmeter (50 volt scale) to TP-1 and the negative lead to TB1-1.
3. Press the POWER button on the transport and increase the Variac output voltage; at approximately 90 volts, the POWER button should light, the tape sensor lamp should come on, and the RUNOUT indicator lamp on the Remote Control Box should come on, indicating K1 has operated. Both cooling fans in the transport should also be running at this time, and the A/B indicator lamps on the meter panel should be on. If these indications do not occur, return the Variac to zero, press the POWER button again, and increase the Variac output as before. If the proper indications are not observed, refer to the troubleshooting table in this section.
4. Continue to increase the Variac output voltage to 115 volts. The dc voltage at TP-1 should be between 26 and 28 volts dc.
5. Place a piece of opaque material in the tape path between the tape sensor light and the tape-threaded sensor cell. This will be referred to hereafter as the "tape sensor mask." The STOP button should light. The take-up motor should rotate at approximately 200 rpm in a counterclockwise direction. The rewind motor should rotate approximately 200 rpm in a clockwise direction.
6. Press the PLAY button, then press the FORWARD button, and then the REWIND button. The voltage at TP-1 should remain between 26 and 28 volts. The voltage at TP-1 should not drop below 26 volts dc until the Variac output voltage is below 105 volts ac.
7. Remote the tape sensor mask. The STOP button should go out.

Capstan Speed

Set the Variac to 115 volts ac, and reinsert the tape sensor mask. Place the capstan motor SPEED switch to HI. Press the PLAY button and observe that the capstan runs at high speed. Press the STOP button, and move the SPEED switch to the LO position. Press the PLAY button. The capstan should run at half speed in the same direction. Remove the tape sensor mask, and move the SPEED switch to the HI position.

Transport Cover Plate Removal

Access to the adjustments located on the top area of the transport shown in figure 13 is obtained by removing the transport cover plate. If reels are on the machine, they should be removed. The cover plate is fastened to the transport by twelve screws; four of these screws are located on the top of the cover plate, and four each are located at the right- and left-hand sides of the transport. These screws secure the side trim plate as well as the flange of the top cover plate. After removing these screws, lift the cover plate up from the rear until the reel hubs clear the holes in the plate. Then slide the cover to the rear until the retaining clip on the front edge of the cover is disengaged. The cover plate can now be completely removed from the transport.

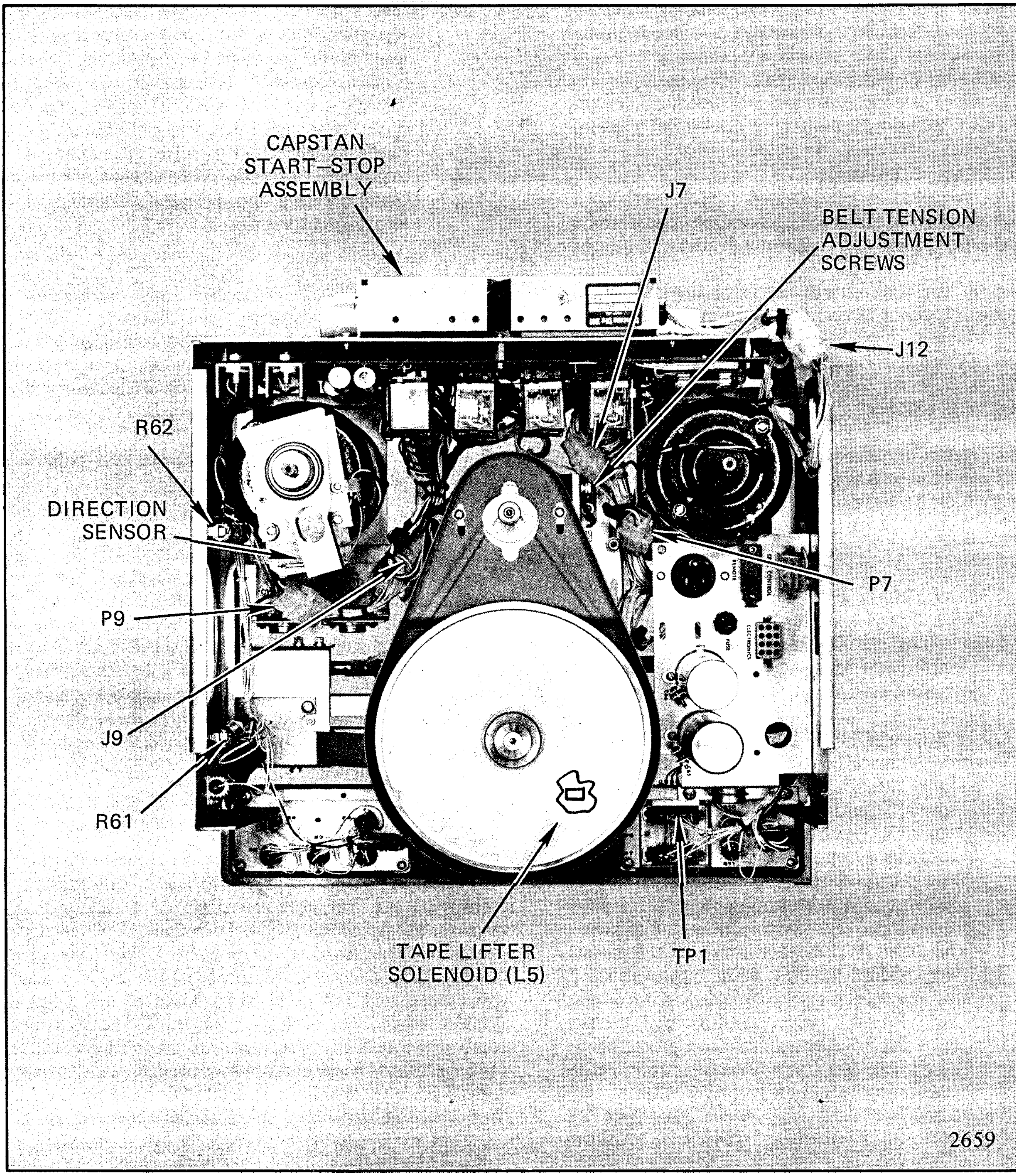


Figure 12. Transport Adjustments, Bottom View

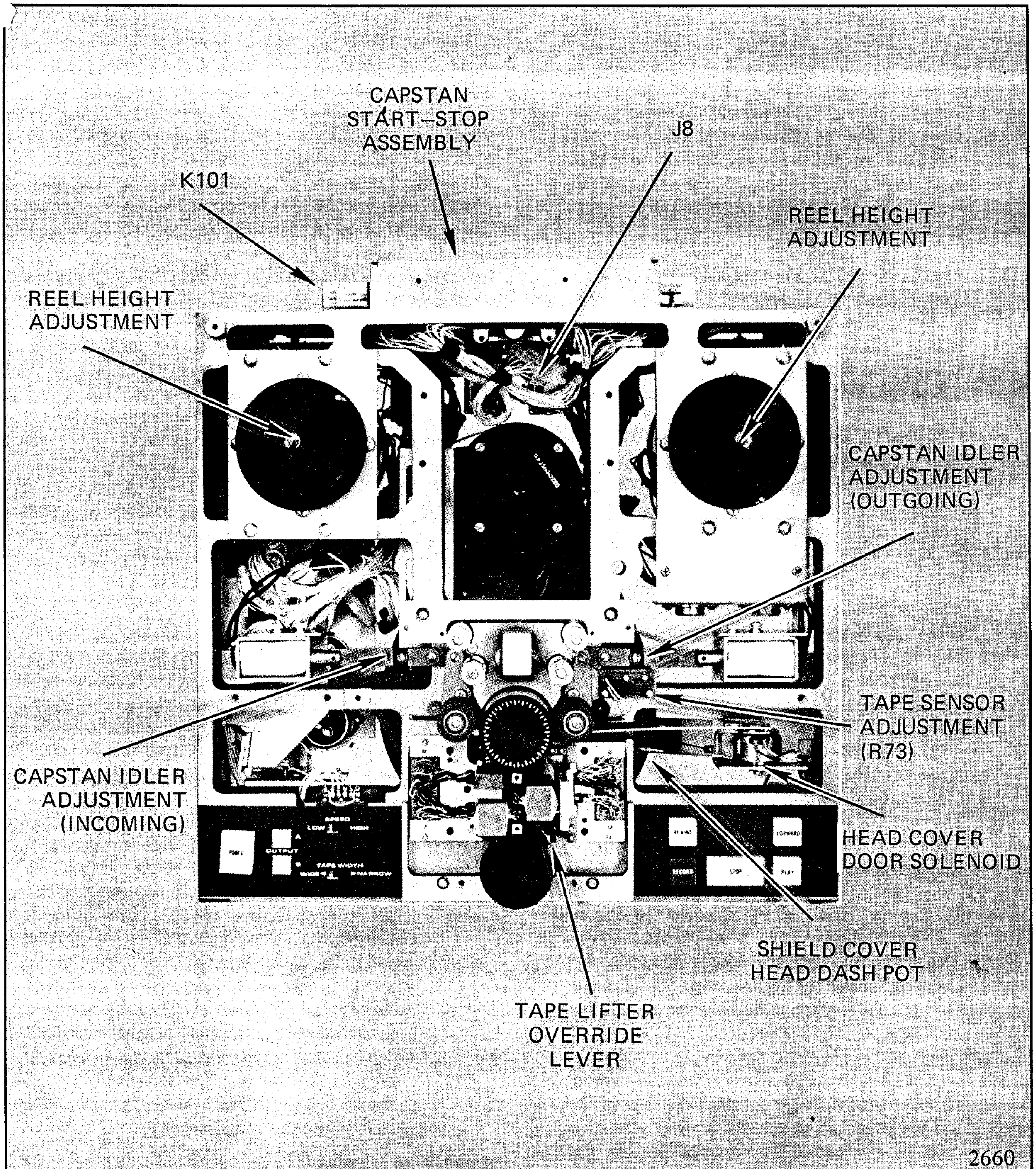


Figure 13. Transport Adjustments, Top View

Tape Sensor Adjustment

Proper operation of the tape sensor circuit is dependent on the adjustment of R73 with respect to the translucence of the tape leader material used. For this reason it is important that the adjustment of R73 be made using the same type of leader that will be used on the machine during recording sessions, etc. The following steps should be performed when adjusting R73.

1. Place a length of translucent tape leader in the normal tape path over the two outgoing guides in such a manner that the leader falls between the photocell and the tape sensor lamp assembly. The leader should be held taut over the tape guides.

2. Position R73 to the extreme counterclockwise position (maximum resistance); then slowly adjust R73 in the clockwise direction until the STOP button illuminates. Note the position of R73.

3. Remove the leader. The STOP button lamp should go out. Slowly adjust R73 in the clockwise direction until the STOP button illuminates again. Note this position.

4. Position R73 mid-way between the two points noted above. The STOP button lamp should go out. The STOP button lamp should come on when the leader is inserted.

Capstan Belt Adjustment

Occasionally it may be necessary to adjust the belt tension or belt alignment on the capstan drive assembly. The following adjustments should also be followed when replacing the belt or any of the drive components, i.e., capstan, capstan motor, flywheel, etc.

Access to the belt drive assembly is accomplished through the bottom of the transport as shown in figure 12. To facilitate adjustments in this area, the transport can be pivoted up to approximately 45 degrees by grasping the front edge moulding on the transport and raising the transport to the canted position.

To expose the belt inside the dust cover, remove the two screws on the front, and the two screws at the rear of the cover, and slide the lower half of the cover down and away from the top section.

Five socket head cap screws located on the capstan motor bracket assembly permit the adjustment of the belt alignment and tension. Three screws located on the motor base, when loosened, allow the motor to be positioned in the vertical plane so that the belt will not skew on the flywheel. The remaining two screws fasten the motor bracket to the transport frame through two slotted holes in the bracket. Loosening these screws allows the motor to be moved back and forth, which adjusts the tension on the belt.

The following procedure should be used when adjustment of the belt is necessary.

1. Spin the flywheel by hand and observe that the belt, as it passes, over the crown of the flywheel remains centered. There should be no skewing of the belt (up or down motion across the crown of the flywheel).

2. If skewing of the belt is noticed, loosen the three screws on the capstan motor base, and cock the motor back and forth until a position is found which allows the belt to ride true on the flywheel without skewing. Tighten the three screws.

3. Position the SPEED switch for 15 ips operation. Press the POWER button, and insert the tape sensor mask. Press the PLAY button and allow the capstan to get up to speed; then press the STOP button. Observe that the flywheel stops at the same time the capstan motor pulley stops with no belt slippage over the motor pulley or flywheel. If slipping occurs, loosen the two screws through the slotted holes on the motor bracket and move the motor back to a point where the belt just stops slipping. Tighten the screws in the motor bracket at this point.

Capstan Idler Tracking

The alignment of the capstan idlers with the capstan is important in maintaining the proper tape tension within the Isoloop. Shims are used under the idler to shift the idler up or down, depending on the alignment needed. Figure 14 shows the proper relationship of the idlers to the capstan and the position at which the shims are placed.

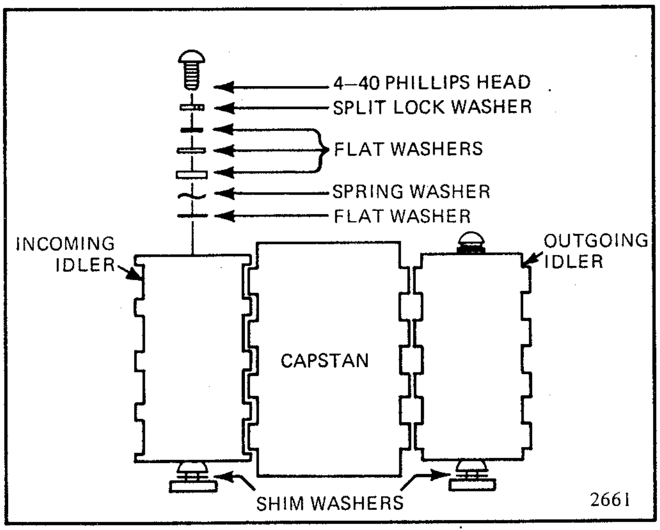


Figure 14. Capstan Idler Alignment

Capstan Idler Pressure Adjustment

Capstan idler pressure is adjusted by means of a spring-loaded screw in the solenoid linkage which varies the linkage arm length. See figures 13 and 15. Perform the capstan idler pressure adjustment as follows:

1. Press the plunger of the ingoing idler solenoid all the way in, and turn the adjustment screw counterclockwise until the idler does not contact the capstan.

2. Repeat step 1 for the ingoing idler.

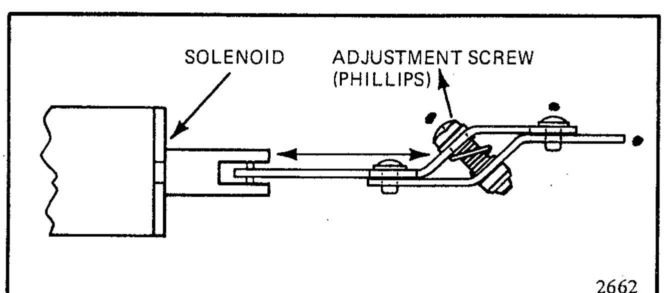


Figure 15. Capstan Idler Linkage Adjustment

3. Insert the tape sensor mask.

4. Press the POWER button, then the PLAY button. The capstan idlers should move toward the capstan.

5. Adjust the ingoing linkage arm screw clockwise until the idler is positively driven by the capstan, then turn the screw approximately 1-1/4 additional turns clockwise.

