Technical Manual

6020 SERIES TAPE TRANSPORT

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NOTICE

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6020 SERIES
TAPE TRANSPORT

Data General

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CHAPTER I
OVERVIEW

THIS MACHINE, AN INTRODUCTION

Data General's 6020 series transports are reliable, 75ips, vacuum column tape drives, available for half inch magnetic tape in 7-track and 9-track format. Data is recorded in IBM-compatible NRZI format at 800 and 556bpi, and the tapes produced are widely interchangeable with other industry standard tape units.

Magnetic tape transports move magnetic tape past a transcription head where data is written and read in nine parallel tracks across the half inch tape width. Format requirements necessitate that the tape can be brought from a stop to full speed (75ips) before 1/4" passes the transcription head, and that the tape speed be accurate within 5%. The fragility of magnetic tape requires that gentle tension of about 8oz be steadily maintained on the tape while it is moving - and when it is accelerating or decelerating.

A system diagram of the transport is shown on the next page. The transport contains four principal systems which work independently to provide reliable, gentle tape handling. They are:

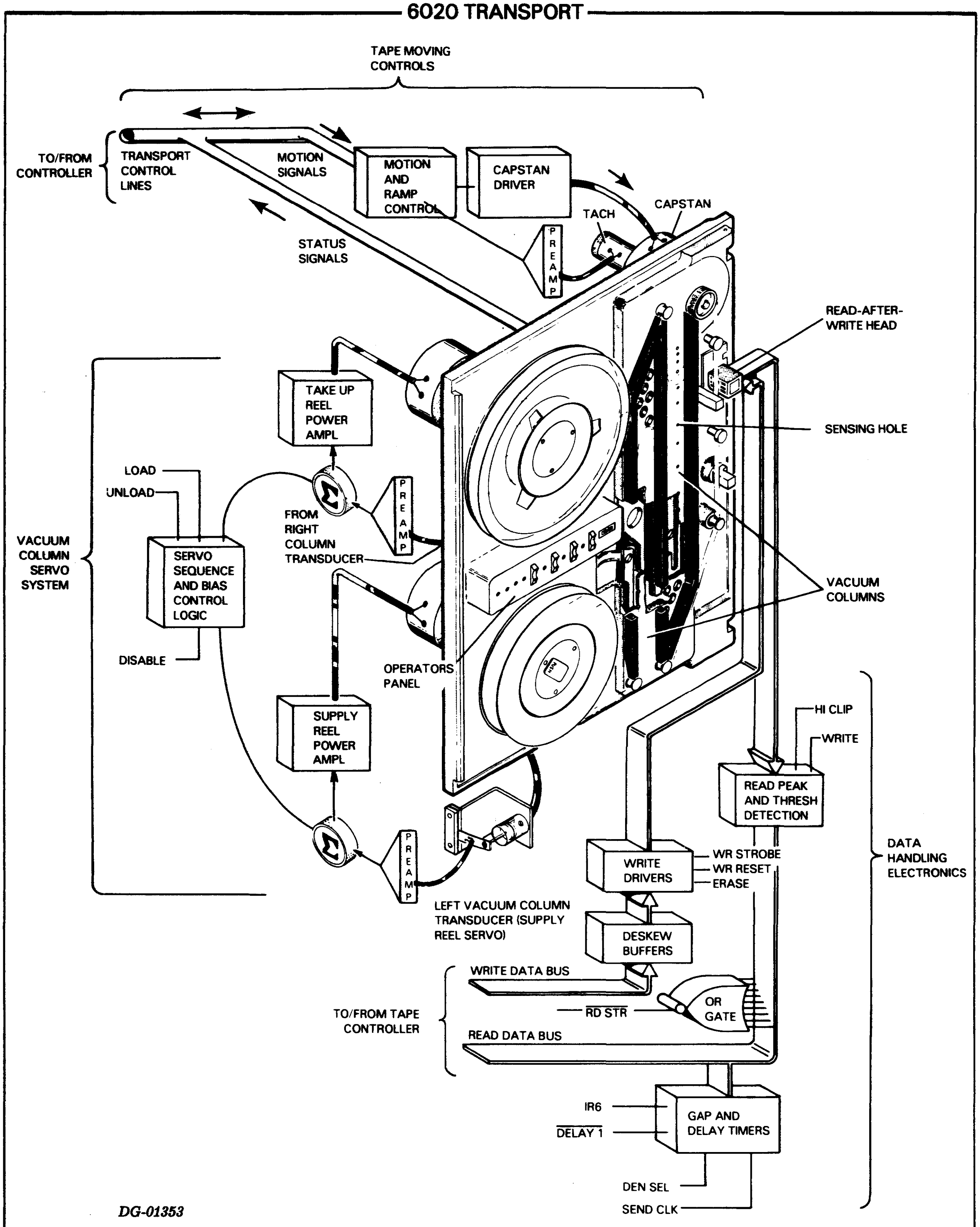
- **The operators panel and control logic**
- **The data handling circuits**
- **The capstan and its servo system**
- **The vacuum column servo systems.**

Operators Panel and Control Logic

The operators panel and its associated control logic direct the local operation of the transport and link it to the computer's tape subsystem when the unit is on line. The operators panel contains switches for powering up the transport, loading the vacuum columns, and assigning the unit's identity in a tape subsystem. The control logic provides system status information to the computer when the unit is on line.

