SECTION I

DESCRIPTION/SPECIFICATIONS

1-1. GENERAL DESCRIPTION.

1-2. The Ampex Series TM-2 Digital Tape Transport is a high speed unit, intended for operation within digital computer systems or in data acquisition systems. A typical TM-2 system is composed of the tape transport, a transport electronics assembly, and an optional manual control panel which permits complete local control of the transport. The system is normally supplied in a rack cabinet.

1-3. TAPE TRANSPORT (Figure 1-1)

1-4. The function of the tape transport is to move the tape, in accordance with signals from the command source (either the manual control panel or external equipment), across the write and read heads. To achieve bi-directional tape motion, two counter-rotating capstans are coupled with roller assemblies. Each roller assembly is operated by an actuator, which responds to the command signals by closing the roller to clamp the tape against the constantly rotating capstan. A tape brake, part of the roller assembly, stops the tape rapidly upon receipt of a stop command.

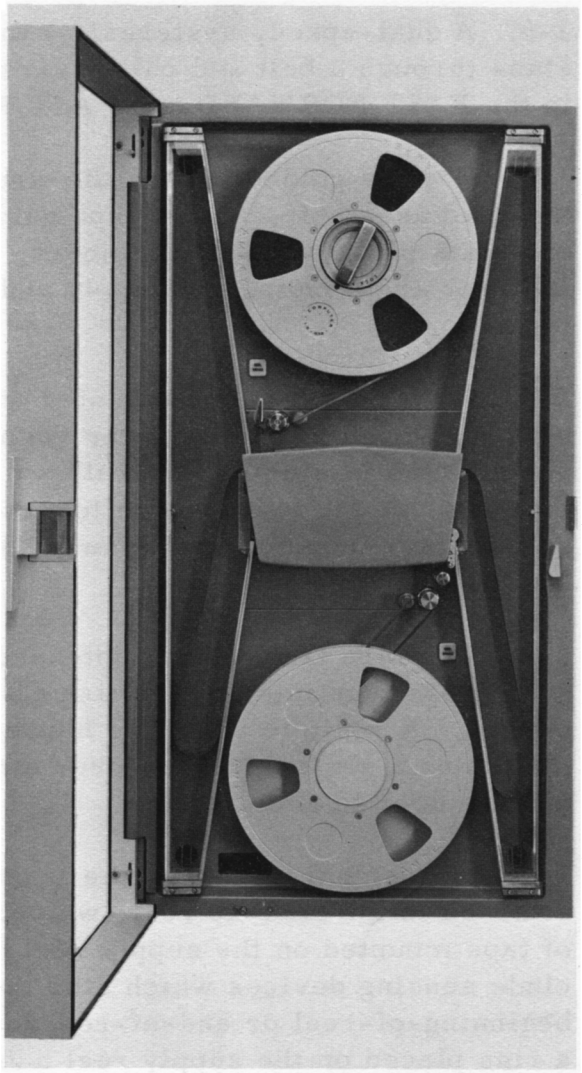

Figure 1-1
Tape Transport

1-5. Rapid acceleration and deceleration of the tape is accomplished by storing lengths of tape in vacuum chambers immediately preceding and following the tape drive area. With this system, the high inertia associated with reel drive elements is by-passed, and only the mass of the tape need be

accelerated or decelerated. The vacuum chambers also provide sensing elements for a servo system which seeks to maintain a nominally constant length of tape in the chamber.

1-6. A dual-speed, hysteresis-synchronous motor is used to drive both capstans through a belt and pulley arrangement. The higher tape speed is used in the FAST FORWARD and FAST REVERSE (REWIND) modes.

1-7. Tape is guided across the write and read heads by guides integral to the head assembly. Other tape guiding elements are located at the entrances and exits of the vacuum chambers, and at the supply and take-up reels. Tape follower arms riding the supply and take-up reels ensure smooth tape packing.

1-8. A vacuum blower, mounted on the rear of the tape transport, is connected through air ducts to the vacuum chambers. This system provides proper tape tensioning, operates in conjunction with transducers to indicate the length of the tape loop within each of the chambers, and maintains a smooth tape loop configuration in the chambers, without danger of folding or kinking.

1-9. The tape transport is intended to operate with the transport access door closed; an interlock switch disables the transport when this door is opened. A positive pressure blower, mounted on the rear of the transport, maintains a slight increase over atmospheric pressure between the transport and the door to exclude dust.