6. Repeat step 5 for the outgoing idler.

7. Remove the tape sensor mask, and thread a full reel of tape on the transport.

8. Press the PLAY button; both idlers should press the tape against the capstan, and tape movement should start smoothly without any loops forming in the tape path.

9. Observe the tape just before it enters between the ingoing idler and the capstan. If any wrinkling or deformation of the tape is observed at this point, the idler pressure is too great. Turn the ingoing linkage arm screw counterclockwise until there is no distortion of the tape as it enters the idler, and the idler is still positively driven.

10. With the finger, press in firmly on the capstan idler solenoid plungers to be certain the plungers are fully seated when the solenoids are energized. The solenoid mounting screws may be loosened, and the solenoid positioned to obtain proper seating of the plunger.

Reel Height Adjustment

Reel height adjustment is required only if tape drags on the reel flanges, or if a new motor or reel hub is installed. The following procedure should be used if reel height adjustment is necessary.

CAUTION

Before attempting adjustment of the reel height, inspect the reels to be sure that the reel flanges are not bent.

1. Check the distance between the reel hub flange and the top of the motor mounting plate. See figure 16.

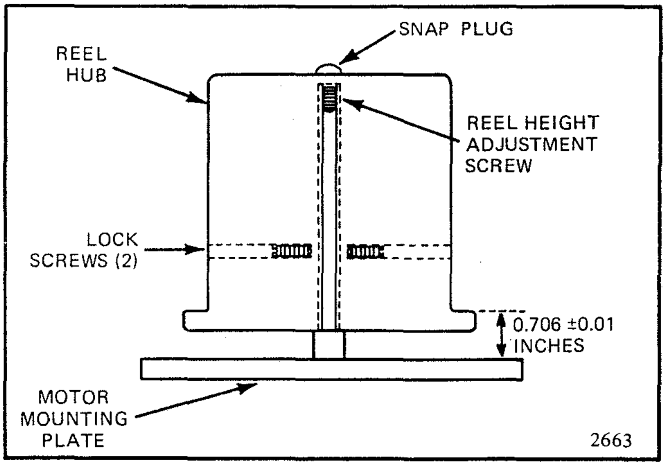


Figure 16. Reel Height Adjustment

2. Loosen the two locking screws (10-32 Allen head) accessible through the holes on the side of the reel hub. Remove the snap plug on the top of the reel hub; this allows access to the reel height adjustment screw. Insert a 10-32 Allen wrench, and adjust the reel hub height for 0.706 ± 0.01 inch between the top of the reel hub flange and the motor mounting plate.

NOTE

Snap plugs covering the reel height adjustment screws are not used on 1 inch tape transport reel hubs.

3. Tighten the two reel hub lock screws.

4. Load and thread a full reel of tape on the transport.

5. Press the POWER button, then the PLAY button. The tape should wind onto the take-up reel without touching the inside of either reel flange.

6. If the tape should drag on either reel flange, loosen the two lock screws, and adjust the reel hub up or down in the direction away from the flange that the tape is dragging on. Repeat the adjustment until the tape winds on and off the reels without touching the reel flanges. The tape should not crease on the shoulders of the ingoing or outgoing tape guides when the reel height adjustment is correct.

Reel Torque Adjustment

The incoming and outgoing tape tension is controlled by the reel motor torque. The amount of torque developed by the take-up and rewind motor is controlled by the setting of R61 and R62. See figure 12. The required torque for each motor is developed when R61 and R62 is set at maximum resistance.

Incoming Tape Tension

The incoming tape tension is controlled by R8 on the transport logic board (see figure 19) in addition to R61 and R62. R8 should also be set for maximum resistance for proper holdback torque on the rewind motor when the transport is operating in the PLAY or RECORD mode.

Head Shield Cover Adjustment

Place the transport in the PLAY mode, observing the time required for the head shield cover to close after the PLAY button is pressed. The cover should close between 1/2 and 3/4 second. Adjust the head shield cover dash pot air port for the proper closing time. See figure 13. When the transport is placed in either the STOP, FORWARD or REWIND mode, the head shield cover should open immediately.

Tape Lifter Adjustment

The tape lifter assembly should seldom need adjustment. However, the following checks can be made to determine proper operation:

1. The tape lifter arms should operate when the transport is activated in the FORWARD or REWIND mode, lifting the tape away from the heads.

2. Moderate finger pressure on the tape lifter override lever (see figure 13) should allow

the tape to return to its normal path over the heads. If excessive pressure is required to override the tape lifter, adjustment of solenoid L5 may be necessary. See figure 12. For smooth operation and moderate pressure to operate the override lever, the solenoid plunger must not seat. Adjustment of the solenoid is accomplished by loosening the two phillip head screws that hold the solenoid to its bracket, and adjusting the position of the solenoid until the proper override operation is obtained. The solenoid must be positioned so that sufficient torque is applied to the lifter arm to hold the tape away from the heads yet not allow the solenoid plunger to seat.

3. When the tape lifter operates, the tape should be lifted away from the record head; the distance between the tape and record head should be 0.005 to 0.015 inch. Adjustment is accomplished by a setscrew located on the tape lifter arm. Access to the setscrew is obtained by removing the head mounting plate. The setscrew should be adjusted until the tape and record head are separated by 0.005 to 0.015 inch when the tape lifter solenoid is energized. This adjustment is made by trial and error. First, adjust the setscrew; replace the head mounting plate and measure the separation between the tape and record head. This process should be repeated until the proper separation is obtained.

Flutter Test

Flutter is checked by recording a 3 kHZ signal and then playing it back into a flutter meter. Flutter checks are useful as a troubleshooting aid in determining which component, or group of components, is contributing to the flutter. Using a flutter meter in which three bandpasses are provided, components contributing to flutter can be determined, as shown in table 5. The following steps are to be followed in checking flutter.

NOTE

It is extremely important that all tape guides, heads, capstan surface, puck idlers, capstan flywheel, and capstan motor spud be thoroughly cleaned, as described at the beginning of this section.

Table 5. Components Contributing to Flutter

Waveband	Component Area
0.5 to 30 cps	Flywheel and capstan
30 to 300 cps	Capstan motor and reversing idler
0.5 to 300 cps	Used to check overall flutter up to 300 cps

1. Connect an audio oscillator to the input of the recording electronics. Set the oscillator frequency to approximately 3kHz (some flutter meters contain their own internal oscillator). Connect the output of the playback electronics to the flutter meter input.

2. Position the SPEED switch for 15 ips operation. Position the tape so that it will start near the beginning of the reel.

3. Record the test signal at 0 VU for approximately 3 minutes. Rewind the tape to the start of the test signal recording.

4. Start the tape and calibrate the input level to the flutter meter. Check the frequency acceptability to the discriminator, then switch to the fullband flutter position (0.5 to 300 cps). Employ 0.5% full scale sensitivity. Flutter should not exceed 0.04% at 15 ips, or 0.07% at 7-1/2 ips.

5. Since it is possible for flutter components to cancel in playback because the phase of the recorded flutter may be opposite to the same component being generated during playback, it is necessary to stop and start the tape during playback at least 15 or 20 times and to accept the worst reading, where the recorded and reproducing phases are additive, as the true worst

flutter case. This must be done on each test. Do not check flutter with a playback head while recording the carrier with another head.

6. Make each flutter measurement at about 100 feet from the beginning of the reel, near the center, and again at about 100 feet from the end of the reel.

7. Identify any prominent frequency components in observed flutter, using an oscilloscope. Sources of such components must be determined and steps taken to minimize them if they cause overall flutter readings to exceed specifications. Several sources are:

   a. Rotation rate of the capstan. A large component at this rate indicates improper belt tension.
   b. Rotation rate of the reversing idler (same rate as capstan).
   c. Rotation rate of the ingoing pressure roller.
   d. Rotation rate of the outgoing pressure roller (rate close to that of c).
   e. Rotation rate of the capstan motor.
   f. Rotation rate of the take-up or supply reel.
   g. Resonant component of the reversing idler mass coupled to elasticity of the tape; approximately 100 cycles on the idler for 1 inch tape, 70 cycles for 2 inch tape. Try running the tape at high speed over the reversing idler. If the latter produces considerable noise, whining, growling, or hissing, it may mean that the bearings have been damaged; in which case the idler should be replaced, since considerable flutter will otherwise be generated. Do not try to repair the idler. Replace it.

SIGNAL ELECTRONICS ALIGNMENT

The 3M Brand Series 500 Professional Audio Tape Recorder is factory aligned for peak performance. It is recommended that, whenever a circuit board, the heads, or other components are changed, the following applicable alignment procedure be performed to insure optimum performance of the tape recorder. All controls are accessible from the front of the console by opening the two doors below the transport. A chart is located on the back of one of these doors that is an aid in locating the circuit boards for each channel, and their associated alignment controls and test points. This chart is reproduced in figure 17.

Power Supply Adjustment

Prior to performing any alignment on the signal electronics, the output voltage of the dc power supply should be checked. Press the POWER button on the transport, and measure the dc voltage at the power supply output terminals. The voltage should be 28 volts dc; if not, adjust the power supply output to the proper voltage.

NOTE

> For maintenance and adjustment information on the signal electronics power supply, refer to the manual supplied with the unit.

Playback Alignment

The 7-1/2 and 15 ips playback alignment is accomplished by using industry standard calibration tapes which conform to the NAB format. These calibration tapes are listed in table 4.

NOTE

> The following alignment procedures, in many cases, make reference to a single channel. In these instances, the procedure should be repeated for all channels requiring alignment.

15 ips Playback Alignment

1. Thoroughly degauss and clean all heads.

2. Remove the head cover plate to expose the head azimuth adjustment screws.

3. Place all output TERMINATION switches to the ON position (600 ohm termination).

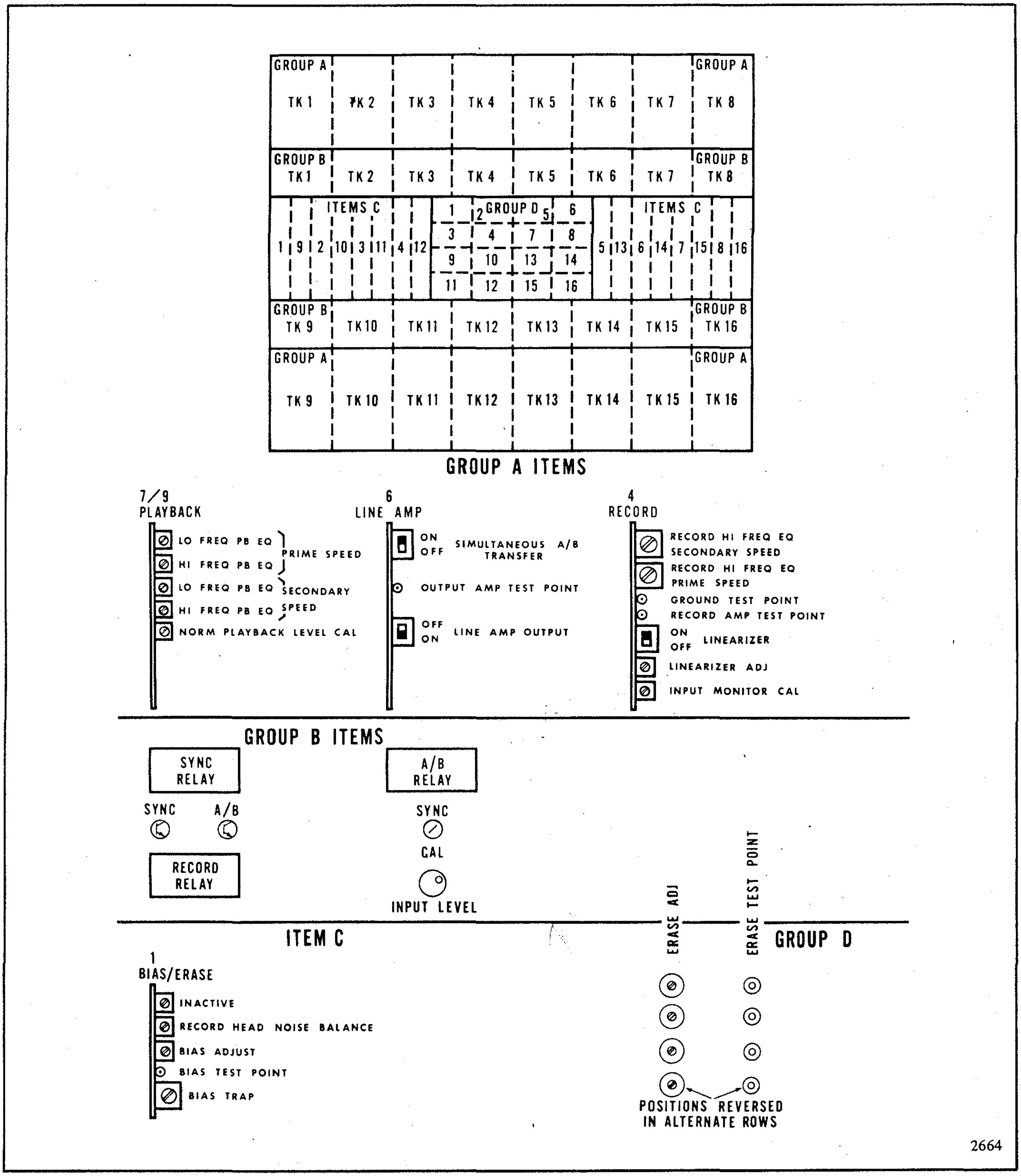


Figure 17. Signal Electronics Adjustment Locations

4. To provide auditory monitoring of the calibration tape tones and tone frequency voice announcements, connect a high gain power amplifier and loudspeaker to one of the OUTPUT jacks of the recorder. The output impedance of the channel driving the monitor should be maintained at 600 ohms.

5. Place the program select switch to NORM, and each mode select switch to SAFE.

6. Place all SIMULTANEOUS A/B TRANSFER switches on the number 6 boards to the ON position.

7. Place the SPEED select switch to the position providing 15 ips tape speed. This will be the HIGH position with recorders having a speed range of 7-1/2 – 15 ips or the LOW position with recorders equipped for 15–30 ips operation.

8. Apply power to the recorder by pressing the POWER button.

9. Press the B OUTPUT button on the transport or remote control unit.

10. Load and thread the 15 ips calibration tape on the transport.

11. Start the recorder in the reproduce mode by pressing the PLAY button. The first tone on the calibration tape is 700 Hz; this tone is used to establish a calibrated output reference level for each reproduce channel. Observe the VU meters; if the output level of each reproduce channel is not within ±1/2 VU of zero, VU adjust the NORM PLAYBACK LEVEL CAL potentiometer on the corresponding PLAYBACK amplifier board (7/9) to produce zero VU output.

12. The second tone from the calibration tape is 15 kHz. At this time, check for proper tape tension in the Isoloop by applying finger pressure to the tape as it moves against the incoming tape guide. If an increase of more than 1/2 VU is observed on the VU meters the incoming capstan idler pressure should be increased. Refer to the Tape Transport Adjustment section herein for details on this adjustment.