Data Handling Circuits

Data is transcribed to tape along a 9-bit wide data path. Static deskew adjustments in each channel ensure that data characters are written in a straight line perpendicular to the length of the tape. A 9-bit wide path moves the data read from tape to the subsystem controller. A bank of amplifiers and peak detectors convert low amplitude analog pulses from the read head to TTL-level signals compatible with the controller. The data reading path also includes certain timing logic to properly synchronize data transfers. Since reading and writing are done independently of each other at the transcription head, data can be verified almost immediately as it is written without reversing the tape to reread a section.


6020 TRANSPORT
TAPE MOVING CONTROLS
TO/FROM CONTROLLER
TRANSPORT CONTROL LINES
MOTION SIGNALS
MOTION AND RAMP CONTROL
CAPSTAN DRIVER
TACH
CAPSTAN
STATUS SIGNALS
PREAMP
READ-AFTER-WRITE HEAD
TAKE UP REEL POWER AMPL
SENSING HOLE
LOAD
UNLOAD
FROM RIGHT COLUMN TRANSDUCER
VACUUM COLUMN SERVO SYSTEM
SERVO SEQUENCE AND BIAS CONTROL LOGIC
VACUUM COLUMNS
DISABLE
OPERATORS PANEL
SUPPLY REEL POWER AMPL
HI CLIP
WRITE
READ PEAK AND THRESH DETECTION
WRITE DRIVERS
WR STROBE
WR RESET
ERASE
DATA HANDLING ELECTRONICS
LEFT VACUUM COLUMN TRANSDUCER (SUPPLY REEL SERVO)
DESKEW BUFFERS
WRITE DATA BUS
RD STR
OR GATE
TO/FROM TAPE CONTROLLER
READ DATA BUS
IR6
DELAY 1
GAP AND DELAY TIMERS
DEN SEL
SEND CLK

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Capstan Servo System

All tape motion is initiated and controlled by the capstan and its servo system shown at the top of the diagram. Motion commands from the tape subsystem controller (not shown) and from the transport's own control system cause the capstan to move the tape forward or backward at 75ips or to rewind at 200ips. All motion is accomplished with carefully controlled acceleration and deceleration curves to maintain accurate tape formatting. Precise control of the capstan's rotational velocity (and thus of the tape's speed) is achieved by using an error signal from the tachometer to supply servo correction information to the capstan driver.

Vacuum Column Servos

Acceleration of the capstan to full speed is high, and vacuum columns provide a reservoir of tape that is readily available for this fast start and stop activity. Tape is gently pulled into a loop within the column by vacuum while both the capstan and a reel motor can add tape to or remove tape from the column as needed. The columns provide buffering that allows the reel motors enough time to "catch up" to the speed of the capstan.

Each reel motor is associated with a vacuum column and a servo system that strives to keep the tape loop in each column positioned near the center of that column. The servo system does this by spinning the reel motor in the correct direction, adding or removing tape from the column, to achieve the right position. There are two reel servos as shown along the left side of the drawing. Each servo operates independently of the capstan servo and from the other reel servo; each includes a transducer and analog circuitry to determine the position of tape in a vacuum column along with the necessary drivers to spin the reel motor in the correct direction, at the correct speed.

Technical Specifications and Ordering Information

The technical specifications of 6020 series transports are summarized in Appendix A. For up-to-date ordering information about this and any other Data General products, consult the latest copy of the DGC PRICE LIST which can be obtained by writing to:

Data General Corporation Westboro, Massachusetts, USA 01581

Spare and replacement parts for DGC equipment must be ordered through the Field Service Department. Consult the nearest field office, or field service headquarters at the address given above.

THIS MANUAL

This manual explains how the DGC vacuum column transports work.

There are seven chapters:

CHAPTER I	provides an overview by summarizing the organization of the machine, by introducing this manual and the conventions used therein, and by summarizing the related documents prepared by DGC.
CHAPTER II	introduces the mechanical organization of the machine and briefly describes the operation of the vacuum columns.
CHAPTER III	introduces the functons of the control logic and describes some of the control sequences and timing networks in the transport and tape subsystem.
CHAPTER IV	explains how data is transferred between tape and the controller.
CHAPTER V	explains how the servos and the failsafe system work.
CHAPTER VI	shows how electrical power is distributed through the transport, and it briefly describes how the power supply works.
CHAPTER VII	includes the list of all signal names used in the transport, with sources and destinations on the logic prints.