1-10. Tape is threaded on the transport by means of a permanent leader, attached to the take-up reel, which is manually connected to each new reel of tape mounted on the supply reel hub. Other features of the transport include sensing devices which stop the tape motion upon contact with the beginning-of-reel or end-of-reel leaders; a write enable switch, actuated by a ring placed on the supply reel hub; interlock circuitry to prevent tape motion when the tape threading clamp is in the closed position; and a fast action reel hold-down knob.

1-11. The tape transport is hinge-mounted to the left side of the rack or cabinet, permitting the unit to be swung open for ease of inspection, maintenance, or service.

1-12. HEAD ASSEMBLY. (Figure 1-2)

1-13. The head assembly is mounted on the tape transport and performs the actual "read" and/or "write" function with respect to the tape. Head assemblies consist of a head mounting plate and head stacks; the exact number and configuration of stacks depends on the tape width, track arrangement, and type of head.

1-14. PHOTOSENSE.

1-15. This optional feature is accomplished by a device which detects reflective markers affixed to the mylar side of the tape. It provides signals to external control circuitry indicating the approach of the beginning or end of the tape. The device is comprised of two units: the head, mounted in the vacuum chamber associated with the file reel, and the electronics chassis, mounted on the rear of the tape transport.

1-16. TRANSPORT ELECTRONICS ASSEMBLY. (Figure 1-3)

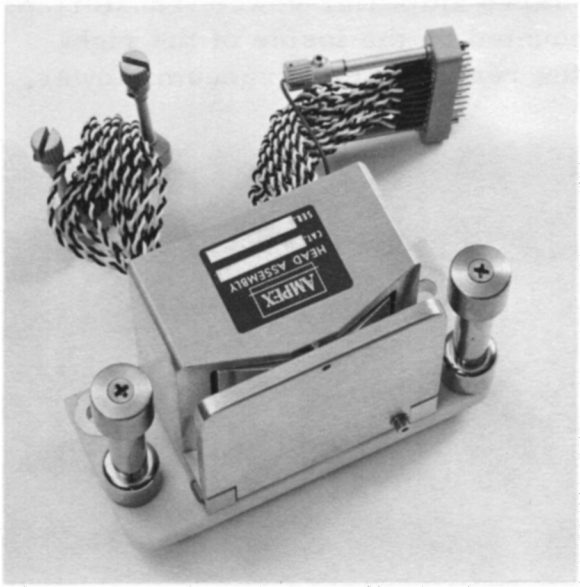

Figure 1-2
Head Assembly

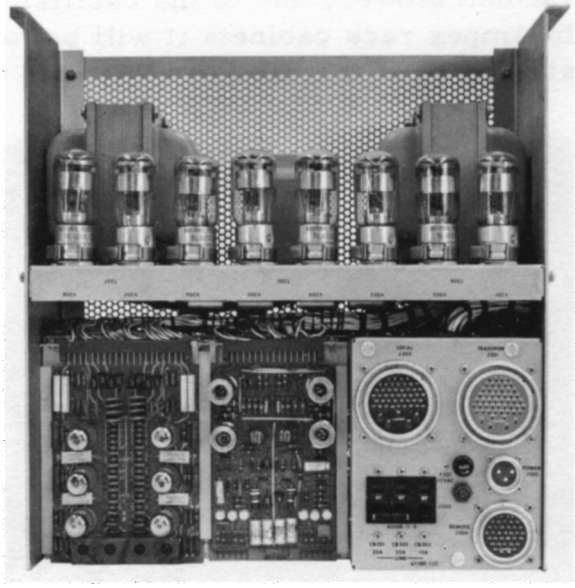

Figure 1-3
Transport Electronics Assembly

1-17. The transport electronics assembly is composed of those electronic units required for operation of the tape transport. Mounted in this assembly are an actuator power supply, a servo motor (reel motor) power supply, a connector chassis, an actuator control unit circuit board, and a dual servo amplifier circuit board. These elements, in conjunction with transducers, switches, and circuitry mounted on the tape transport, exercise complete control over the tape unit in accordance with signals generated by the manual control panel or by external equipment.

1-18. MANUAL CONTROL PANEL. (Figure 1-4)

1-19. The manual control panel is used when local control of the tape transport is required, or when it is desired to remove the transport from the control of external equipment for maintenance procedures. Although the manual control panel is an optional accessory, equivalent control circuitry must be provided if no manual control panel is supplied.