13. If adjustment of the capstan idler pressure was necessary during step 12, rewind the calibration tape to the 700 Hz reference tone and repeat step 11.

14. Continue to play the 15 kHz test tone, and adjust the playback head azimuth adjustment screw (see figure 18) for a peak signal level on all VU meters. Care should be taken to ensure that the largest peak is found, as two lesser peaks may be noticed while performing this adjustment.

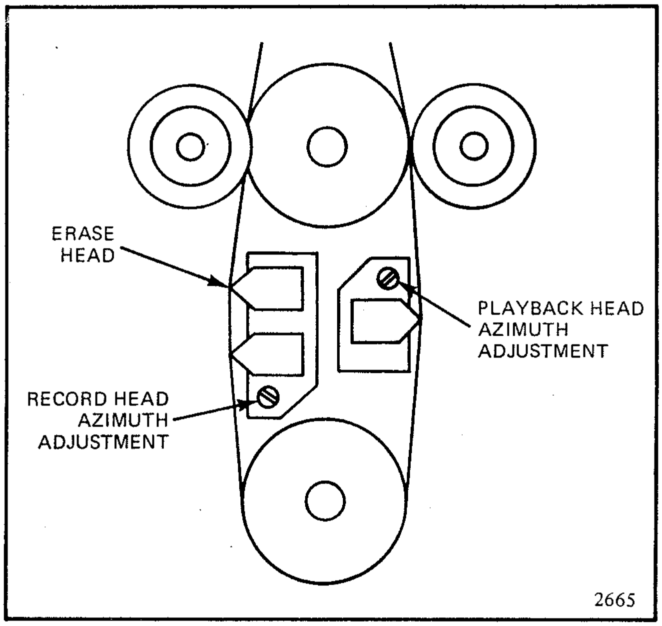


Figure 18. Record and Playback Head Azimuth Adjustments

15. Connect the OUTPUT of channel 1 to the vertical input of the oscilloscope, and the horizontal input of the scope to the recorder OUTPUT channel corresponding to the center track.

16. Shuttle the calibration tape to the commencement of the 2.5 kHz test tone.

17. Press the PLAY button and observe the lissajous pattern on the oscilloscope.

Adjust the playback head azimuth adjustment screw to obtain minimum phase error between the two output signals.

18. Play the calibration tape through all test tones (30 Hz to 15 kHz) and minimize the phase error.

NOTE

If the phase error should approach 180 degrees between 2.5 and 5 kHz, the wrong peak was selected during the adjustment in step 14. Repeat step 14, 17, and 18, if necessary.

19. Compare the phase relationship between channel 1 and all other channels while playing the 15 kHz tone, and readjust the playback head azimuth screw to obtain a phase error of not more than 90 degrees.

20. Shuttle the calibration tape to the commencement of the 10 kHz test tone.

21. Press the PLAY button and adjust the PRIME SPEED HI FREQ PB EQ potentiometer on the PLAYBACK boards (7/9) to obtain zero VU on the corresponding channel VU meter.

22. Check the 700 Hz playback reference level by repeating step 11.

23. Shuttle the calibration tape to the commencement of the 50 Hz tone.

24. Press the PLAY button and adjust the PRIME SPEED LO FREQ PB EQ potentiometer on the PLAYBACK boards (7/9) to obtain zero VU on the corresponding channel VU meter.

25. Play all test tones from 30 Hz to 15 kHz. The frequency response should be within ±1 VU from 100 Hz to 12 kHz, increasing to +2, -1 VU at 15 kHz. The 30 and 50 Hz tones shall be within +1, -3 VU of the 700 Hz reference level.

NOTE

Readjustment of the PRIME SPEED LO FREQ PB EQ potentiometers may be necessary to bring the low frequency tones within the response limits stated in step 25.

7 ½ ips Playback Alignment

The 7-1/2 ips playback alignment is performed in the same manner as the 15 ips alignment described earlier except for the following.

1. The 7-1/2 ips calibration tape shall be used.

NOTE

At the time of this publication, a 7-1/2 ips 16 track 2 inch calibration tape was not available from the customary supplier. Until such time this tape becomes available and the user requires a need for performing alignment at this secondary speed, the 1 inch calibration tape specified in table 4 may be used. When using the 1 inch calibration tape on a 2 inch transport, tracks 9 through 16 may be aligned by simply loading and threading the tape in the normal manner. To enable the 1 inch test tape to guide over tracks 1 through 8, a spacer should be placed on the reel tables before the 1 inch test tape reels are loaded and threaded on the transport.

2. A VTVM shall be used to monitor the reproduced output of the test tone signal levels rather than the VU meters.

3. The playback head azimuth adjustments and the NORM PLAYBACK LEVEL CAL adjustment made at 15 ips should not be disturbed unless 7-1/2 ips is to be used as the speed of primary usage.

With the above considerations the 7-1/2 ips alignment should be performed as follows:

1. Play the 700 Hz reference tone at the beginning of the calibration tape and note the output level from each channel on the VTVM. Use a meter scale that will give a middle to three quarter scale reading on the VTVM.

NOTE

The 700 Hz reference tone, and the frequency run on the 7-1/2 ips calibration tape is recorded at a level of 10 VU below zero VU to accommodate the heavier recording preemphasis used at the higher frequencies. For this reason, a more accurate measurement can be obtained when using a VTVM to monitor the output level of the test tones rather than the VU meters.

2. Shuttle the calibration tape to the commencement of the 10 kHz test tone. Play the 10 kHz tone and adjust the SECONDARY HI FREQ PB EQ potentiometer to produce the same level on the VTVM noted in step 1.

3. Shuttle the calibration tape to the commencement of the 50 Hz test tone. Play the 50 Hz tone and adjust the SECONDARY SPEED LO FREQ PB EQ potentiometer to produce the same level on the VTVM noted in step 1.

4. Play all test tones from 30 Hz to 10 kHz. The frequency response should be within ±1 dB from 100 Hz to 10 kHz. The 30 and 50 Hz tones shall be within +1, -3 dB of the 700 Hz reference level.

NOTE

Readjustment of the SECONDARY SPEED LO FREQ PB EQ potentiometers may be necessary to bring the low frequency tones within the response limits stated in step 4.

Record Alignment

The following alignment procedure should be performed, using the same type of tape to be used for subsequent recording whenever possible. The recorder was factory aligned for use with 3M type 202 or 203 tape. It is essential that the preceding playback alignment be checked before performing the record alignment.

Bias Frequency Adjustment

1. Insert the tape sensor mask.

2. Place the transport in the record mode and allow the recorder 3 minutes to stabilize.

3. With a frequency counter, measure the bias frequency at one of the ERASE TEST POINTS. If necessary, adjust C11 on the transport logic board to obtain a frequency of 120 kHz ± 500 Hz at the test point. Access to C11 is obtained by tilting the transport up, and adjusting C11 on the logic board through the hole provided at the rear of the transport.

Bias Level Adjustment

1. Load and thread a degaussed reel of tape on the transport. Set the SPEED switch to 15 ips.

2. Connect an audio oscillator to the INPUT of the channel under test. Set the oscillator to 15 kHz at a level of +4 dBm.

3. Connect a VTVM to the OUTPUT of the channel under test.

4. Press the B OUTPUT button. Place the mode select switch corresponding to the channel under test to the READY position.

5. Start the recorder in the record mode. Turn the BIAS ADJUST potentiometer on the BIAS/ERASE board of the channel under test to the maximum CCW position. Slowly turn the BIAS ADJUST potentiometer in the cw direction, watching for a peak signal indication on the VTVM.

When the peak is established, continue to turn the BIAS ADJUST potentiometer in the cw direction until the signal level on the VTVM drops 2 dB from the established peak reading. The record head bias is now set for 4 dB overbias at 15 kHz, which is equivalent to peak at 1.0 kHz, and recommended when using 3M heads and type 202 or 203 tape.

6. Adjust the INPUT LEVEL control corresponding to the channel under test for zero VU, as measured on the VU meter panel.

7. Repeat the above for the remaining channels.

NOTE

A VTVM may be connected to the BIAS TEST POINT during the bias adjustment. As the bias is adjusted for each channel, the VTVM reading is recorded. This data can then be used during preventive or corrective maintenance checks.

Bias Trap Adjustment

1. Remove all input signals from the recorder. Connect a VTVM to the RECORD AMP TEST POINT on board No. 4.

2. Place the transport in the RECORD mode, and adjust the BIAS TRAP trimmer capacitor on board No. 1 for minimum signal on the VTVM. Repeat this adjustment on all channels.

Record Head Azimuth Alignment

1. Thread a degaussed reel of tape on the transport. Set the SPEED select switch for 15 ips operation. Apply a 2.5 kHz +4 dBm signal to the recorder input.

2. Connect the outputs from the reproduce electronics corresponding to the top and center tracks to the inputs (vertical and horizontal, respectively) of an oscilloscope to produce a lissajous pattern. Press the B OUTPUT button.

3. Start the recorder in the RECORD mode, and adjust the record head azimuth screw (see figure 17) for minimum phase error. Sweep the input oscillator frequency over the range of 30 Hz to 15 kHz while maintaining an input level of +4 dBm. Check each combination of any two tracks, and optimize the phase error for less than 90 degrees.

Record Equalizer Adjustment

1. Thread a degaussed reel of tape on the transport. Apply a 1 kHz +4 dBm signal to the input.

2. Press the B OUTPUT button, and start the recorder in the RECORD mode. Adjust the INPUT LEVEL control for 0 VU on the corresponding VU meter.

3. Press the A OUTPUT button and adjust the INPUT MONITOR CAL potentiometer on the No. 4 board for 0 VU on the corresponding VU meter.

4. Press the B OUTPUT button, and adjust equalizer trimmer capacitors on the RECORD amplifier No. 4 boards in accordance with the test conditions given in table 6.

Table 6. Record Equalizer Test Conditions

Speed (ips)	Input Signal	Adjust for VU Meter Reading of:
7-1/2 (secondary)	10 kHz @ -6 dBm	-10 VU
15 (primary)	10 kHz @ +4 dBm	Zero VU
30 (secondary)	15 kHz @ +4 dBm	Minimum signal

5. Set the SPEED select switch for 15 ips operation. Slowly sweep the input signal maintaining a level of +4 dBm from 30 Hz to 15 kHz. The response should be within

±2 VU 100 Hz to 15 kHz, and +2, -4 VU at 50 and 30 Hz.

6. Set the SPEED switch to 30 ips if the recorder is provided with this speed, and repeat the frequency response check outlined in step 5.

7. Set the SPEED switch to 7-1/2 ips if the recorder is provided with this speed. Slowly sweep the input signal maintaining a level of +4 dBm from 30 Hz to 10 kHz. The response should be within ±2 VU 100 Hz to 10 kHz, and +2, -4 VU at 50 and 30 Hz.

Sync Level Adjustment

1. Apply a 700 Hz +4 dBm signal to the INPUT, and place the recorder in the record mode. Adjust the INPUT LEVEL control for zero VU on the corresponding VU meter, if necessary. Record this signal for approximately 1 minute at 15 ips.

2. Rewind the tape to the beginning of the recorded 700 Hz signal. Place the program select switch in the CUE position and the channel under test mode select switch in the SYNC position. Start the recorder in the PLAY mode and adjust the SYNC CAL control for zero VU on the corresponding VU meter.

Linearizer Adjustment

NOTE

As delivered, the recorder is adjusted for use with Scotch Brand low-noise tape types 202 or 203. If the recorder is to use a different type of tape, the LINEARIZER ADJ control may require adjustment, as outlined below.

1. Place the LINEARIZER switch on No. 4 board to the OFF position.

2. Apply 1 kHz at +10 dBm to the INPUT. Connect a Wave Analyzer and VTVM to the reproduce OUTPUT.

3. Adjust the 1 kHz oscillator input signal level for exactly 3 percent third harmonic distortion, as measured on the wave analyzer.

4. Place the LINEARIZER switch on the No. 4 board to the ON position. Adjust the LINEARIZER ADJ potentiometer to obtain minimum distortion on the wave analyzer. The third harmonic distortion level should be less than 0.8 percent with the LINEARIZER switch ON and 3 percent with the LINEARIZER switch OFF. Leave the LINEARIZER switch ON after this adjustment is completed.

NOTE

The recorder may be operated with the linearizer distortion reduction circuit disabled if it is felt that this circuit is misaligned. This is accomplished by placing the LINEARIZER switch in the OFF position until proper alignment can be performed. Third harmonic distortion products will be more prevalent at the higher recording levels when operated under this condition.

Noise Balance Adjustment

Before making the noise balance adjustments, it is absolutely essential to degauss and clean all heads very carefully. Remove power from the recorder while degaussing the heads. Perform the noise balance adjustment as follows:

1. Load and thread a used reel of degaussed tape on the transport.

2. Connect a high gain power amplifier and loudspeaker to the reproduce OUTPUT jack of the channel under test. Short the INPUT of the channel.

3. Place the recorder in the RECORD mode, and advance the gain control on the external monitor amplifier until the tape noise is heard loudly.

4. Adjust the RECORD HEAD NOISE BALANCE potentiometer on the No. 1 board for minimum thumping and crackle.

5. Adjust the ERASE ADJ capacitor to further minimize thumping and crackle.

Erasure Test

1. Connect an audio oscillator to the INPUT of the channel under test. Set the oscillator for 1 kHz output at a level of +10 dBm.

2. Connect a VTVM to the ERASE TEST POINT of the channel under test.

3. Connect a wave analyzer to the OUTPUT of the channel under test.

4. Place the mode select switch corresponding to the channel under test to the READY position. All other mode select switches should be in the SAFE position.

5. Start the recorder in the RECORD mode and adjust the ERASE ADJ capacitor for peak on the VTVM. Then adjust the 1 kHz input signal level to obtain 3 percent third harmonic distortion as read on the wave analyzer.

6. Remove the input signal and rewind the tape to the start of the 1 kHz recorded signal.

7. Place the mode select switch in the SAFE position. Start the recorder in the RECORD mode.

8. When the 1 kHz signal appears, establish a reference level on the wave analyzer; then, initiate erasure of the track by placing the mode select switch to the READY position.

9. Return the mode select switch to the SAFE position, and rewind the tape once again.

10. Playback the erased segment of tape, noting the amount of signal erasure on the wave analyzer with respect to the reference level established in step 8 above. The signal should be at least 72 dB below the reference level; if not, turn the erase level potentiometer (R3) on the BIAS/ERASE board (No. 1) a few turns clockwise and repeat steps 4 through 10. The voltage measured at the ERASE TEST POINT should be less than 0.55 volt ac when 72 dB of erasure is accomplished.

Signal / Noise Test

1. Clean and degauss the heads. Load and thread a degaussed reel of tape on the transport.

2. Connect a VTVM to the OUTPUT of the channel under test.

3. Record a segment of tape with an input signal of 1 kHz at +10 dBm. Establish a reference level of the reproduced 1 kHz signal on the VTVM.

4. Record a segment of tape with the input signal removed, and note the noise level as measured on the VTVM.

5. The difference between the VTVM readings noted in steps 3 and 4 represent the signal-to-noise ratio of the channel under test.