I

LOGIC CONVENTIONS

Drawings

Data General logic prints are drawn in close accordance with MIL-STD-806C. With this convention, logical functions are drawn as physically implemented. That is, where discrete gates are used to implement a function, these gates are shown. On the other hand, where a more complex integrated circuit is used, for instance a multiplexor, the function it performs is shown as a rectangular box.

Signal Levels

Throughout this manual, a distinction is frequently made between electrical levels and logical values. To minimize confusion, electrical levels are always indicated by an "H" or "L", and logical values by a "1" or "0". As an electrical level, an "H" indicates that the signal is high (greater than +1.7 volts). An asserted, or true, signal is indicated by a logical "1" and a false signal by a "0".

Signal Names

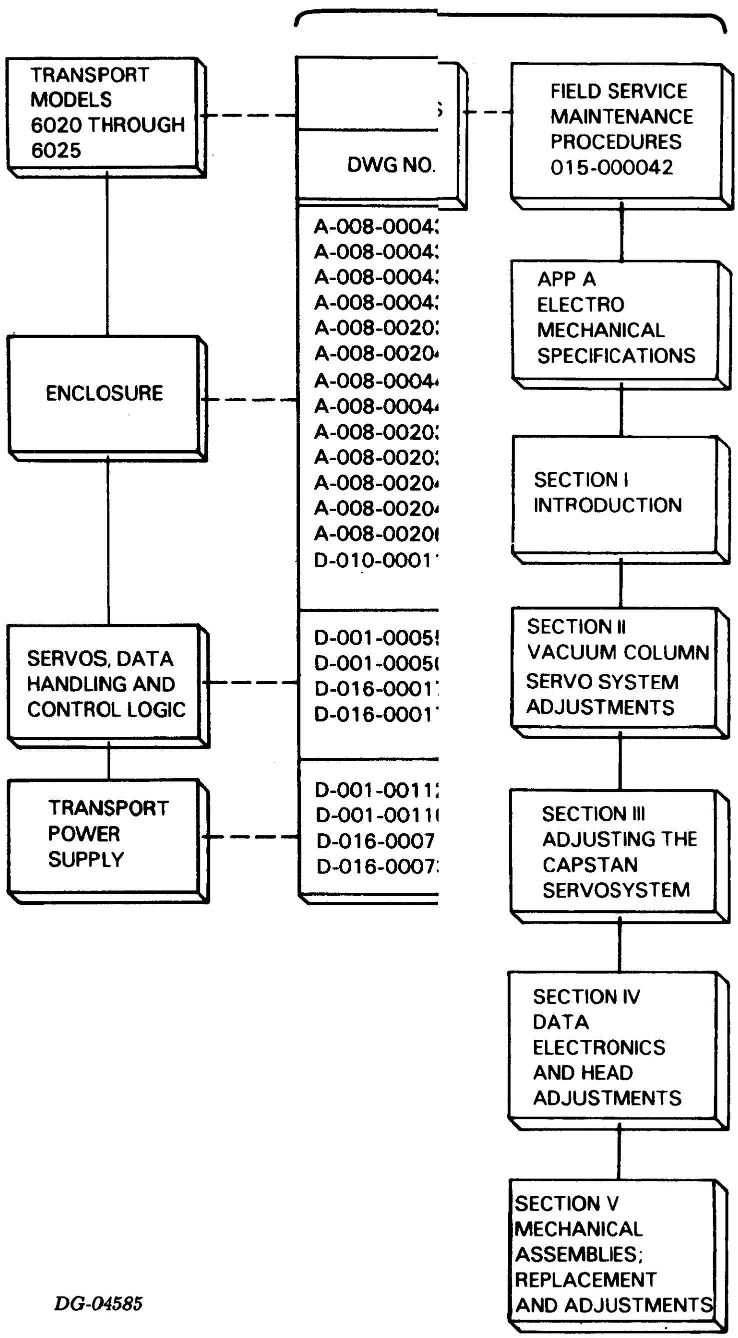
In Data General equipment the assertion state of a signal can be either low or high, depending on how it is defined. To distinguish between the two types of signals a naming convention has been adopted which defines the relationship between the logical value and the electrical level of a signal. If the signal includes a horizontal bar over the name, as "WRITE", then that signal is asserted when it is at a low electrical level. Conversely, a signal without the bar, "WRITE", is asserted when high.

Two signals having the same name but differing by the bar almost always refer to the same logical function and are electrical inverses of each other. Thus WRITE will be low when WRITE is high, and the two signals will be true at the same time.