1-20. VOLTAGE REGULATOR. (Figure 1-5)

1-21. The voltage regulator is used to provide a stabilized ac voltage to the vacuum blower, and to the oscillator and servo amplifier power transformer. In Ampex rack cabinets it will be found mounted on the inside of the right side panel of the cabinet as viewed from the rear, near the vacuum blower.

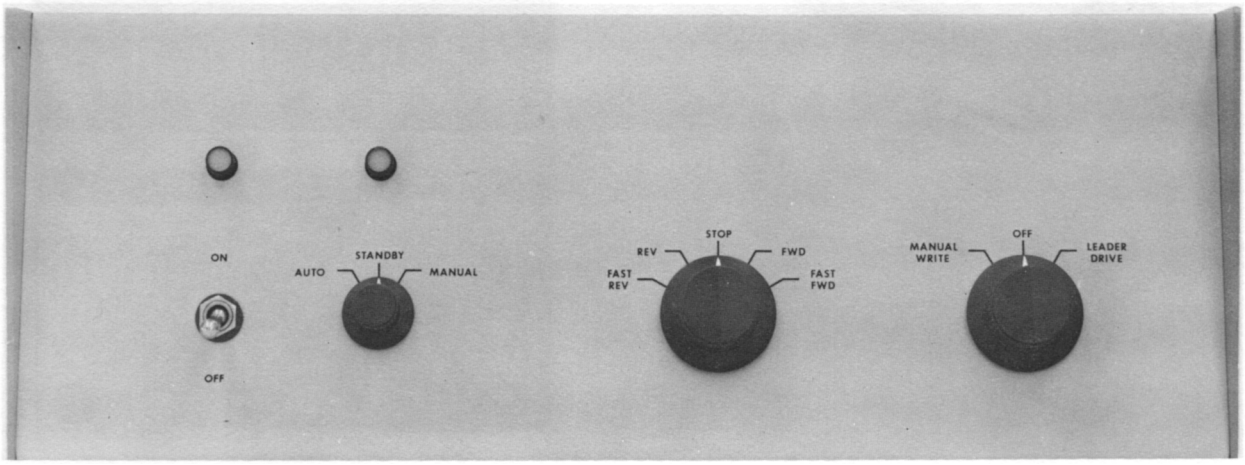

Figure 1-4
Manual Control Panel

1-22. COOLING FAN.

1-23. Units supplied with an Ampex rack cabinet are equipped with a cooling fan mounted in the top of the cabinet. This fan exhausts heated air at the top of the cabinet, drawing cold air through louvers at the bottom to cool the tape transport.

1-24. FUNCTIONAL DESCRIPTION.

1-25. To facilitate a general discussion of machine operation, the following terminology will be used throughout this instruction manual:

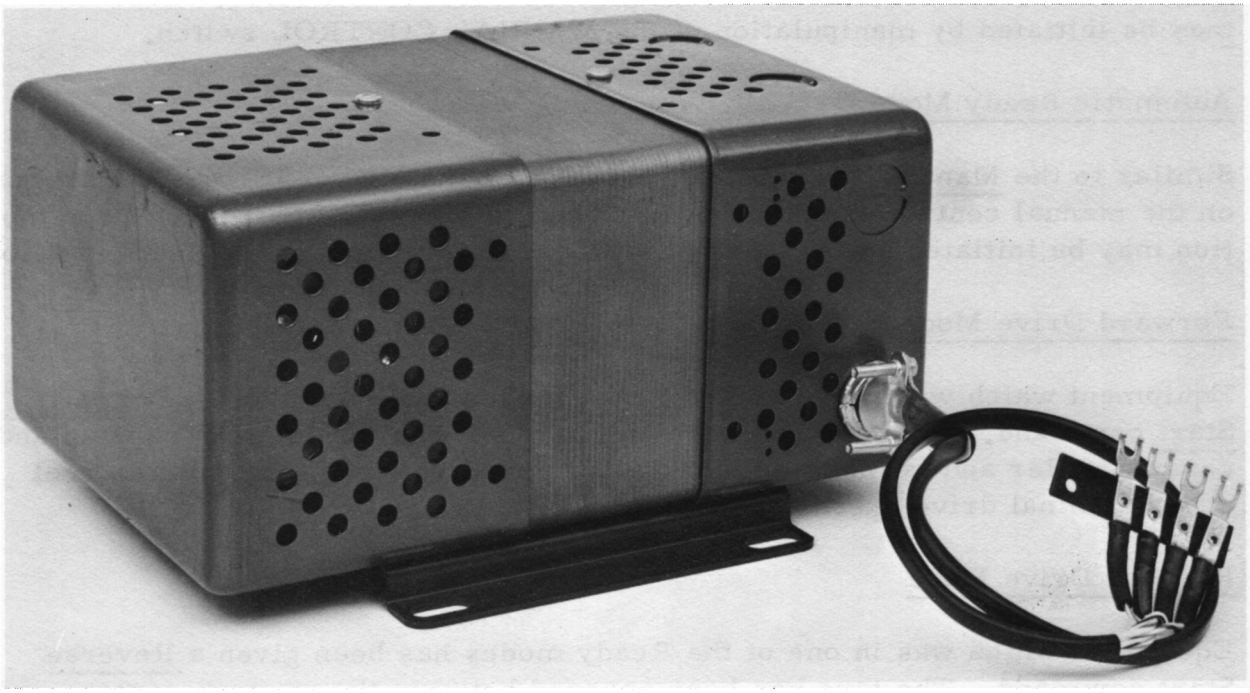

Figure 1-5
Voltage Regulator

Off Mode

Equipment not in operation. No commands have been given and no power applied to the equipment.

Standby Mode

An On command has been given, applying primary power (117 vac) to the equipment. All internal or external interlocks and time delays are complete and the capstans are turning. The supply and take-up reels are locked in position by the reel brakes, and the servo systems which seek to maintain nominally constant length loops in the vacuum chambers are disabled.

Manual Ready Mode

Similar to the Standby mode, except that the MODE SELECTOR switch on the manual control panel has been placed in the MANUAL position. The reel brakes are released and the vacuum chamber servos activated. Tape motion may be initiated by manipulation of the MANUAL CONTROL switch.

Automatic Ready Mode

Similar to the Manual Ready mode, except that the MODE SELECTOR switch on the manual control panel has been placed in the AUTO position. Tape motion may be initiated by issuance of a proper Start command as detailed below.

Forward Drive Mode

Equipment which was in one of the Ready modes has been given a Forward Start command. The tape has been engaged between the forward capstan and capstan roller and is moving from the file (supply) reel to the take-up reel at the nominal drive speed.

Reverse Drive Mode

Equipment which was in one of the Ready modes has been given a Reverse Start command. The tape has been engaged between the reverse capstan and capstan roller and is moving from the take-up reel to the file reel at the nominal drive speed.

Fast Forward Drive Mode

Identical to the Forward Drive mode, except that the equipment has been given a Fast command. The tape moves from the supply reel to the take-up reel at twice the nominal drive speed.

Fast Reverse Drive Mode (Rewind)

Identical to the Reverse Drive mode, except that the equipment has been given a Fast command. The tape moves from the take-up reel to the supply reel at twice the nominal drive speed.

ON Command

While not a command in the strictest sense of the word, this term indicates application of primary power to the equipment, placing the equipment (after completion of time delays and interlocks) in the Standby mode. An indicator light shows the power ON condition.

OFF Command

Like the foregoing, not a command in the strictest sense of the word, but used to indicate removal of all power from the equipment.

Forward Start Command

This command may be effected by the following means:

1) With the equipment in the Manual Ready mode, operate the MANUAL CONTROL switch to the FWD position.

2) With the equipment in the Automatic Ready mode, apply a command signal to the AUTO FORWARD input.

Reverse Start Command

This command may be effected by the following means:

1) With the equipment in the Manual Ready mode, operate the MANUAL CONTROL switch to the REV position.

2) With the equipment in the Automatic Ready mode, apply a command signal to the AUTO REVERSE input.

Fast Command

This command may be effected by the following means:

1) With the equipment in the Manual Ready mode, operate the MANUAL CONTROL switch to the FAST FWD or FAST REV position (depending on the desired direction of tape motion).

2) With the equipment in the Automatic Ready mode, apply a command signal to the REWIND FAST CONTROL input.

Stop Command

This command may be effected by the following means:

1) With the equipment operating in the Manual mode (forward or reverse directions, normal or fast tape speeds), operate the MANUAL CONTROL switch to the STOP position. The equipment will now be in the Manual Ready mode.