NOTE

Noise figures stated in the system specifications are obtained by the use of bandpass filters. Such filters exclude all noise outside the stated passband.

TROUBLESHOOTING

The modular construction of the 3M Brand Series 500 Professional Audio Recorders provide not only

centre glitch on (min) max of waveform
adj. for max signal (w VTVM)

ORDER
- BIAS FREQ.
- ERASE
- BIAS TRAP
- NOISE BALANCE (use ears)

a fast and easy method of repair but also an excellent method of troubleshooting. The signal electronics assembly is so arranged in modular form allowing individual circuit boards of any channel to be replaced or exchanged with a similar board from a known good channel. When boards are interchanged, alignment of the channel(s) may be necessary to provide peak performance.

Failure of the recorder to operate properly may be caused by a malfunction in the recorder, or by external causes. Before troubleshooting the recorder, verify that the power and signal connections are correct, and that all of the operational controls are properly set.

Some of the troubles most likely to be encountered are presented in table 7. However, the best troubleshooting tool is a familiarity with the equipment and a thorough understanding of its theory of operation.

Figure 19 shows the major parts location on the transport logic board to help in troubleshooting.

The following paragraphs contain some general precautions which should be observed when performing maintenance on the recorder.

1. Do not strike the reversing idler. It is delicate and located in a vulnerable position at the front of the mechanism. If damaged, flutter will be excessively high.

2. Exercise great care in installing head mounting plates. They can be screwed into place with a head lead pinched between the mounting plate and the transport casting, thus breaking wire insulation or cutting a head lead. Be certain no leads will get in the way before installation.

3. Exercise great care in removing and replacing the mu metal cover over the playback head stack. The slot at the rear cover can slice head lead insulation, thereby grounding head leads or actually cutting through them. Be certain that this cover is fully seated so that the lower lip will not scrape on tape as it passes by. Otherwise tape edge may be cut and bad tracking over the heads may result.

4. Do not go from READY to SAFE when the recorder is operating in the RECORD mode. First stop the transport. This will

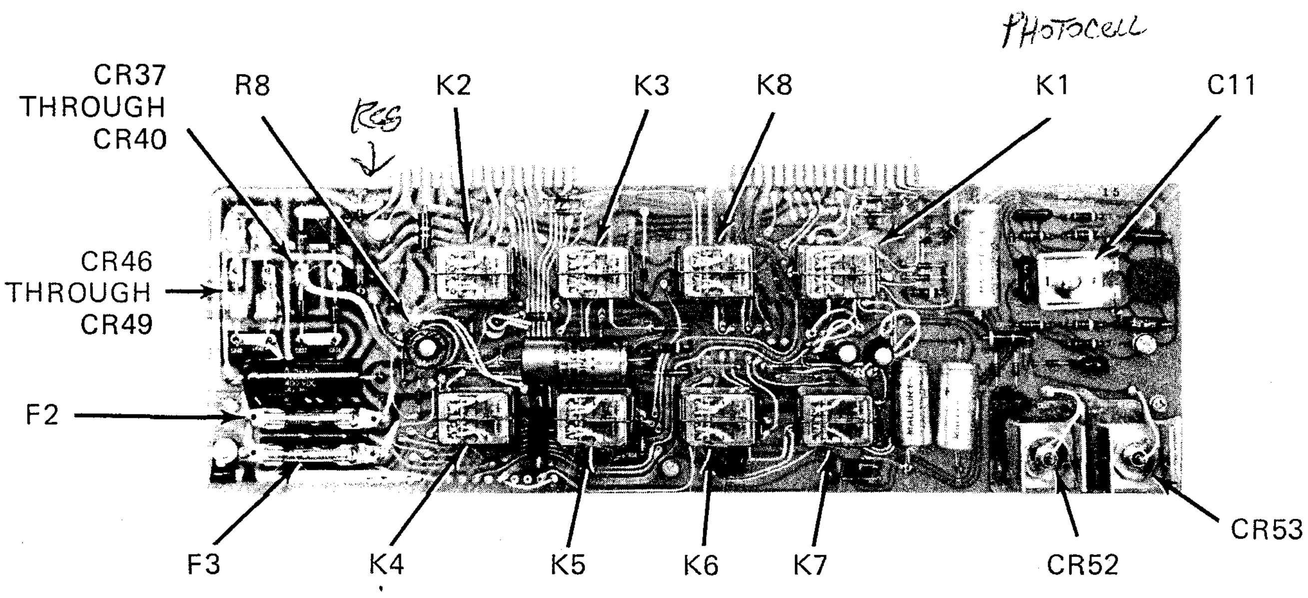


Figure 19. Transport Logic Board

STOP GO TO REWIND
DELAY IN OPERATION
REW WORKS PROPER
REWIND FWD
REC STOP PLAY
PLAY OR REC GOES to BOTH F.F. + REW TOGETHER

prevent the possibility of a thump from being recorded on the tape and possible magnetization of the record head.

5. Do not remove any of the electronics cards when the power is on. It requires only a few seconds to turn off the power, remove a card, restore power and be ready to operate. Otherwise it is possible to magnetize a head or damage a meter.

FIELD SERVICE

Regular scheduled maintenance service is available from the Mincom Division service office on a contract basis. If immediate service is required, it may be obtained on an emergency basis. Every effort is made to furnish the needed repair as soon as possible. For a complete description of 3M's maintenance service plans and their costs, contact the Mincom Division service office.

FACTORY REPAIR SERVICE

If desired, the recorder or major assemblies, may be returned to the factory (transportation prepaid) for repair. When recorder or assembly is returned:

1. Indicate the symptom of defect. State as completely as possible, both on an instrument tag and on the order form, the nature of the problem encountered. Too much information is far better than too little. If the trouble is intermittent, please be specific in describing the instrument's performance history.

2. Give special instructions. If any changes in the instrument or assembly have been made, and it is desired to retain the modified form, please indicate this specifically.

3. To facilitate expeditious repair, your Contract or Purchase Order authorizing the work should be directed to Mincom Division – 3M Company – 300 South Lewis Road – Camarillo, California 93010 – Attn: Contracts Department.

4. Pack securely and label. Proper packaging saves money. The small amount of extra care and time it takes to cushion a part or instrument properly may prevent costly damage while in transit. Make certain that the address is both legible and complete; failure to do so often results in needless delay. Address all shipments and correspondence to:

   Mincom Division
   3M Company
   300 South Lewis Road
   Camarillo, California 93010

   Attn: Receiving Inspection

5. Show return address on repair correspondence. Please clearly indicate the exact address the equipment should be returned to after repair is completed. Terms are net 30 days – f.o.b., Camarillo, California.

Table 7. Troubleshooting Guide

Symptom	Cause	Correction
	TRANSPORT	
1. Transport stops when leader passes photo cell V60.	Tape sensor adjustment R73 out of adjustment.	Adjustment R73 in accordance with Tape Sensor Adjustment procedure.
2. STOP button lights when tape is not threaded.	Lamp DS8 burnt out.	Replace DS8.

Table 7. Troubleshooting Guide (Cont.)

Sympton	Cause	Correction
TRANSPORT (Cont.)		
	Defective component on tape sensor board.	Troubleshoot sensor board (56013B075) Q1 or Q2 possibly defective.
3. STOP button does not light when tape is threaded.	V60 defective.	Replace V60.
4. Transport coasts to stop from PLAY mode when STOP button is pressed.	Relay K7 cannot be operated during stop sequence because the reed switch is not closed.	Adjust flag stops and clearance of magnets over reed switches on direction sensor board (56004A100).
5. Transport coasts to stop from FORWARD mode when the STOP button is pressed. Possibly causing tape breakage.	Same as 4, above.	Same as 4, above.
6. Transport coasts to stop from REWIND mode when STOP button is pressed.	Same as 4, above except K6.	Same as 4, above.
7. Tape continues in REWIND when STOP button is pressed. Does not clear after tape runs out or POWER switch is turned off and on.	K7 hung up. Contacts 5 and 9 sticking.	Replace K7.
8. Transport throws loop when starting in PLAY mode, generally worse near end of reel rather than beginning.	Ingoing solenoid capstan idler needs adjustment.	Adjust ingoing capstan idler linkage.
9. Capstan coasts to stop from PLAY or RECORD mode when STOP button is pressed.	Defective contacts on either K5 or K101.	Replace K5 or K101.
	CR101, R101 or C101 defective on Capstan Start-Stop Assembly (56013A170)	Troubleshoot Capstan Start-Stop Assembly. Replace defective components.
10. Sluggish Solenoid operation: L1, L2.	Misalignment or in need of lubrication.	Try lubricating first with graphite or silicone. Loosening to improve alignment may change absolute position of linkages when plunger is seated necessitating their further adjustment.

Table 7. Troubleshooting Guide (Cont.)

Symptom	Cause	Correction
TRANSPORT (Cont.)		
11. Tape lifter hangs up.	Misalignment or in need of lubrication.	Plunger must not drag too forcefully against core of solenoid. Body should be so positioned to avoid such side drag, and to provide best compromise of depth of travel to satisfy easy override yet adequate lifting power.
12. Tape lifter difficult to override manually.	Plunger approaches full seated position too closely.	
13. Tape lifter fails to lift tape from heads.	Plunger operating too far from seated position.	Loosen two mounting screws, lubricate plunger and shift body (holes are oversize) to achieve above requirements.
14. Transport appears completely dead.	Blown fuse F1.	Replace with 5 amps slow blow.
	Intermittent operation of power switch S6.	Press a few times to observe if lights come on.
	C66 charged to greater than 30 volts but no 27 volt dc at collector of Q60 or at test point means Q60 is defective.	Replace Q60 after checking load resistance from collector to ground for short circuit defect. Clear defect before again applying power.
15. All lamps excessively bright and short lived.	Regulator Q60 and associate circuit, Q1, R14, R15, and CR50 not functioning.	Replace Q60. Catcher diode CR51 will also require replacement if condition persisted for more than a few seconds. Check resistance of 27 volt load to be certain Q60 will not be overloaded. Transport may be operated without CR51 until replaced.
16. Flutter and Wow excessive.	Numerous sources possible. Most likely are: a) Insufficient capstan idler pressure either ingoing or outgoing. b) Defective reversing idler. c) Capstan bell tension in need of adjustment. d) Dirty flywheel and motor pulley.	Localize cause of trouble using oscilloscope while referring to Transport Alignment Procedures in this section.
ELECTRONICS		
1. A-B monitor lamps are dim or do not come on when POWER button on transport is pressed.	Short circuit on 28 vdc bus in electronic module assembly.	Remote one plug-in board at a time and re-insert to determine if fault is in cards or module wiring.
	Defective 28 vdc power supply.	Troubleshoot power supply using instruction manual supplied with the unit as a guide.

Table 7. Troubleshooting Guide (Cont.)

Symptom	Cause	Correction
ELECTRONICS (Cont.)		
2. A-B transfer causes clicks in output.	Leaky capacitor C15 in output of record monitor amplifier on board 4 or at output of preamplifier C6 on board 7/9. Also can be leaky input capacitor on line amplifier board 6.	Exchange boards 4, 6, and 7/9 one at a time from known good channel to determine defective board. Troubleshoot defective board looking at capacitors mentioned as being most possible cause of trouble.
3. Loss of signal in record board 4.	Defective field effect transistor Q2. Easily damaged by static charge from soldering iron or tool held in hand.	Replace Q2. Be very careful to avoid static charges. Ground soldering iron to ground bus on board.
4. Noise or intermittent operation in any area of electronics module.	Dirty contacts at base of card plug.	Remove and reinsert board. Use ink eraser to clean contact surfaces.
5. High distortion.	Insufficient bias.	Adjust record bias as prescribed under Signal Electronics Alignment.
	Magnetized head, either record or reproduce head.	Degauss heads.
	Noise balance control misadjusted.	Adjust for minimum noise after degaussing all heads.
6. Poor noise figure.	Noisy Q1 or Q2 on preamplifier board 7/9.	Substitute another preamplifier board to compare noise and replace transistors.
	Head cables badly routed, near hum fields.	Reroute for minimum noise. Keep away from power cord. This can be very important.
	Defective playback head requiring excessive gain.	Try breakin' tape if head appears to be smeared over by oxide material. Replace head if necessary.
	Lack of good system ground can produce hum or buzzing. Third wire in power cord not always effective as good ground.	Connect casted frame of transport to good earth ground.
7. Wrong output level.	Improper choice of line impedance or termination.	Check TERMINATION switch position of the channel in question. Output transformer impedance may be changed from normal 600 ohm output to 150 ohms by moving lead from terminal 6 to terminal 4.

NEW COMPACT 16-TRACK, 2-INCH RECORDER/REPRODUCER

C. Dale Manquen, Electronic Engineer
Mincom Division Minnesota Mining & Manufacturing Company
300 South Lewis Road Camarillo, California 93010
Presented at the 35th AES Convention October 1968 in New York

ABSTRACT

The use of a single electronics housing to hold 16 tracks of record and reproduce electronics has permitted the construction of a two inch recorder/reproducer that is as small as a normal four track machine. The system features full remote operation, high strength construction, and a new capstan drive method that sets a new standard in timing accuracy.

GENERAL

The current trend in master recording has been to utilize an ever-increasing number of recorded tracks to add versatility to the recording process. Eight track machines using one inch wide tape have become a common tool in the studio, but the limitations of eight tracks have spurred a demand for even more channels of -recorded information. Since the transition to eight track was somewhat painful, an analysis of the trouble- some areas was in order before embarking on a new program which might have the same pitfalls. Experience shows that the rising cost of operating errors caused by carelessness, confusion, and fatigue justify a great deal of effort to make the operation of multitrack machines both rapid and straightforward. The design effort requires a great amount of human engineering before any electrical or mechanical engineering can be undertaken. Some of the factors that must be considered are the intelligibility of multiple meter displays, methods of input/output monitor selection, location of Re6ord/Safe/Syne selectors, and the accessibility of components and wiring for calibration and maintenance. The physical size of the machine has a direct beating on its portability and its interchangeability with present eight track recorders. The fact that-it must fit through a 30 inch door is not a license to take more space than is absolutely necessary. Smaller machines tend to be more rugged and thus require less maintenance. Once the above considerations have been combined to yield a physical package, the real engineering can begin. The transport problems that must be overcome to handle ten-pound reels of tape smoothly can be quite tricky. The vibrations and dynamic loads that are developed by an unbalanced reel in fast modes can shake a machine to pieces. Since wide tape is very prone to trap an air blanket between the layers of tape, high power reel motors must be used to keep the winding tensions high in fast forward and rewind. The stubborn behavior of wide tapes when any steering or guiding is attempted requires accurately aligned components that are rigid enough to resist high loads. The capstan and its drive system must have very little speed variation to permit splicing segments from both ends of a reel with- out any pitch change. The ways that the above problems can be resolved are as numerous as the engineers who tackle them. The following description covers one approach to the problem.