Closely related, or bussed, signals are indicated by effectively subscripting a common label. For instance, suppose that BUS 0 through BUS 5 are all required to completely specify a function. All or part of such a group of signals is identified by placing brackets around the range of subscripts included, as BUS 0-5 . In this case, the suffix carries the information that there are six BUS lines under discussion, from BUS 0 through BUS 5, inclusive.

REFERENCE DOCUMENTS

The diagram on the next page lists the documentation available at the time this manual is printed. (See the publication date on the title page inside the front cover.) DGC Technical Manual No. 015-000001 describes the controller used in DGC NRZI tape subsystems. The "Components Guide" (DGC No. 015-000028) contains logic diagrams and truth tables for the integrated circuits, as well as the part numbers of discrete components used in Data General's equipment.


TRANSPORT MODELS 6020 THROUGH 6025
ENCLOSURE
SERVOS, DATA HANDLING AND CONTROL LOGIC
TRANSPORT POWER SUPPLY
DWG NO.
A-008-0004
A-008-0004
A-008-0004
A-008-0004
A-008-0020
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A-008-0020
D-010-0001
D-001-0005
D-001-0005
D-016-0001
D-016-0001
D-001-0011
D-001-0011
D-016-0007
D-016-0007
FIELD SERVICE MAINTENANCE PROCEDURES 015-000042
APP A ELECTRO MECHANICAL SPECIFICATIONS
SECTION I INTRODUCTION
SECTION II VACUUM COLUMN SERVO SYSTEM ADJUSTMENTS
SECTION III ADJUSTING THE CAPSTAN SERVOSYSTEM
SECTION IV DATA ELECTRONICS AND HEAD ADJUSTMENTS
SECTION V MECHANICAL ASSEMBLIES; REPLACEMENT AND ADJUSTMENTS

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I

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CHAPTER II
MECHANICAL ASSEMBLIES

II

INTRODUCTION

The 6020 series tape transports consists of eight principal assemblies: the vacuum blower assembly, the enclosure assembly, the vacuum columns and manifolds, the capstan assembly, the reel motors and hubs, the BOT/EOT sensor, the head assembly, and the write protect assembly. There are additional components such as ventilating fans, tape guides, printed circuit boards, and the suction tape cleaner. All but the power supply and the vacuum blower are mounted on the main casting. Two printed circuit boards are mounted on the back of this casting which swings open frontwards to provide easy accessibility to all of the transport parts. The mechanical assemblies are described in this section.

An electromechanical wiring diagram, views, and part numbers of all parts in the 6020 series transports are included in the illustrated parts breakdown (DGC No. 016-000491) shipped with each transport.

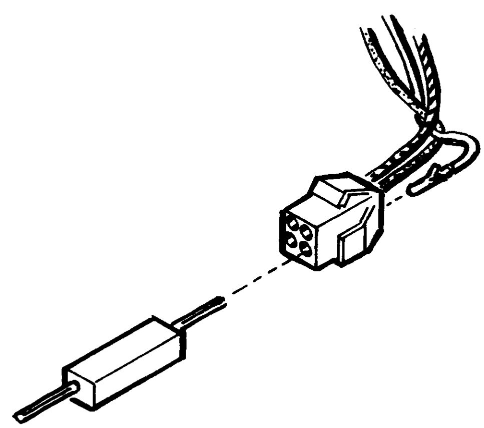
INTERNAL WIRING AND CABLES

There are three major cables which distribute logic and servo power and certain logic signals between printed circuit boards. Subassembly cables connect subassemblies in the transport enclosure or on the front casting to appropriate connectors on printed circuit boards. There are subassembly cables associated with the ventilating fans, the vacuum blower, the servo transducer, the BOT/EOT sensor, the write lock switch, the capstan and the transcription heads.

Cable Connectors

The sketch below shows how some of the cable connectors are assembled. A small detent on each pin in the plugs must be depressed to remove the pins from the connector body.

ASSEMBLING CABLE CONNECTORS



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Vacuum Blower Assembly

The vacuum blower creates the vacuum needed to operate the vacuum tape buffers; it is shown in the illustration below. It consists of an ac induction motor, a starting capacitor, a centrifugal blower, a solenoid-actuated flap valve, a cable, a drive belt, pulleys, a mounting plate and assorted mounting hardware. The motor and centrifugal blower are fastened to the mounting plate in fixed positions; a semi-elastic flat belt drives the blower. The belt is self-tensioning, so that no adjustment is required. The flap valve mechanism is attached to the blower outlet with a short length of flexible tubing and secured with hose clamps.

The blower motor is turned on and the flap valve opens when the TTL signal REMOTE ENERGIZE II asserts. Air is drawn into the inlet of the blower, placing the main vacuum manifold at a negative pressure approximately 30 inches of water. The flap valve provides quick release of the vacuum system when the blower is shut down by closing the blower's outlet. Shutdown is quicker with the flap valve than with normal coasting of the blower after power is removed. This is particularly important when the interlock system detects a failure and disables the servos, for residual vacuum in the tape columns could damage the tape when the servos are first turned off.