2) With the equipment operating in the Automatic mode, remove any previously applied Forward Start or Reverse Start command. Any previously applied Fast command should also be removed. When a Stop command is given during a fast mode, any subsequent Start command must be delayed until the capstan speed has returned to normal.

NOTE

Detailed requirements for the command signals mentioned above will be found in the Specifications section of this section. (Refer to paragraph 1-33.)

1-26. Assume that the tape transport is in the Standby mode, with power applied, all interlocks and time delays completed and tape properly threaded. The two counter-rotating capstans are turning, the vacuum blower is holding

approximately 30 inches of tape in each of the two vacuum chambers (although the servo systems are inoperative), and the reel brakes are applied.

1-27. Assume now that the tape transport is placed in either the Manual Ready or Automatic Ready mode. The reel brakes are removed and the servos activated, so that any discrepancies from proper loop length in the vacuum chambers are corrected.

1-28. Assume now that the transport receives a Forward Start command. The actuator control circuitry in the control electronics assembly applies a high dc voltage to the windings of the actuator associated with the forward capstan. This actuator, which resembles a polarized relay, turns its armature slightly so as to close the forward capstan roller. This drives the tape past the heads at a rate determined by the speed of the capstan. Tape motion will continue in this direction until such time as a Forward Stop command is received in the control electronics assembly. At this point, the actuator control unit will reverse the signal to the actuator, moving the actuator to its open position.

1-29. As the capstan roller moves away from the capstan, a weight mounted on the opposite end of the rocker arm from the capstan briefly presses against the tape, which is supported by a metal brake post. This overcomes the inertia presented by the tape and halts tape motion. The equipment is now ready to accept another command signal. (It should be noted that the tape motion across the heads is not stopped by the reel motors. The reel motors are stopped by dynamic braking under the control of the reel servo systems.)

1-30. Assume that the equipment is in the Forward Drive mode, with the capstan removing tape from the supply (left) vacuum chamber and adding it to the take-up (right) vacuum chamber. The result will be a tendency for the loop in the left chamber to diminish in size while the loop in the right chamber will tend to grow longer. The servo systems sense these changes and counteract them by paying out tape or reeling in tape as required. The actual sensing is accomplished through slots in the base of the chambers, connected to pneumatic transducers. The tape in the vacuum chamber forms an effective wall between the vacuum on one side of the tape and the slightly higher than atmospheric pressure (because of a positive pressure blower adding air to the space between the transport frame and the closed transport access door) on the other side of the tape. A vacuum sensing device (transducer) connected to this slot reflects variations in vacuum resulting from exposure of more or less of the slot to atmosphere, i.e., the length of the

loop within the chamber. The vacuum sensing device takes the form of a diaphragm, expansion or contraction of which moves the core of a differential transformer. The primary of this transformer is excited by a signal from an oscillator. When the core of the transformer is equidistant from the two secondaries, the output of a demodulator excited by the transducer is minimal. This null condition is intended to occur when the ends of the tape loops in the column are approximately 13.5 inches apart. Any variation in loop length results in generation of an error signal, changing the demodulator output. The demodulator output in turn controls a dc servo amplifier, which in turn controls firing of thyratrons in the servo motor power supply. Depending upon the polarity of the demodulator signal (determined by the direction of core shift in the transducer) either the clockwise or counterclockwise thyratrons will fire to cause rotation of the reel motor. This rotation will feed more tape into the vacuum chamber if the loop size has been diminishing, or remove tape from the chamber if the loop has been growing in size. This action continues until the loop reaches its optimum length, at which time the core of the transformer has returned to its central position, removing the error signal from the demodulator input.

1-31. Assume that the command source signals the transport to enter a high-speed mode. The Fast command signals a relay on the capstan drive motor assembly to switch power from the low speed winding of the capstan drive motor to the high-speed winding. The actuator for the appropriate tape direction remains closed, holding the tape against the capstan with the capstan roller. The servo systems continue to maintain appropriate loop length in the vacuum chambers.

1-32. Assume that the tape is moving from the take-up reel to the supply reel at high speed (Fast Reverse mode). As the take-up reel is nearly emptied (determined by the angle of the lower tape packer arm) a microswitch is tripped to shift operation to the normal Reverse Drive mode.