DESIGN COALS OF THE SYSTEM

The system to be considered here is the combination of a 3M Isoloop audio tape transport equipped for two-inch wide tape and a sixteen track record/playback electronics package. The overall size is less than 30 inches square by 5 feet high. Full remote control has been provided with special attention being paid to making the operation simple and dependable. The performance specifications are generally the same as the present 3M C-401 recorders with some improvements. In addition, the C-401 printed circuit cards are utilized to make the machine more compatible with existing equipment. The basic console and transport are essentially identical to the current versions. The transport is pivot mounted in the top of a rectangular plastic-laminated wood console. Below the transport is mounted a single electronics package which is 24 inches wide by 21 inches high. The meter display panel is mounted above the transport on metal risers. The system is completed by the addition of a self-contained power supply in the lower rear of the console and a remote control cable on the end of a 25 foot cable.

Model 56 Prototype   Note single door, small casters, two erase capacitor mounting plates

REEL DRIVE SYSTEM

One of the biggest problems that was encountered in the design of the two-inch transport was the reel drive system. It was known at the outset that the reel motors that are used on transports employing one-inch tape would not be adequate to handle the heavier two-inch tape. Various planetary reduction systems were considered, but the final choice was to use direct drive supplied by a motor with two and one-half times the conventional motors output. Since the two inch transport is intended for horizontal operation only, the reel hub that has been designed has no locks or holddown mechanism. It would indeed be very difficult to force ten pounds of reel and tape to do anything but stay in place. A new feature is that the hub height may be easily adjusted by a hex head screw that is accessible from the top of the hub.

During this work, it was noted that some criterion for the measurement of the relative packing tension on a reel of tape was needed. The wide tape tends to trap an air blanket during high speed operation which leads ~ to a very loosely wound tape. The result is that what started as one reel of tape now becomes "one plus" reels of tape. One way of measuring the relative packing density is to measure the compression at the outside of the reel that is produced when a force of 16 ounces is exerted radially inward. A maximum deflection of 1/16 inch for a 3600-foot reel was considered to be tight enough to prevent any damage due to handling.

The reel control logic is unchanged from current machines, but some of the component values were altered to suit the larger motors. The maximum rewind and fast forward speeds have been reduced to help contro1 the air blanket. This loss in speed increases the rewind time for a 3600-foot reel from 90 seconds for a one-inch machine to 160 seconds for a two-inch version.

The problem of reels for two-inch tape deserves some consideration at this point. The normal audio reels consist of two flanges of .050 inch aluminum mounted on a loose-fitting hub. The nominal clearance between the flanges and the tape edges is typically .100 inch. In addition to protecting the edges of the tape, the flanges also provide some guiding of the tape in fast modes when the air blanket allows the tape to slide from side to side on the winding reel.

Handling of two inch tape on normal audio reels has shown the normal flange to be too weak to protect the tape. Permanent deformation may result from just lifting a reel by its top flange. For this reason, the two inch transport has been designed to use the semi-precision reels that are commonly designated "video reels". The .090 inch thick flanges of these reels are accurately positioned by a shoulder machined into the hub. The improvements in runout and flange wobble that are possible with these reels greatly reduce the hazards to the tape. A side benefit is a great reduction in the-vibration due to reel imbalance at high speeds.

CAPSTAN DRIVE SYSTEM

The capstan drive system has undergone an extensive redesign. The normal rim-driven rubber tire flywheel has been replaced by a crowned flywheel that is linked to the motor by a polyester belt. The belt drive was used on very early 3M Professional Audio Recorders, but it suffered from two shortcomings. First, the polyester belt developed a static charge that attracts dirt that will cause flutter. This has been corrected by enclosing the drive system in a vacuum-formed plastic cover. The second problem was acoustic noise transmitted from the motor to the transport casting and thus radiated into the control room. A change in motor design has reduced the acoustic noise of a rigidly-mounted motor to a level below the noise of the present resiliently-mounted motor. The belt drive has very little low frequency flutter because the runouts of the machined metal parts can be controlled very tightly. Speed accuracy is determined by the tolerances on the drive members and thus requires no adjustment. The speed variation from beginning to end of reel is so small that there need be no concern when splicing sections from various parts of a reel. The resultant capstan speed drift from beginning to end of reel is typically .01%. Wideband flutter from .5 Hz to 5 KHz is a maximum of .075% when a tape is recorded and reproduced on the transport being tested.

The capstan and reel motor parameters determine the speed with which the tape may be started in the play mode. Starting loops have been completely eliminated by using the capstan to accelerate the tape smoothly. The capstan motor is stopped in normal standby and fast modes. When the PLAY button is pressed, both pressure rollers engage simultaneously and the capstan motor is started. This technique achieves stable tape motion in less than one second at any point in the reel. When the STOP button is pressed, the rollers release and the capstan motor is braked by a pulse of direct current. An interlock prohibits the reengagement of the PLAY mode for two seconds to ensure that the capstan has stopped.

HEAD MOUNTING PLATE

Another component requiring major changes is the head mounting plate. Provisions have been included on all transport castings for a second head cable connector plug, but head mount plates suitable for up to eight tracks had mounting tabs for only one plug. The new plate is enlarged to accommodate a second plug and also strengthened to twice the previous load-bearing capability. Both the record head and the reproduce head have hum shields and variable azimuth adjustments. Particular attention has been given to minimization of head vibration since this can result in resonant peaks in the flutter spectrum.

SIGNAL ELECTRONICS PACKAGE

The signal electronics package is a much more radical departure from the present design than is the transport. The major assembly of this package is a card cage that houses 64 printed circuit cards. Overall module size is 21 inches high by 24 inches wide by 12 inches deep.

The front of the module is covered by two doors that open to allow access to all of the cards and control components. The rear of the module, which holds the input/output transformers and connectors, is split horizontally to permit access to the internal wiring. Inside the module are three rows of printed circuit cards and two rows of control components. The top and bottom rows of 24 cards each contain eight tracks of record and playback cards grouped by track sequence rather than function. The center row houses all 16 tracks of bias/erase amplifiers. In the two open spaces between the rows of cards are the control components. This area contains three relays per track for record, sync, and input/output monitor select; two potentiometers for input level control and sync level calibration; and two plug-in transistors for the relay logic circuits (see Figure 2.).

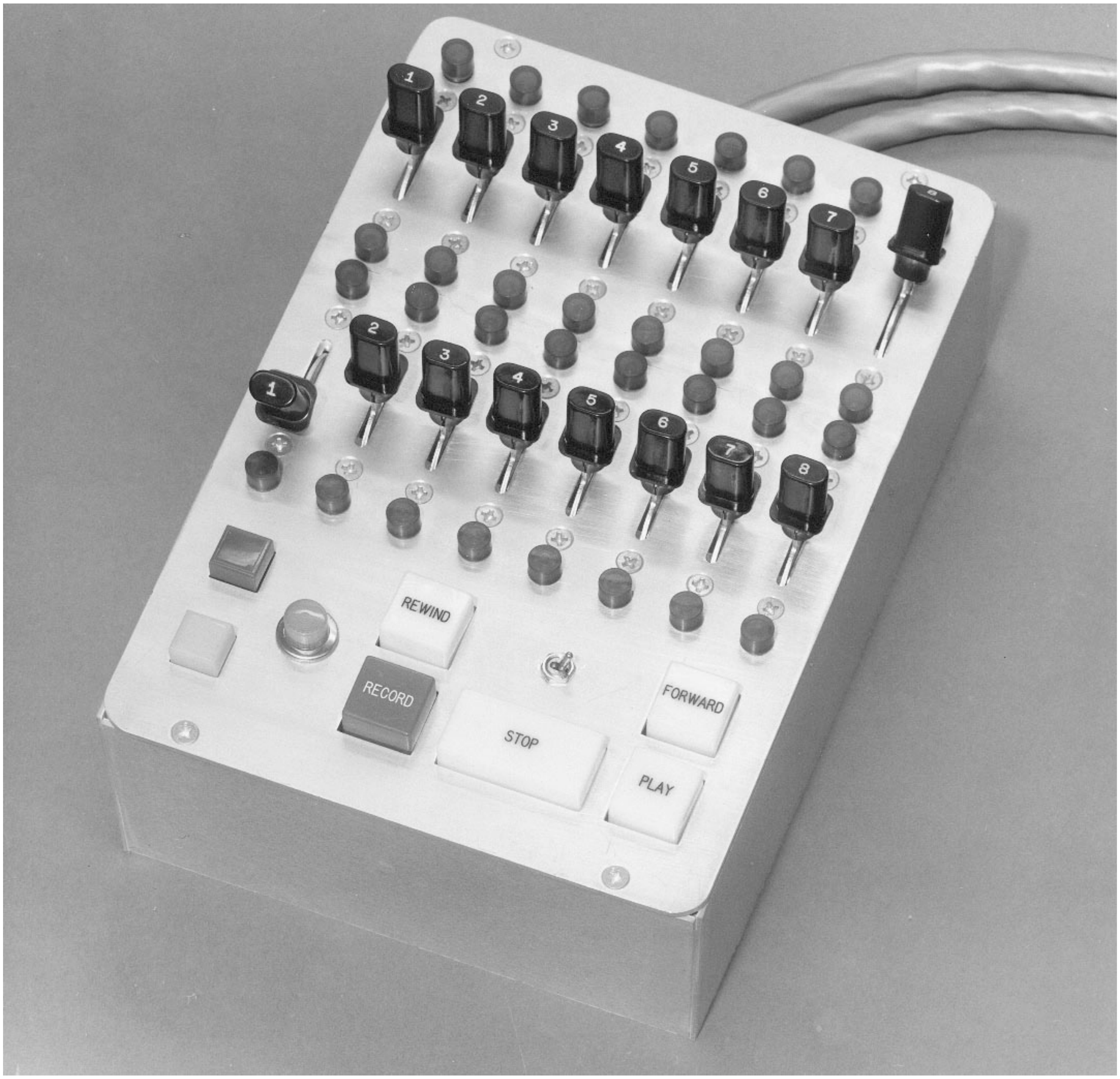
OUTPUT DISPLAY PANEL

The output display panel is mounted above the transport for easy viewing. Sixteen, 2-1/2 inch, VU.meters are employed. Human engineering dictates that two horizontal rows of eight meters each, mounted one above the other, provides most readily observable indications with a minimum of confusion. Each meter is numbered for ready channel identification. Above each meter are two indicator lamps and a spring-loaded toggle switch for input/output monitor selection. Pressing the switch to the left engages and holds the monitor relay to permit "A" or input monitoring. Pressure to the right releases the relay for "B" or playback monitor. This switching can be activated for all tracks simultaneously by using the master A/B buttons on the transport.

CONTROL BOX

The Record/Safe/Sync[1] controls and indicator lights are clustered on a remote panel that also houses a set of transport mode controls. This remote control assembly is supplied with 25 feet of cable to permit operation from a mixing console. The operation of a tape machine from the remote control box is similar to normal operation, but the box includes extra convenience features that are not possible without it. For example, the addition of a Normal/Cue program select switch allows two distinct sequences of-operation.

[1] Sync denotes the use of a record head for playback purposes.



Prototype control panel with cardboard box.
Panel was parts of two 8-track panels Heli-arced together.

For normal operation, the control circuit will activate the Sync mode on any preset track only when the record mode is active on the transport. With this logic, after a selection has been recorded with some tracks in the Sync mode, the same tape can be replayed in the normal reproduce mode without resetting any switches. If a second recording attempt is necessary, starting the transport in RECORD will again activate the Sync mode on the previously selected tracks.

A common situation occurs where the above logic is not adequate. If it is desirable to listen to a prerecorded track for cueing purposes before the record mode is punched in, the "cue" position of the program select switch is used. This "cue" mode permits monitoring the Sync playback in RECORD, PLAY, or STOP. Since Sync is monitored in PLAY, it is not possible to obtain the instant playback from the reproduce head while using the cue program.

Both Normal and Cue are necessary to cover all possible conditions of operation. Remote control units that are currently in the field have demonstrated that this choice of programs is one of the most useful features included in the remote box. Very little time is required for operators to master its use.

Adequate high speed muting is provided in both 'normal" and "cue' because the Sync mode is deactivated in FAST FORWARD and REWIND.

POWER SUPPLY

With the exception of the transport logic, all signal and control circuits are driven by a common power supply. The power supply is a self- contained unit that is fastened to the floor of the console. The supply has short circuit current foldback limiting to allow continuous operation into a shorted load.

The module is protected from reverse voltage by a reverse biased diode connected in shunt with the incoming +28 volt power bus. This eliminates the impedance of a series diode for normal operation, but places a virtual short across any power supply that might accidentally be reversed during service or -replacement.

PLAYBACK PREAMP

The cards used in the new module are identical to the cards used in the current 3M machines. A brief description of each follows:

The playback preamp provides equalization and phase correction for two tape speeds. The first two of four direct-coupled stages provide tape head equalization with both high and low frequency adjustments. The next stage is a phase splitter that drives a phase rotation network that is relay switched to optimize both speeds. The final stage is an emitter follower to drive the level calibration controls. The +28 volt line is filtered by an active decoupler to provide minimum loss and thus ensure the maximum possible supply voltage for the phase splitter.

A small shielded transformer is also mounted on the playback preamp card. During Sync operation, this transformer steps up the playback voltage from the record head so that it can drive the preamp input at a level that is about equal to the normal playback head.

LINE AMPLIFIER

The line amplifier is a quasi-complementary circuit with heavy feedback loops. The transformer coupled 600 ohm output is capable of +28 dBm with less than 1% distortion from 30 Hz to 15 kHz.

The first stage is an emitter follower to drive the amplifier stage through a low impedance feedback network. The single class A stage supplies gain for feedback and for closed loop gain. The quasi-complimentary output transistors are capable of five watts continuous output. D.C. bias feedback ensures stable operation for a wide range of voltage and temperature.

RECORD AMPLIFIER

The record amplifier card contains a record amplifier and an input monitor preamplifier. The single stage monitor preamp provides sufficient level to drive the line amp to +14 dBm output at normal input reference levels.

The first stage of the record amplifier raises the signal level before insertion into an RC equalizer for high and low frequency boosts. This network is followed by a junction FET stage to limit the noise introduced by the high impedance equalizer network. The head driver is a Darlington amplifier feeding a series resistor for constant current operation in the record head. An adjustable diode network is included in the driver to compensate for third harmonic distortion as the tape nears saturation.

BIAS/ERASE AMPLIFIER

A common transformer that bridges the 120 kHz bias bus feeds the bias and erase amplifiers. The first stage of each of the independent amplifiers is a class A stage to supply drive to the push-pull output pairs. The output of the erase amplifier is coupled to the erase head by a variable capacitor tuned to resonate the circuit. The bias-amplifier is coupled through a bias level pot and an adjustable noise balance circuit. Test points are provided for monitoring both the bias and the erase currents.