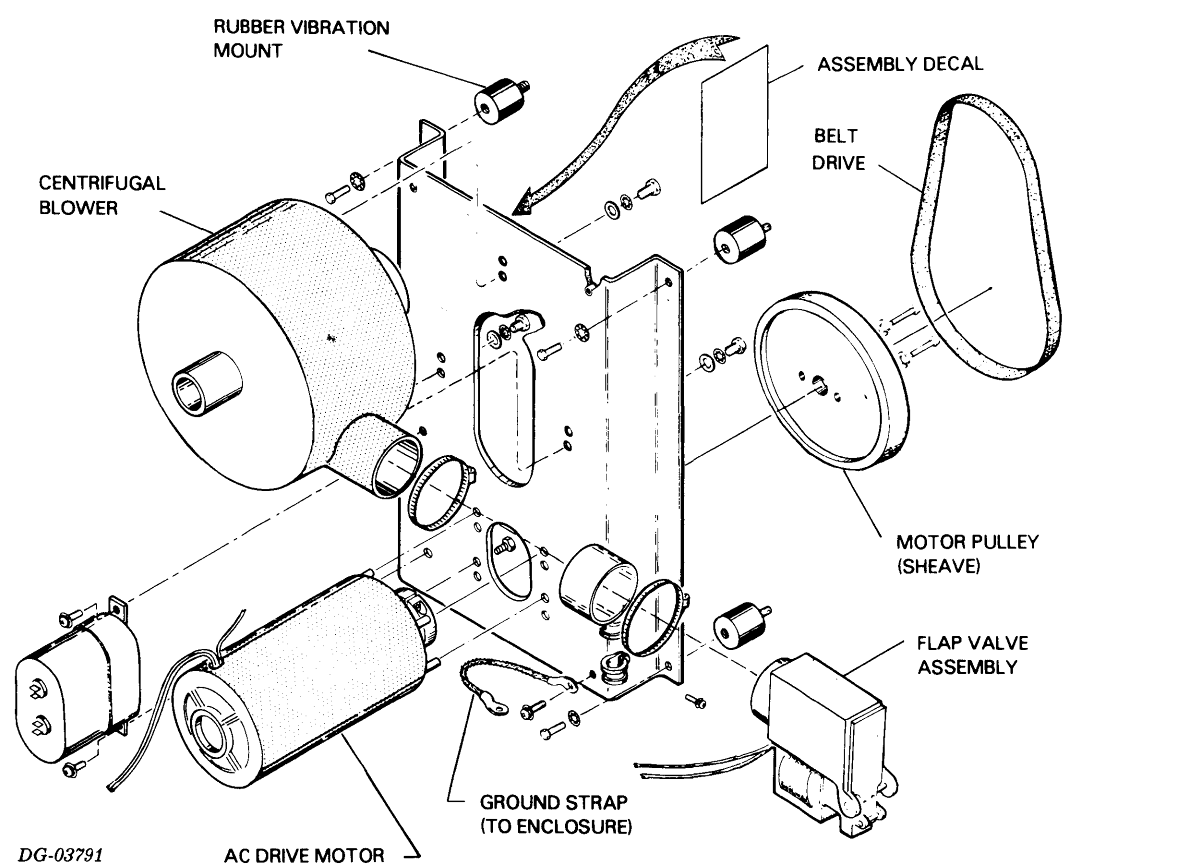
The entire assembly mounts on four rubber spacers, bolted to the rear of the transport enclosure. The four bolts holding the assembly to the enclosure are accessible from behind the enclosure. A grounding strap is installed between the mounting plate and the transport enclosure.

An access plate on the rear of the transport enclosure can be removed to expose the blower assembly and allow maintenance personnel to change the drive belt.

An alternate drive pulley (on the motor shaft) and solenoid are required for 50Hz operation.

NOTE *Earlier units use a different vacuum blower assembly than the one described here. These units are equipped with a V-belt and require adjustment as the belt wears. Refer to DG Field Service Manual for the 6020 Series transport, Ordering No. 015-000042 for the adjustment procedure.*

VACUUM BLOWER ASSEMBLY



POWER SUPPLY

The transport power supply provides low voltage dc power at several levels to energize the servo and logic circuits. The power supply components mount within the transport enclosure as shown in the following figure. There are five major subassemblies;

- AC relay module
- Power transformer and resonating capacitor
- Rectifier and filter pan
- Regulator and power amplifier board
- Cooling fan

The ac relay module is a removable subassembly that mounts in an opening at the rear of the enclosure. It houses the ac power cord, line fuses, and solid state relays that distribute ac power to the power supply, blower and fan.