1-33. SPECIFICATIONS.

Operating Characteristics

TABLE I

	1/2" Tape 112.5 ips	1/2" Tape 120 ips	1/2" Tape 150 ips	1" Tape 120 ips
Start Time [1]	2.0 msec	2.0 msec	2.0 msec	2.0 msec
Start Distance [2] (Band in inches) 1 inch = 25,5 mm	.120-.164	.124-.180	.155-.225	.124-.180
Stop Time [3]	1.5 msec	1.5 msec	1.5 msec	1.5 msec
Stop Distance [4] (Band in inches)	.047-.084	.050-.090	.063-.113	.060-.120
Instantaneous [5] Speed Variation	See Figure 1-6	See Figure 1-6	See Figure 1-6	See Figure 1-6
Short Term Average [6] Speed Variation	±2%	±2%	±2%	±2%
Long Term Average [7] Speed Variation	±1%	±1%	±1%	±1%
Dynamic Skew (max) [8]	3.5 usec	3.5 usec	3.5 usec	7.0 usec

1 Defined as time from application of Start command until tape passing read/write head reaches and remains within instantaneous speed variation specification.

2 Defined as distance moved by tape over read/write heads during start time.

3 Defined as time from application of Stop command until tape motion stops.

4 Defined as distance moved by tape over read/write head during stop time.

5 Defined as speed variation from specified nominal speed at any instant in time; variation is at maximum during start transient and decay to minimum final value.

6 Defined as variation from specified nominal speed averaged over any interval of 10 msec occurring 2 msec or more after application of Start command.

7 Defined as variation from specified nominal speed averaged over any interval of 15 msec occurring 50 msec or more after application of a Start command.