MAINTENANCE

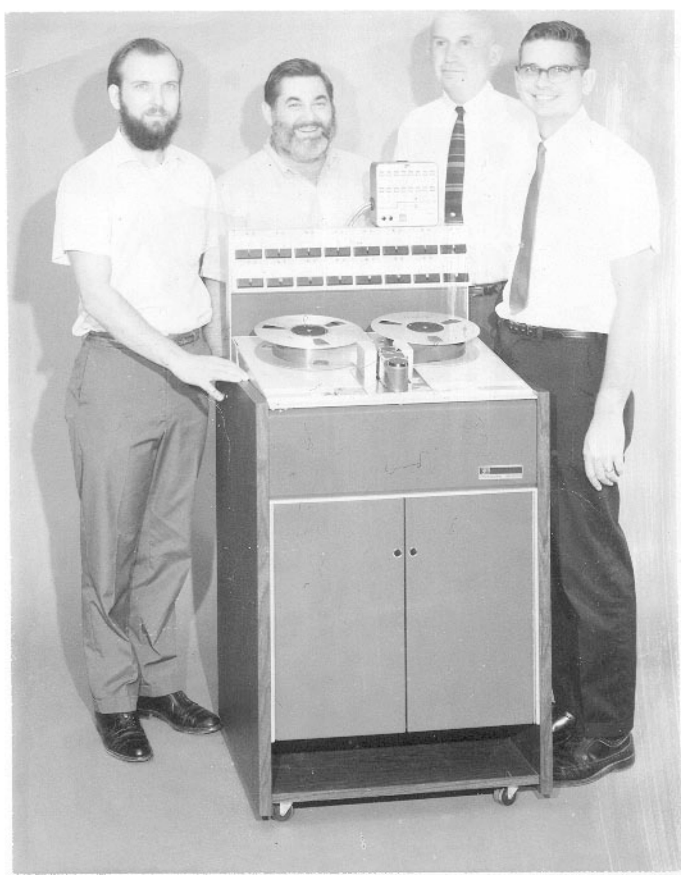
Although the problems of keeping 16 tracks operating properly at all times must be expected to be numerous, an effort has been made to keep servicing time to a minimum. The use of plug-in cards allows a relatively unskilled person to isolate and replace a defective circuit without a great loss of time. The number of cards in the current 3M eight track machine is 56, but modifications made possible by this new packaging technique require only 64 cards for sixteen tracks.

Even though all of the signal switching is now done by relays rather than switches, these -relays and their control transistors are replaceable from the front of the module. In the event that a replacement transistor is not available, removing a defective sync control transistor will disable Sync on a troublesome channel but will not hinder the RECORD mode. Removal on an A/B control transistor locks that track in the B or playback mode.

SUMMARY

The recorder described above has been designated the C-405 sixteen track recorder/reproducer. It and its companion C-402 sixteen track reproducer represent a first step into the expanding two-inch tape market.

The author wishes to acknowledge the assistance of the other members of the team who made this development work possible; John Mullin - Manager - Professional Audio Lab, Don Kahn - Mechanical Designer, and Jim Leatherman, Electronic Technician.



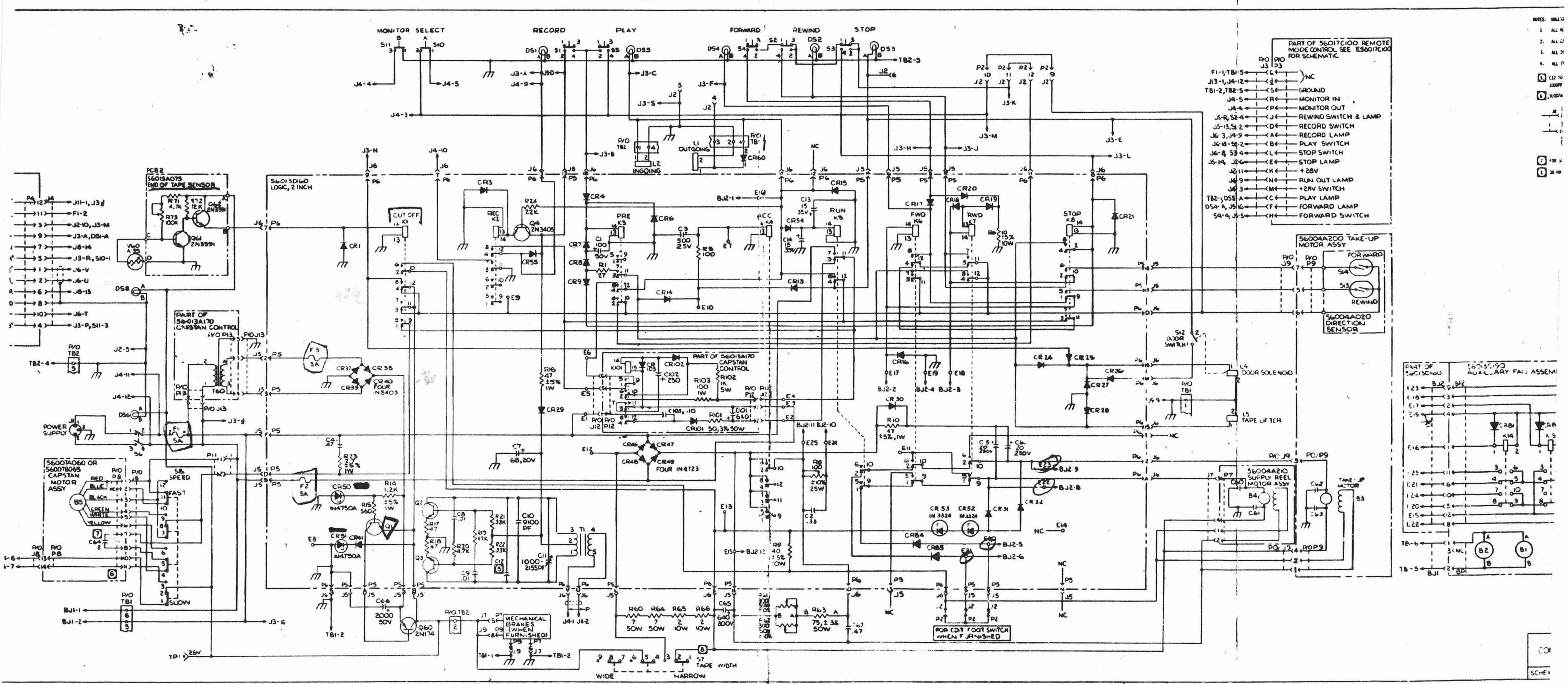
M-56 Design Team
L-R Dale Manquen, Don Kahn, Jack Mullin, Jim Leatherman

C 13/14 ARE TO HOLD CAP RUN RELAY ON UNTIL BOTH SOLENOIDS release pinch rollers.

MOTOR/FUSE BLOWING? = CHECK BRUSHES!!

8/16/24 TRK

M - 56

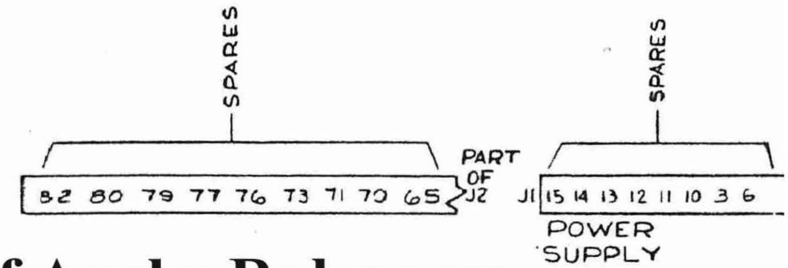


CR51 IN4750A
Q1 2N3093
Q60 = SK 3012 PNP GERMANIUM

REMOVE CR53 + 52 TO GIVE FULL POWER TO WIND MOTORS (FAST!!)

Figure 23. Composite Schematic (Sheet 1 of 3)

From the Archives of AnalogRules.com



OR DESTINATIONS

G	H	J	K
J7-B	J7-F	J7-NN	J7-TT
D	J	RR	VV
P	E	MM	SS
C	H	PP	UU
L	R	J7-WW	J7-XX
N	T	J6-YY	J6-XX
K	P	QQ	VV
M	S	SS	WW
V	Z	PP	UU
X	BB	JJ	NN
U	Y	FF	LL
W	AA	HH	MM
DD	JJ	EE	KK
FF	LL	Z	DD
CC	NN	X	BB
J7-EE	J7-KK	J6-Y	J6-CC

COMPONENT DESIGNATION TABULATION

TRACK NO.	R-A	R-B	R-C	R-D	R-E	R-F	R-H	R-J	R-K
1	R101	R201	R301	R401	R501	R601	R701	R801	R901
2	R102	R202	R302	R402	R502	R602	R702	R802	R902
3	R103	R203	R303	R403	R503	R603	R703	R803	R903
4	R104	R204	R304	R404	R504	R604	R704	R804	R904
5	R105	R205	R305	R405	R505	R605	R705	R805	R905
6	R106	R206	R306	R406	R506	R606	R706	R806	R906
7	R107	R207	R307	R407	R507	R607	R707	R807	R907
8	R108	R208	R308	R408	R508	R608	R708	R808	R908
9	R109	R209	R309	R409	R509	R609	R709	R809	R909
10	R110	R210	R310	R410	R510	R610	R710	R810	R910
11	R111	R211	R311	R411	R511	R611	R711	R811	R911
12	R112	R212	R312	R412	R512	R612	R712	R812	R912
13	R113	R213	R313	R413	R513	R613	R713	R813	R913
14	R114	R214	R314	R414	R514	R614	R714	R814	R914
15	R115	R215	R315	R415	R515	R615	R715	R815	R915
16	R116	R216	R316	R416	R516	R616	R716	R816	R910

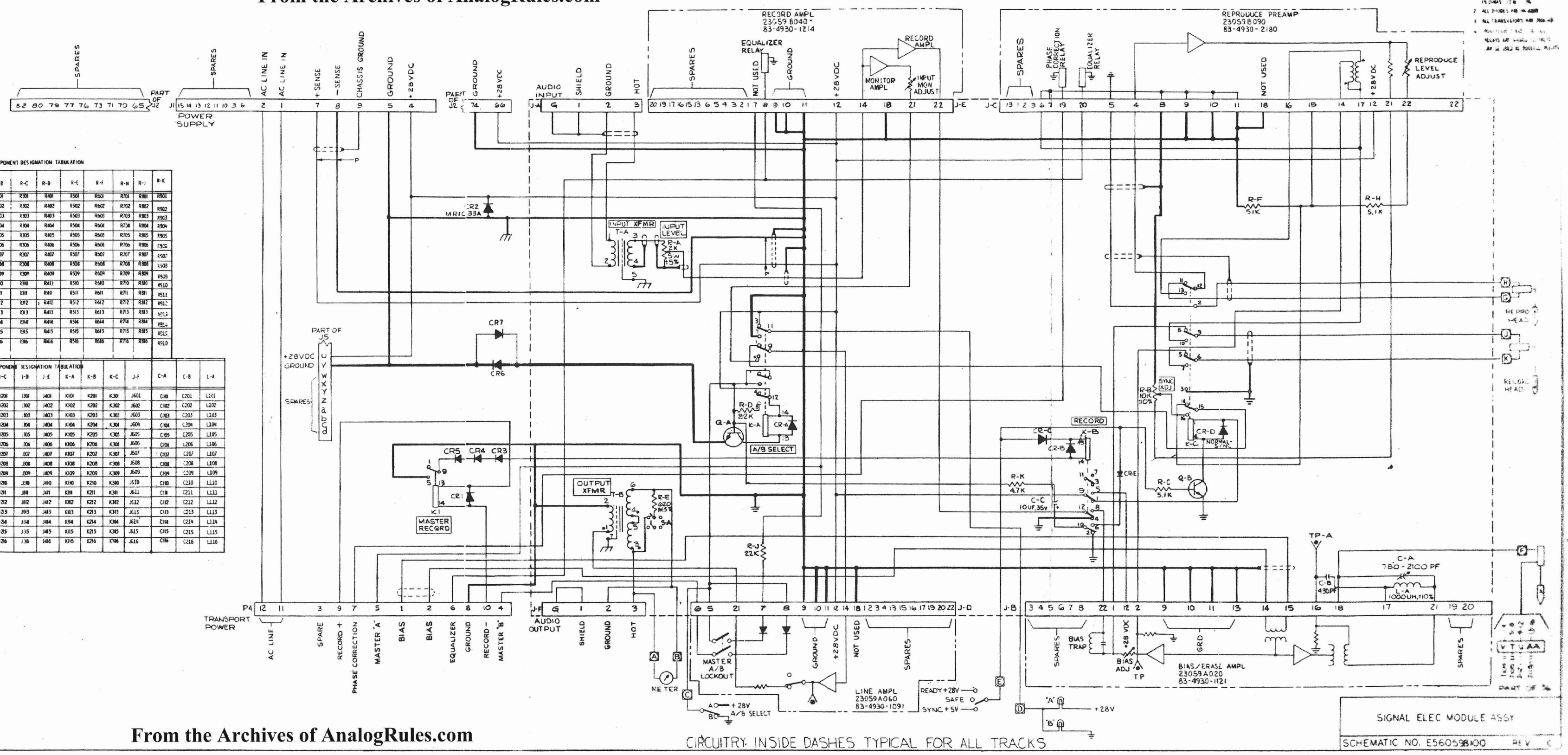
ULATION

CR-A	CR-B	CR-C	CR-D
CR101	CR201	CR301	CR401
CR102	CR202	CR302	CR402
CR103	CR203	CR303	CR403
CR104	CR204	CR304	CR404
CR105	CR205	CR305	CR405
CR106	CR206	CR306	CR406
CR107	CR207	CR307	CR407
CR108	CR208	CR308	CR408
CR109	CR209	CR309	CR409
CR110	CR210	CR310	CR410
CR111	CR211	CR311	CR411
CR112	CR212	CR312	CR412
CR113	CR213	CR313	CR413
CR114	CR214	CR314	CR414
CR115	CR215	CR315	CR415
CR116	CR216	CR316	CR416

COMPONENT DESIGNATION TABULATION

TRACK NO.	J-A	J-B	J-C	J-D	J-E	K-A	K-B	K-C	J-F	C-A	C-B	L-A
1	J501	J101	J201	J301	J401	K101	K201	K301	J601	C101	C201	L101
2	J502	J102	J202	J302	J402	K102	K202	K302	J602	C102	C202	L102
3	J503	J103	J203	J303	J403	K103	K203	K303	J603	C103	C203	L103
4	J504	J104	J204	J304	J404	K104	K204	K304	J604	C104	C204	L104
5	J505	J105	J205	J305	J405	K105	K205	K305	J605	C105	C205	L105
6	J506	J106	J206	J306	J406	K106	K206	K306	J606	C106	C206	L106
7	J507	J107	J207	J307	J407	K107	K207	K307	J607	C107	C207	L107
8	J508	J108	J208	J308	J408	K108	K208	K308	J608	C108	C208	L108
9	J509	J109	J209	J309	J409	K109	K209	K309	J609	C109	C209	L109
10	J510	J110	J210	J310	J410	K110	K210	K310	J610	C110	C210	L110
11	J511	J111	J211	J311	J411	K111	K211	K311	J611	C111	C211	L111
12	J512	J112	J212	J312	J412	K112	K212	K312	J612	C112	C212	L112
13	J513	J113	J213	J313	J413	K113	K213	K313	J613	C113	C213	L113
14	J514	J114	J214	J314	J414	K114	K214	K314	J614	C114	C214	L114
15	J515	J115	J215	J315	J415	K115	K215	K315	J615	C115	C215	L115
16	J516	J116	J216	J316	J416	K116	K216	K316	J616	C116	C216	L116