The ferro-resonant power transformer converts the ac line voltage to several coarsely regulated voltages for the power supply.

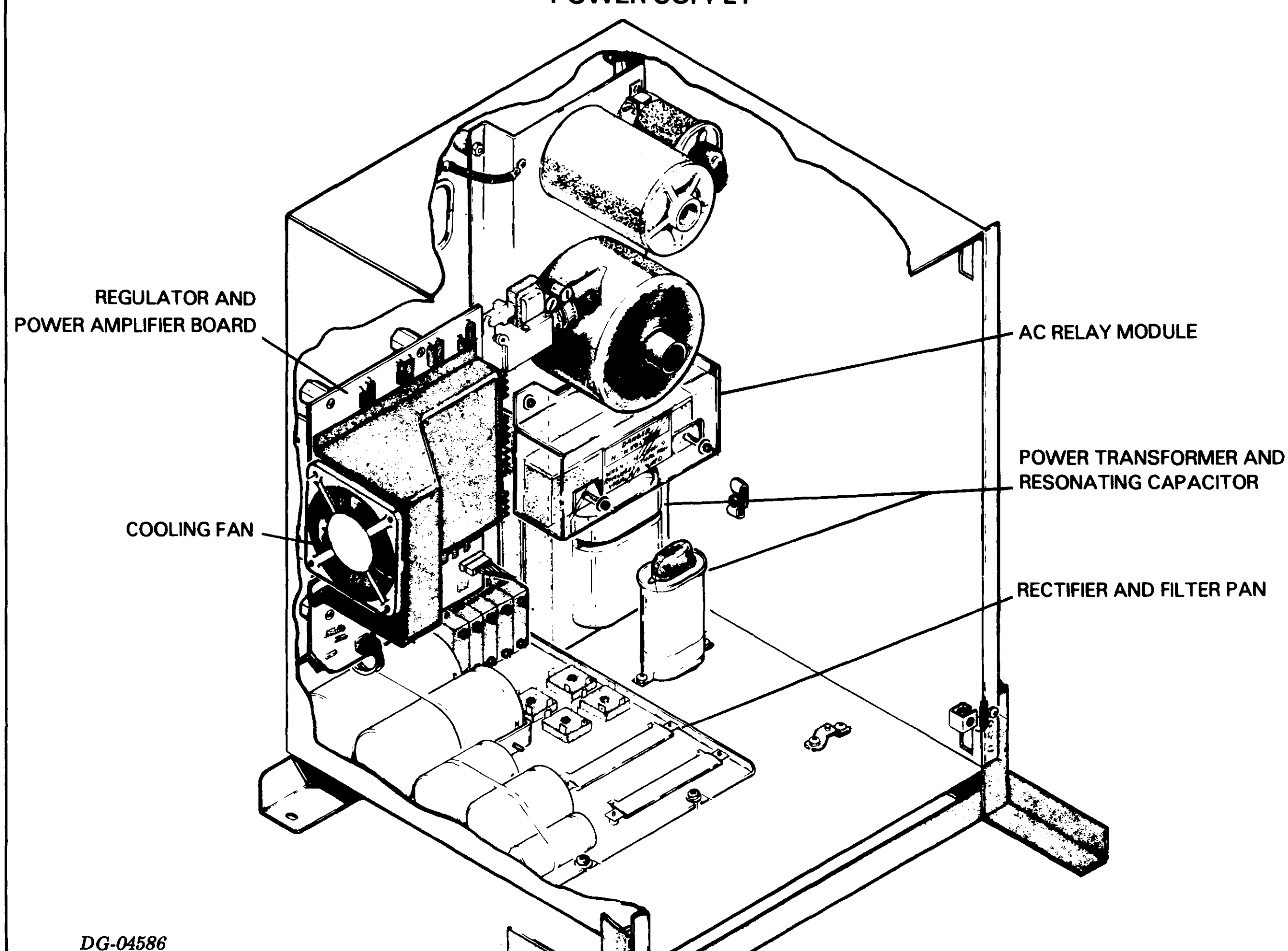
The rectifier and filter pan converts the ac outputs from the transformer to filtered dc voltages for the transport. The removable pan also supports a five pole dc circuit breaker that protrudes through the rear of the enclosure.

The regulator and power amplifier board contains circuits that regulate +5 volts and control some of the dc outputs from the rectifier and filter pan. It also contains the power amplifiers for the reel motors. The base of the card fits into a slot in a support bracket, and four screws secure the card. It is covered by a black plastic air plenum that channels air from the cooling fan across the heat sinks.