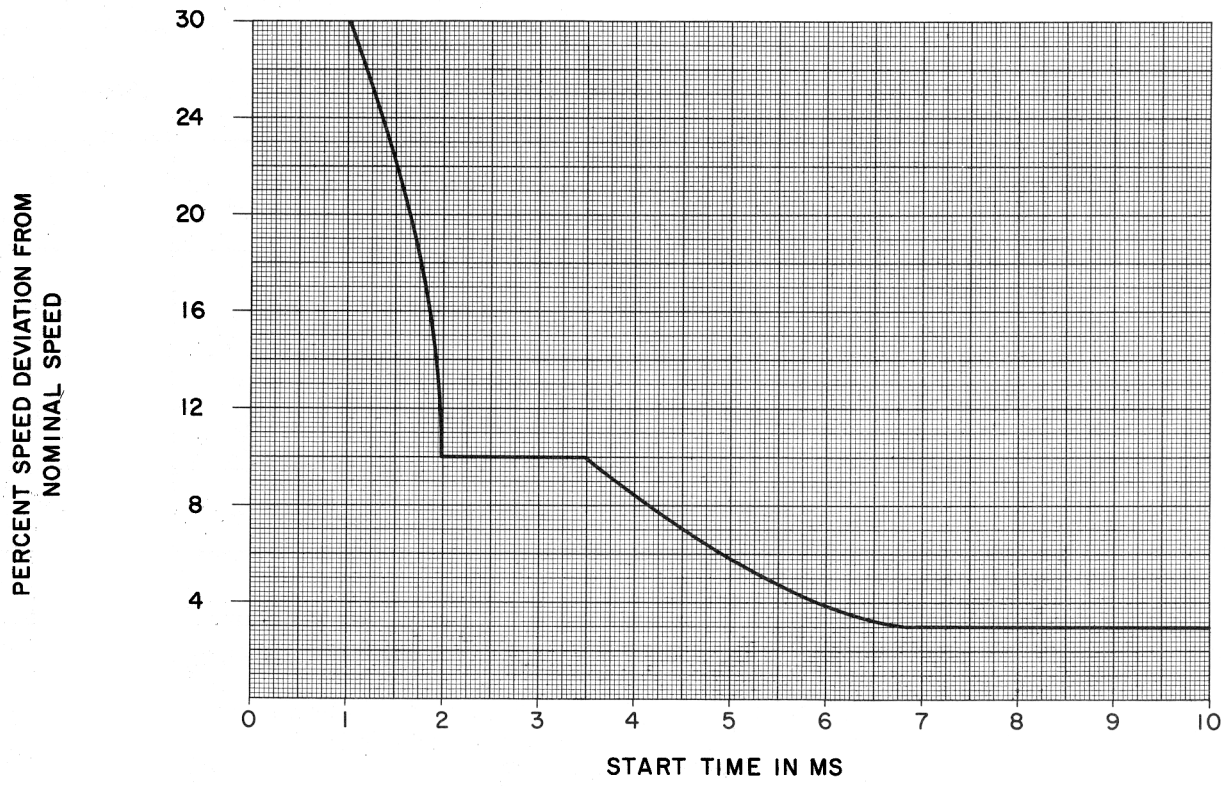

Figure 1-6
Instantaneous Speed Variation

8 Defined as the varying time displacement between the recorded signals of any two heads in the same stack with tape traveling over the heads at the specified nominal speed in either direction. This time displacement is the result of lateral displacement of the tape as it is moved and guided across the head and will be greatest between the two outermost tracks.

NOTE

Total interchannel time displacement error is expressed as Static Skew + (0.5) (Dynamic Skew). Static skew is determined by the tolerances of the head assembly.

Fast Forward and Fast Reverse (Rewind) speed	Twice nominal drive speed ±5%
Acceleration time from nominal to high speed	8 seconds maximum
Deceleration time from high to nominal speed	5 seconds maximum

NOTE

The transport is not programable during deceleration time.

Programming

Actuator Duty Cycle

(The actuators cannot be run continuously at maximum rate. Table II indicates the duty cycle over extended periods. Commands must not be initiated at intervals closer than those stated, and must in all cases be separated by 2.5 msec minimum.)

TABLE II

Mode of Operation	Commands Per Second	Maximum Program	Duty Cycle [1]
Unidirectional	400	4 commands	0.10
Unidirectional	240	9 minutes	0.75
Unidirectional	120 or less	Continuous	1.0
Bidirectional [2]	400	4 commands	0.1
Bidirectional [2]	240	Continuous	1.0

1 Duty cycle defined as $\frac{\text{Program Time}}{\text{Program time + Non-program time}}$

2 Minimum stop delays must be included in program as indicated in Figure 1-7. A Stop command is required between each tape direction reversal.

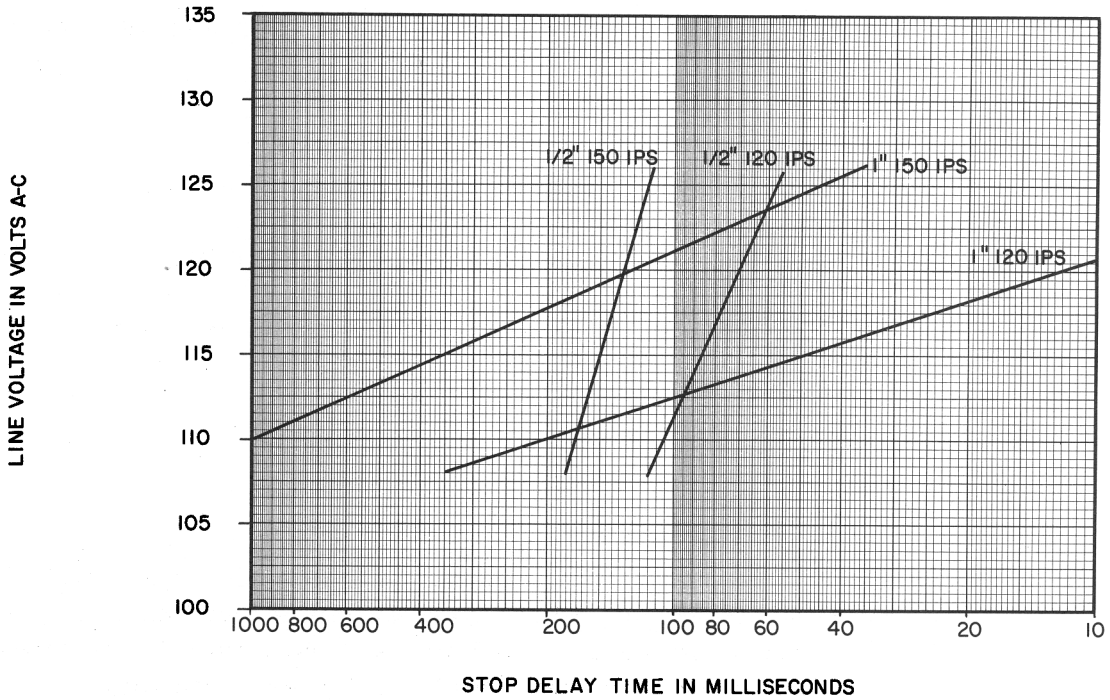

Figure 1-7
Stop Delay Requirements

Access Door Interlock--Places tape unit in Standby mode when transport access door is opened. A mechanical override is provided to facilitate service with the door open.