M-56



DR DESTINATIONS

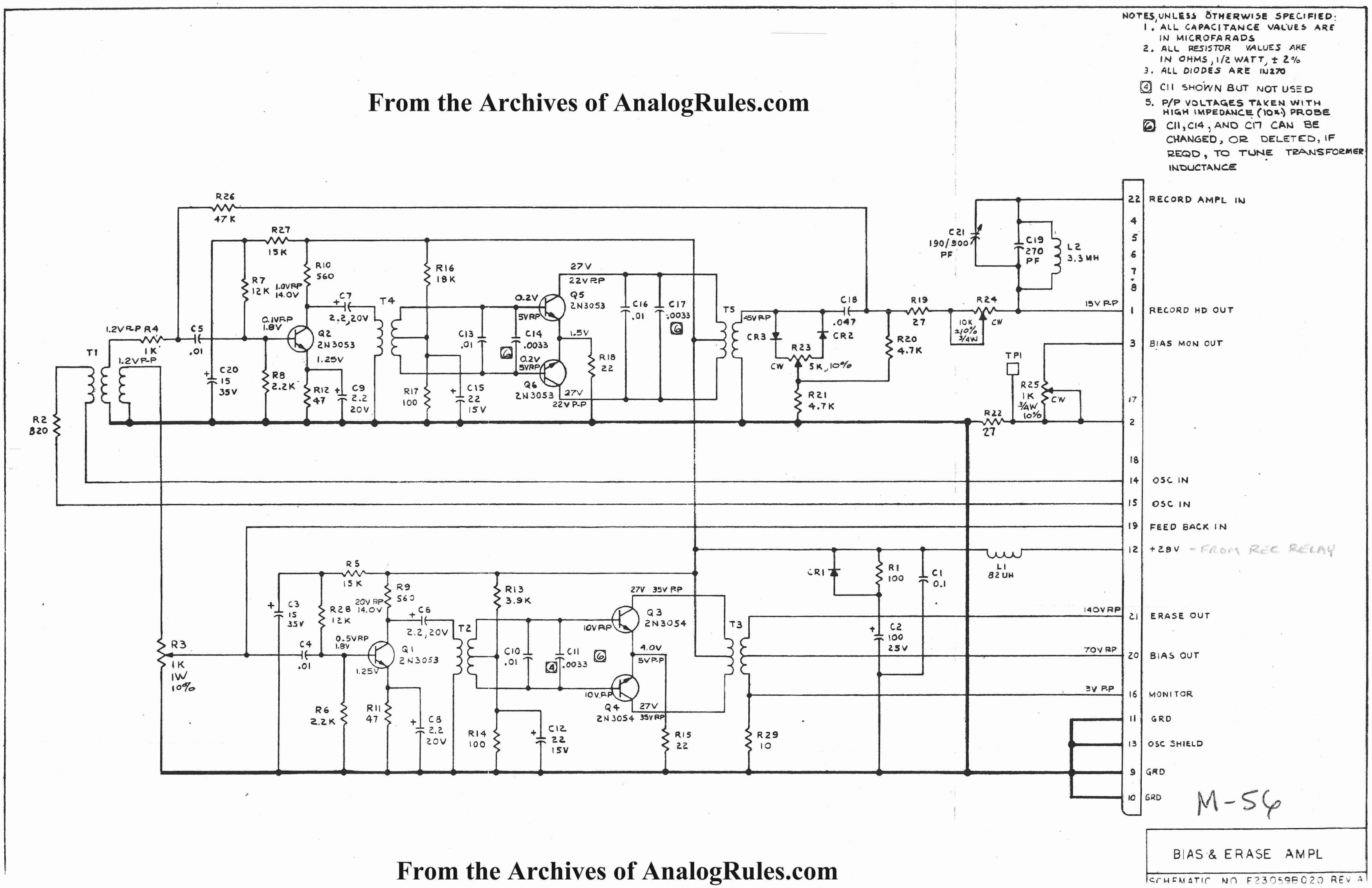
G	H	J	K
J7 B	J7 F	J7 NN	J7-TT
D	J	RR	VV
A	E	MM	SS
C	H	PP	UU
L	R	J7-WW	J7-XX
N	T	J6-TT	J6-XX
K	P	RR	VV
M	S	SS	MM
V	Z	PP	UU
X	BB	JJ	NN
U	Y	FF	LL
W	AA	HH	MM
DD	JJ	EE	KK
FF	LL	Z	DD
CC	HH	X	BB
J7 EE	J7-KK	J6-Y	J6-CC

COMPONENT DESIGNATION TABULATION

TRACK NO.	R-A	R-B	R-C	R-D	R-E	R-F	R-H	R-J	R-K
1	R101	R201	R301	R401	R501	R601	R701	R801	R901
2	R102	R202	R302	R402	R502	R602	R702	R802	R902
3	R103	R203	R303	R403	R503	R603	R703	R803	R903
4	R104	R204	R304	R404	R504	R604	R704	R804	R904
5	R105	R205	R305	R405	R505	R605	R705	R805	R905
6	R106	R206	R306	R406	R506	R606	R706	R806	R906
7	R107	R207	R307	R407	R507	R607	R707	R807	R907
8	R108	R208	R308	R408	R508	R608	R708	R808	R908
9	R109	R209	R309	R409	R509	R609	R709	R809	R909
10	R110	R210	R310	R410	R510	R610	R710	R810	R910
11	R111	R211	R311	R411	R511	R611	R711	R811	R911
12	R112	R212	R312	R412	R512	R612	R712	R812	R912
13	R113	R213	R313	R413	R513	R613	R713	R813	R913
14	R114	R214	R314	R414	R514	R614	R714	R814	R914
15	R115	R215	R315	R415	R515	R615	R715	R815	R915
16	R116	R216	R316	R416	R516	R616	R716	R816	R910

COMPONENT DESIGNATION TABULATION

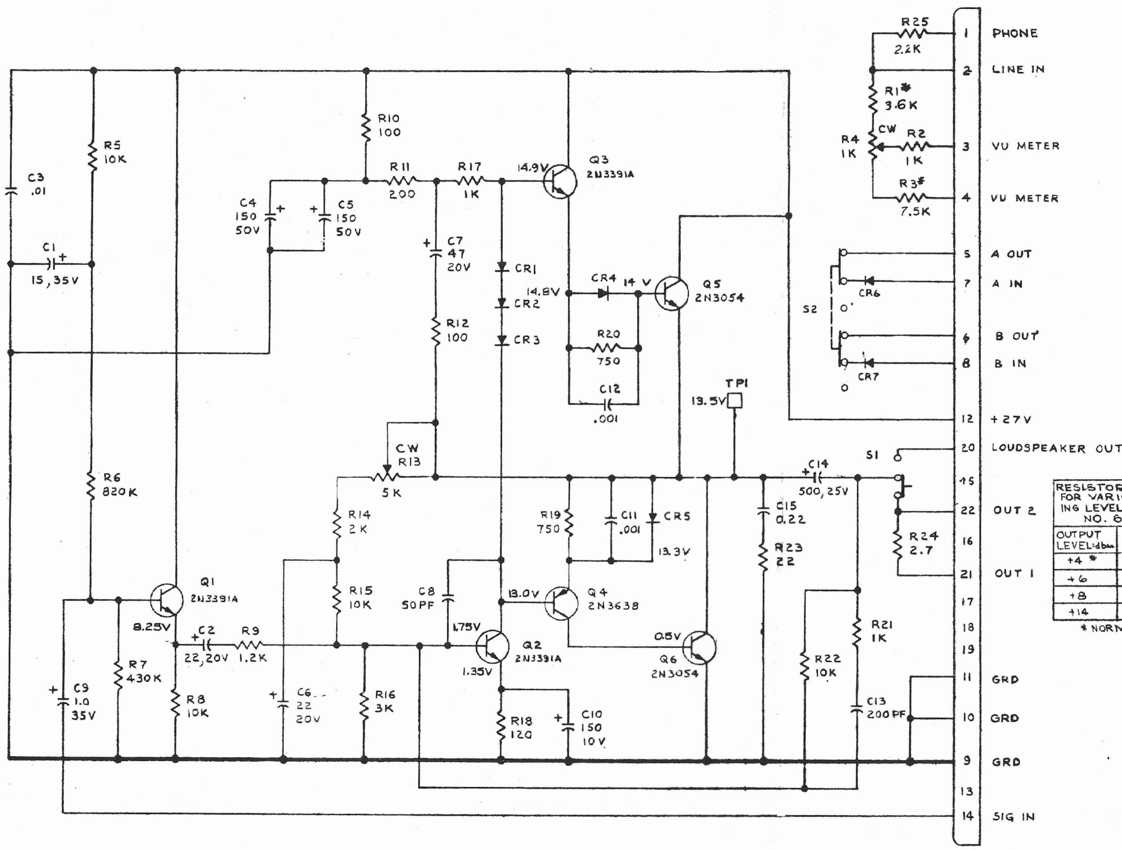
CR-A	CR-B	CR-C	CR-D	TRACK NO.	J-A	J-B	J-C	J-D	J-E	K-A	K-B	K-C	J-F	C-A	C-B	L-A
CR101	CR201	CR301	CR401	1	J501	J101	J201	J301	J401	K101	K201	K301	J601	C101	C201	L101
CR102	CR202	CR302	CR402	2	J502	J102	J202	J302	J402	K102	K202	K302	J602	C102	C202	L102
CR103	CR203	CR303	CR403	3	J503	J103	J203	J303	J403	K103	K203	K303	J603	C103	C203	L103
CR104	CR204	CR304	CR404	4	J504	J104	J204	J304	J404	K104	K204	K304	J604	C104	C204	L104
CR105	CR205	CR305	CR405	5	J505	J105	J205	J305	J405	K105	K205	K305	J605	C105	C205	L105
CR106	CR206	CR306	CR406	6	J506	J106	J206	J306	J406	K106	K206	K306	J606	C106	C206	L106
CR107	CR207	CR307	CR407	7	J507	J107	J207	J307	J407	K107	K207	K307	J607	C107	C207	L107
CR108	CR208	CR308	CR408	8	J508	J108	J208	J308	J408	K108	K208	K308	J608	C108	C208	L108
CR109	CR209	CR309	CR409	9	J509	J109	J209	J309	J409	K109	K209	K309	J609	C109	C209	L109
CR110	CR210	CR310	CR410	10	J510	J110	J210	J310	J410	K110	K210	K310	J610	C110	C210	L110
CR111	CR211	CR311	CR411	11	J511	J111	J211	J311	J411	K111	K211	K311	J611	C111	C211	L111
CR112	CR212	CR312	CR412	12	J512	J112	J212	J312	J412	K112	K212	K312	J612	C112	C212	L112
CR113	CR213	CR313	CR413	13	J513	J113	J213	J313	J413	K113	K213	K313	J613	C113	C213	L113
CR114	CR214	CR314	CR414	14	J514	J114	J214	J314	J414	K114	K214	K314	J614	C114	C214	L114
CR115	CR215	CR315	CR415	15	J515	J115	J215	J315	J415	K115	K215	K315	J615	C115	C215	L115
CR116	CR216	CR316	CR416	16	J516	J116	J216	J316	J416	K116	K216	K316	J616	C116	C216	L116



NOTES, UNLESS OTHERWISE SPECIFIED:
1. ALL CAPACITANCE VALUES ARE IN MICROFARADS
2. ALL RESISTOR VALUES ARE IN OHMS, 1/2 WATT, ± 2%
3. ALL DIODES ARE IN270
4 C11 SHOWN BUT NOT USED
5. P/P VOLTAGES TAKEN WITH HIGH IMPEDANCE (10K) PROBE
6 C11, C14, AND C17 CAN BE CHANGED, OR DELETED, IF REQD, TO TUNE TRANSFORMER INDUCTANCE
22 RECORD AMPL IN
1 RECORD HD OUT
3 BIAS MON OUT
14 OSC IN
15 OSC IN
19 FEED BACK IN
12 +28V - FROM REC RELAY
21 ERASE OUT
20 BIAS OUT
16 MONITOR
11 GRD
13 OSC SHIELD
9 GRD
10 GRD
R26 47K
R27 15K
R10 560
R16 18K
R7 12K
R8 2.2K
R12 47
C9 2.2 20V
C7 2.2, 20V
Q2 2N3053
Q5 2N3053
Q6 2N3053
C13 .01
C14 .0033
C15 22 15V
R17 100
R18 22
C16 .01
C17 .0033
C18 .047
R19 27
R20 4.7K
R21 4.7K
R23 5K, 10%
CR2
CR3
R24 10K ±10% 3/4W
C21 190/300 PF
C19 270 PF
L2 3.3 MH
TP1
R25 1K 3/4W 10%
R22 27
R2 820
R4 1K
C5 .01
C20 15 35V
T1
T2
T3
T4
T5
R3 1K 1W 10%
C4 .01
C3 15 35V
R28 12K
R5 15K
R9 560
C6 2.2, 20V
Q1 2N3053
R6 2.2K
R11 47
C8 2.2 20V
R13 3.9K
C10 .01
C11 .0033
Q3 2N3054
Q4 2N3054
R14 100
C12 22 15V
R15 22
R29 10
CR1
R1 100
C1 0.1
C2 100 25V
L1 82 UH
M-56
BIAS & ERASE AMPL
SCHEMATIC NO F23059B020 REV A

NOTES: UNLESS OTHERWISE SPECIFIED
1. CAPACITANCE VALUES ARE IN MICROFARADS
2. RESISTANCE VALUES ARE IN OHMS, 1/2 WATT, ± 5%
3. ALL DIODES ARE IN4002

M-56



RESISTORS TO BE SELECTED FOR VARIOUS LINE OPERATING LEVELS AT OUTPUT OF NO. 6 BOARD		
OUTPUT LEVEL-dbm	VALUE OF R1	VALUE OF R3
+4 *	3.9K *	7.5K *
+6	4.7K	6.2K
+8	6.2K	4.3K
+14	7.5K	3.3K