CAUTION *AC power is always present within the power supply assembly whenever the transport is plugged into a live ac line. To avoid a dangerous electrical shock, do not remove the plastic protective cover over the ac relay module.*

NOTE *See Power Supply Module in Appendix B if you have an early version of the 6020 tape drive.*

POWER SUPPLY

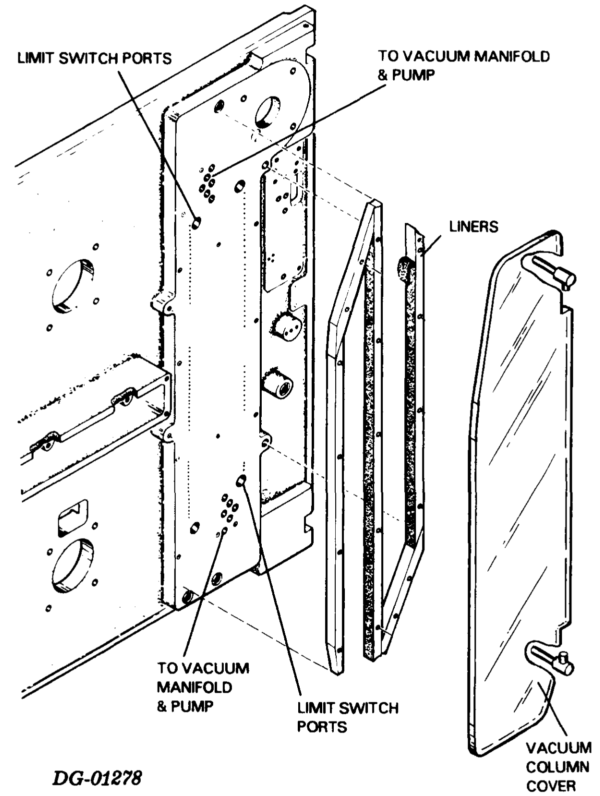


VACUUM COLUMNS AND MANIFOLDS

The vacuum columns are reservoirs which hold a loop of tape that can be quickly and gently accelerated or decelerated. These columns buffer the tape motion and allow for the slower response of the tape reels. They also maintain the tape at a constant tension. The organization of the vacuum columns, manifolds and the buffers' failsafe switches is shown in the illustration on this page.

The columns are cavities formed between machined liners that are bolted to the surface of the casting and covered with a clear plastic cover. There is sufficient clearance between the surface of the casting and the plastic cover to allow tape to slide freely inside the columns. The fit is sufficiently close, however, so that there will not be undue leakage of air from the open end of the column to the closed, evacuated end. Atmospheric pressure exerts an evenly distributed pressure on the tape, forming it into a loop when vacuum is present at the closed end of the column.

VACUUM COLUMNS



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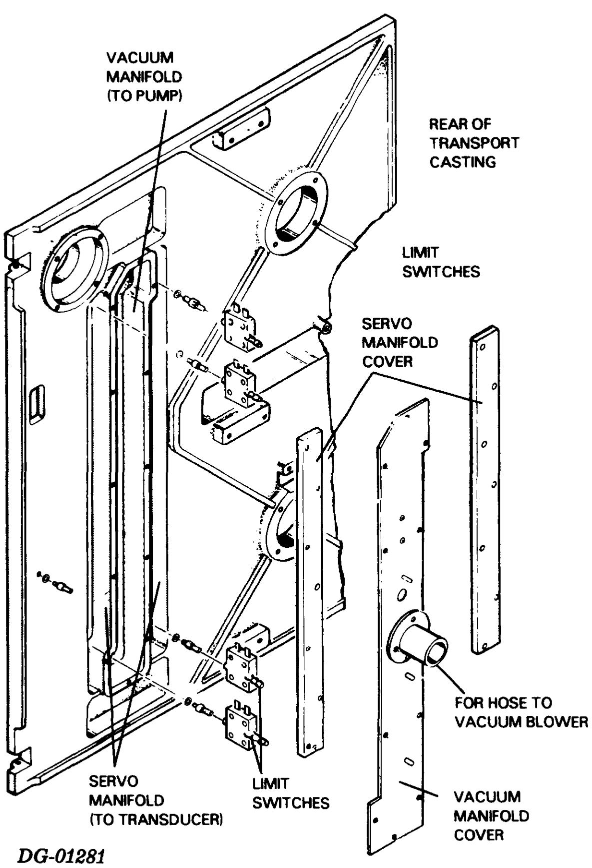
The manifolds are machined into the back of the casting and closed with metal covers. (The manifold covers are sealed with a sealing compound and should not be opened.) The main vacuum manifold connects the closed end of both columns together and to the vacuum blower. A small slide cover and vent allow adjustment of the final vacuum level in the manifold. The servo manifold are located on each side of the main vacuum manifold; they connect a row of sensing holes in each column with a vacuum transducer and a servo system.