Long Loop/Short Loop Interlock--Interrupts command input circuits whenever a short loop or long loop is incurred; simultaneously applying Stop commands to both actuators, permitting reel servos to attempt to correct the condition. After 100-150 msec, if condition has not been corrected, tape transport is placed in Standby mode.

Leader Clamp Interlock--Closing the leader clamp places the tape unit in the Standby mode.

Servo Motor Thermal Interlock--A thermal overload switch opens the reel motor circuit if the internal temperature reaches an unsafe level, and automatically closes when the temperature decreases to a safe level.

Outputs

Interlock Interruption--In the Automatic mode, a -24 vdc signal is removed from the Auto Ready line when any of the following conditions is incurred: closure of tape leader clamp, long or short loop condition, opening of the transport access door, vacuum failure, or operation of the servo adjustment switch. The Auto Ready signal is also removed when the MODE SELECTOR switch on the manual control panel is placed in the Standby or Manual mode positions.

Long Loop/Short Loop Warning--A signal is provided when tape loops in the vacuum chambers exceed specified limits. Contact rating of the switch is 150 ma maximum at -24 vdc.

Tape Leader Sensing--A conductive leader sensing guide is located near each reel; each guide consists of three rings insulated from each other. The inner ring is grounded and serves as a ground return for remote circuits. Maximum capacity of each contact is 60 ma at 24 vdc. Arc suppression must be provided if contacts are connected to an inductive load.

Controls

Commands

The tape unit may be operated from the computer programmer or from the manual control panel. Interlocks are provided to protect the operator as well as the tape. Manual control panel commands are discussed below. Other command signals are as follows:

Start/Stop Signals--Start and Stop commands for forward and reverse operation are generated by a level change of 8 vdc (+12 vdc, -0 vdc) into 1000 ohms with a maximum rise time of 20 usec. The maximum level of these commands with respect to ground must not exceed 25 vdc. A positive-going change is a Start command; removal of this command (a negative-going change) is a Stop command.

Separation of Forward and Reverse Commands--Isolated command inputs are used for Forward and Reverse tape directions.

High-Speed Tape Motion--Fast commands are generated by a 24 vdc signal (0.25 amp max.). Removal of this level returns the capstan drive motor to normal speed.

Command Timing--An interlock is provided to prevent acceptance of commands which will close both actuators at the same time when commands are separated by a minimum of 2.5 msec, as required under Programming above.

Manual Control Panel

The manual control panel provides the following controls:

Power Switch--Master switch for all power used in tape transport.

Mode Selector--Places tape transport in Automatic, Standby, or Manual mode.

Manual Control Switch--In the Manual mode, controls tape motion between fast forward, forward, stop, reverse, or fast reverse.

Manual Write/Leader Drive--In Manual mode, supplies 24 vdc to external system which may be used to energize write relays. Also

in Manual mode, overrides end-of-tape leader stop to permit tape motion.

Interlocks and Indicators

Rewind Time Delay--In the Manual mode, a delay of from 5 to 25 seconds is used to prevent operation of tape during deceleration time of capstan.

Input Power Requirements

TABLE III

Freq.[1] (cps)	Tape Width	Input Voltage	Current (Standby Mode)	Current (Operating Modes)
50 ±2 or 60 ±2	1/2"	117 vac ±7%	6.0 amp	9 to 12 amp max.
50 ±2 or 60 ±2	1"	117 vac ±7%	6.0 amp	10 to 20 amp max.

1 Frequency must be held within ±0.3% of nominal to meet Long Term Average Speed Variation specification.

Environmental

Shock and Vibration	None
Temperature	60° to 80° F. = 16°C ... 27°C
Relative Humidity	40% to 65%
Altitude	0 to 10,000 feet
Atmosphere	Practically dust and particle free
Cooling	A minimum of 400 cfm air flow is required over the servo motors. If additional heat-generating components are located in an enclosed cabinet, additional cooling air may be required.