* NORMAL VALUES

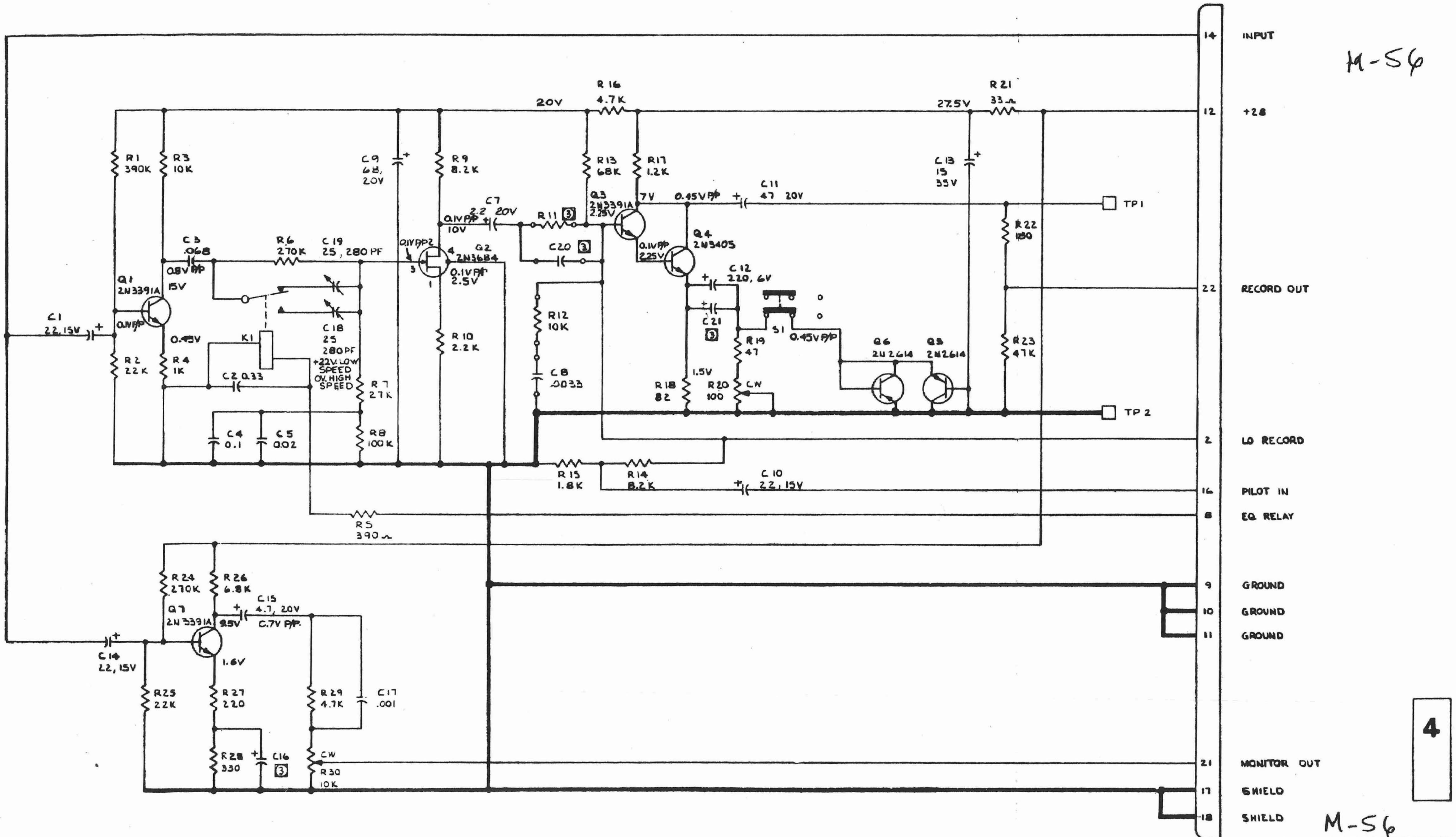
6

From the Archives of AnalogRules.com

LINE DRIVER AMPLIFIER

SCHEMATIC NO. E23059A060 REV G

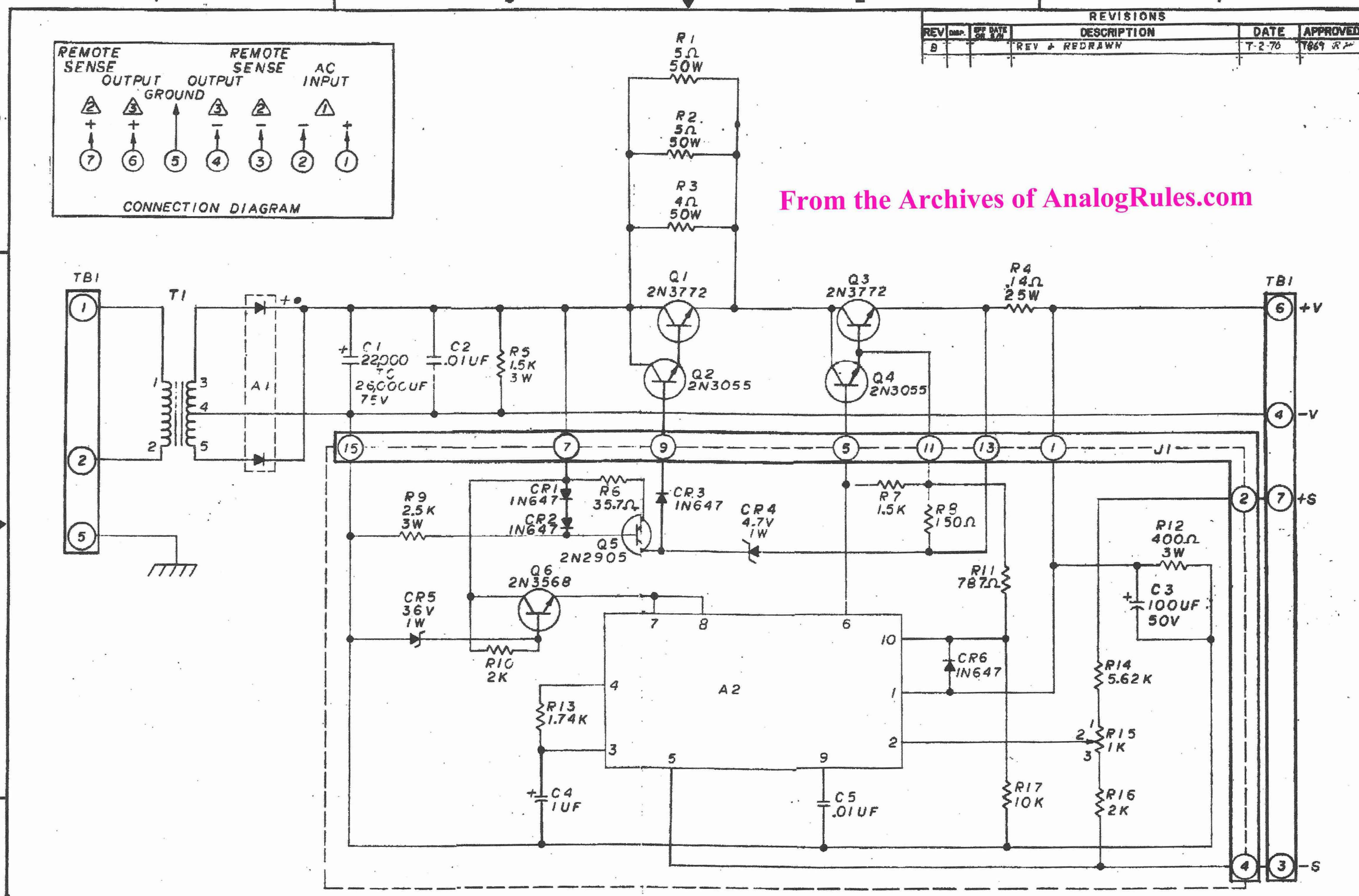
NOTES: UNLESS OTHERWISE SPECIFIED
1. CAPACITANCE VALUES ARE IN MICROFARADS
2. RESISTANCE VALUES ARE IN OHMS, 1/2 WATT, ±5%.
3. C16, C20, C21 & R11 ARE NOT FURNISHED. R11 IS JUMPERED OUT.
4. P/P VOLTS AT OVU 1 KC



NAB RECORD AMPLIFIER

SCHEMATIC NO. E230598040 REV F

From the Archives of AnalogRules.com



3-INPUT: 105-125VAC, 48-62HZ, SINGLE PHASE
2-OUTPUT: 28VDC NOM 0-9AMP @ 40°C AMB
0-5AMP @ 70°C AMB
1-ALL RESISTORS ARE 1/2 W UNLESS OTHERWISE SPECIFIED

NEXT ASSY	USED ON
APPLICATION	

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES UNLESS NOTED FRACTIONS ± ANGLES ± 3 PLACE DECIMALS ± 2 PLACE DECIMALS ±

MATL.
FINISH

DESIGNER	6-24-70
DRAWN BY	SDC 6-23-70
DRAFTING	6-29-70
PROD ENG	6-24-70
DESIGN	
APPROVED	

ADC PRODUCTS
MINNEAPOLIS, MINNESOTA

SCHEMATIC DIAGRAM POWER SUPPLY

SIZE	CODE IDENT NO.	DRAWING NO.
C	70674	PS142A
SCALE	WT.	SHEET 3

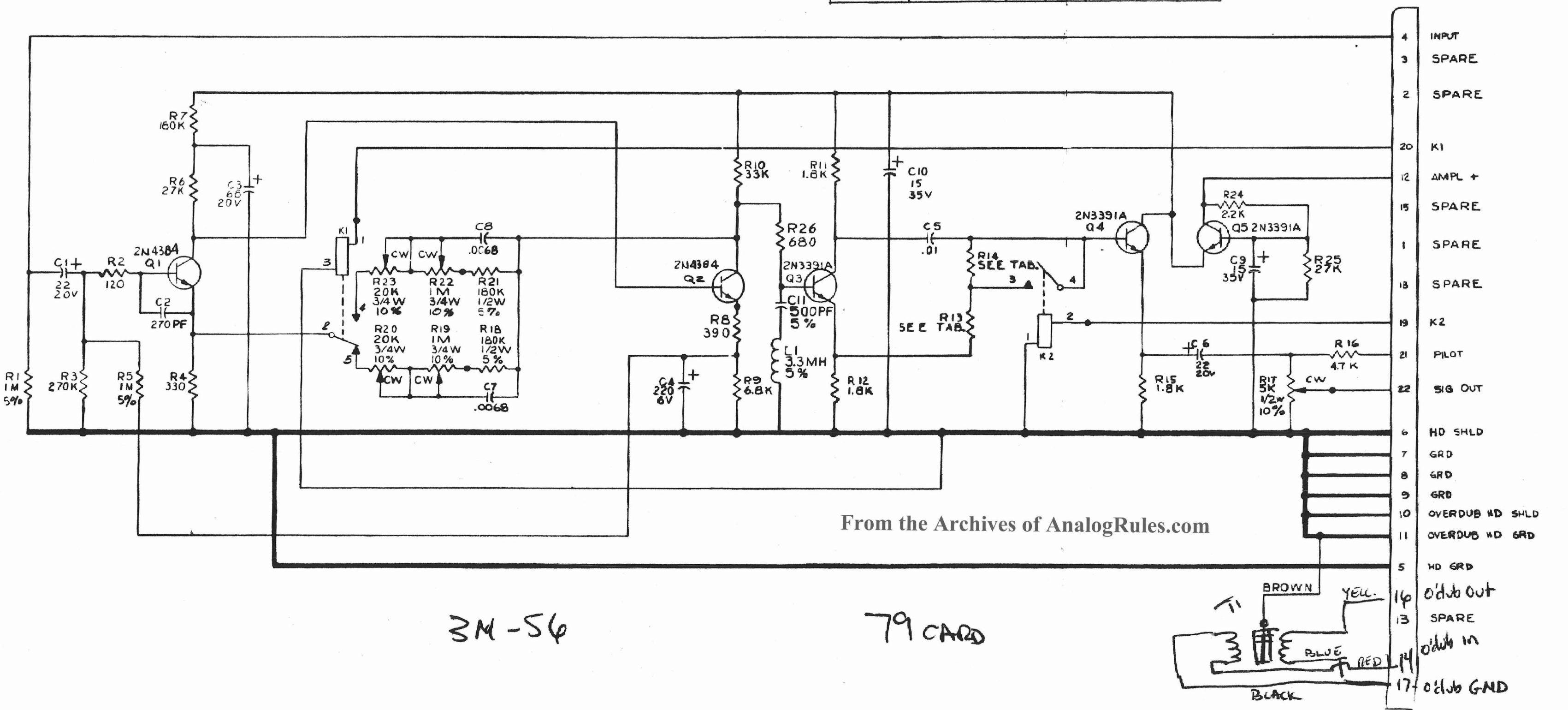
REPRO AMP

M-56

NOTES: UNLESS OTHERWISE SPECIFIED
1. ALL RESISTANCE VALUES ARE IN OHMS, 1/2 WATT, 2%
2. ALL CAPACITANCE VALUES ARE IN MICROFARADS.

COMPONENT VALUE TABULATION

DASH NO.	CAT. NO.	CONFIG	VALUE R13	VALUE R14
-1	83-4930-2180	7.5-15 IPS	1.8K	1.8K
-2	83-4930-2511	15-30 IPS	910Ω	910Ω



3M-56

79 CARD

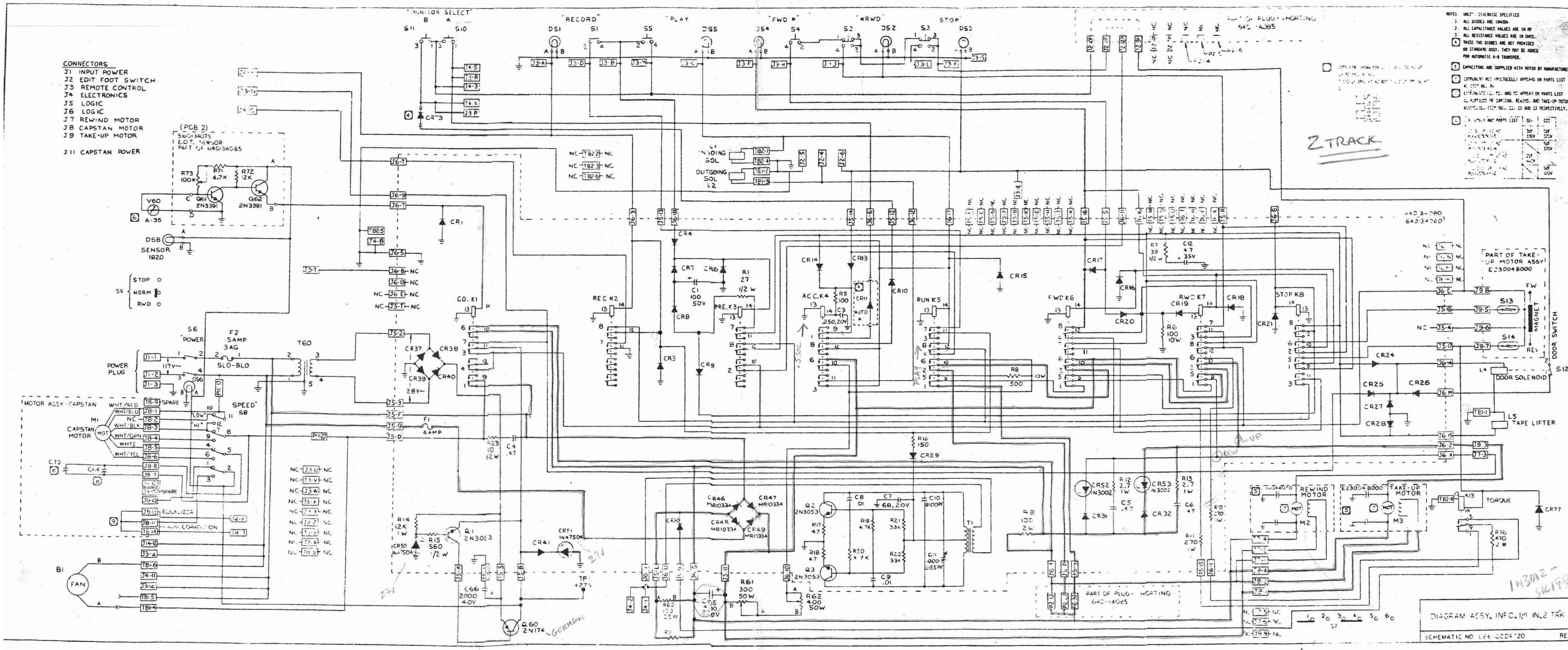


Figure 27A. Tape Transport Wiring Diagram