Start-up of the tape buffers proceeds in a necessary, orderly sequence under the control of the local control circuitry described in Chapter III. When the buffers are operating, the vacuum pump draws vacuum in both columns through the main vacuum manifold. This pulls a loop of tape into both columns. The tape loop in a column divides the row of sensing holes into two parts. The holes between the tape loop and the closed end of the column "see" nearly the full manifold vacuum. Those between the tape loop and the open end of the vacuum column "see" atmospheric pressure. The sensing holes connect to a servo manifold where a partial vacuum fluctuates in response to the position of tape in the column.

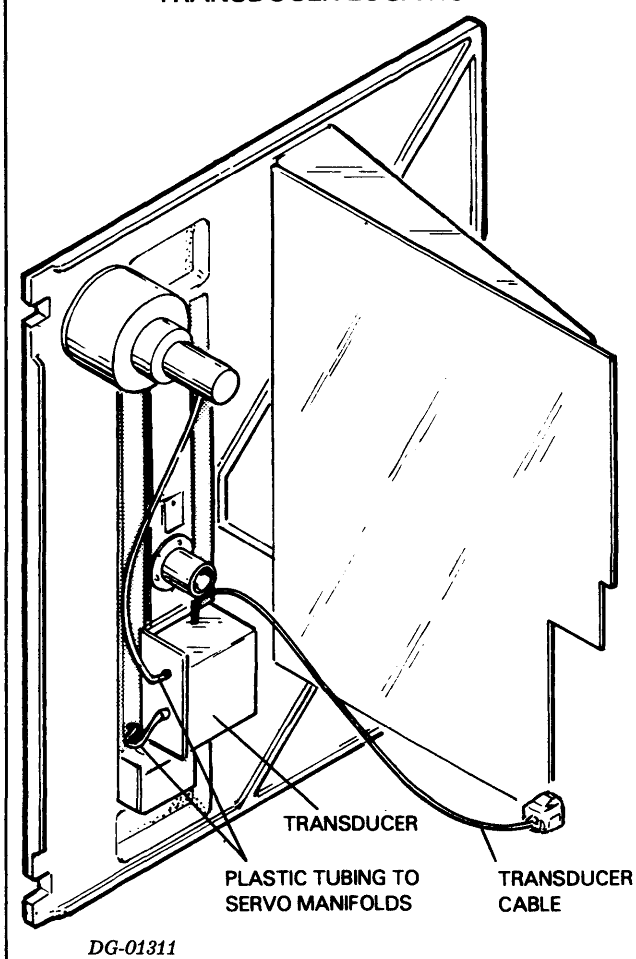
MANIFOLDS



Hose nipples are threaded into the back of the casting at the extremities of each vacuum column. They connect through plastic tubes to pressure switches mounted on the main printed circuit board. These pressure switches are part of a failsafe system that monitors the tape buffers' operation. (These switches and the failsafe system are described in Chapter V.)

The transducer converts pressure fluctuations in the servo manifolds to electrical signals proportional to the position of the tape loop in a vacuum column. Each manifold connects through a plastic tube to a transducer. Illustrations and an electrical description of the transducers is contained in Chapter V. The location of the transducer is shown below.

TRANSDUCER LOCATION

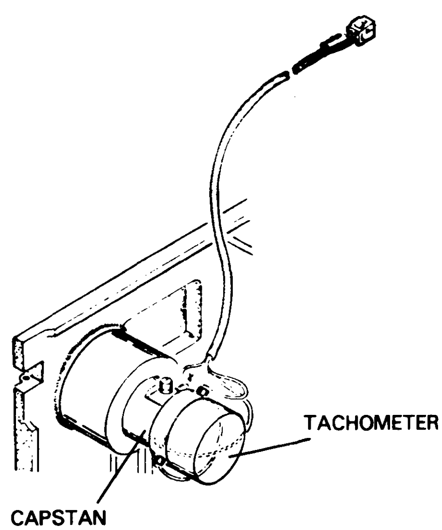


II

CAPSTAN/TACHOMETER ASSEMBLY

The capstan moves the tape forward and backward in response to motion commands within the transport or from the subsystem controller. The tachometer provides the capstan's servo system with an electrical signal proportional to the capstan's rotation velocity. The capstan motor and tachometer are mounted together on a single shaft to form a single piggy-back unit. (Under NO condition should an attempt be made to separate the tachometer from the capstan motor.) The dual assembly mounts against a precision machined surface on the rear of the casting and normally does not require any shims. The position of the capstan motor is shown below. Four socket head screws attach the capstan assembly to the casting.

CAPSTAN/TACHOMETER LOCATIONS



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REEL MOTORS AND HUB ASSEMBLIES

The reel motors spin the tape reels in response to servo commands so that the tape remains balanced in each vacuum column. They attach to the casting with four socket head machine screws. The motors mount against precision machined surfaces on the back of the casting and normally do not require any shims.

Tape reels attach to a hub assembly on each motor's shaft. One reel (the take up reel) is fixed in position on its hub. The other reel (the supply reel) contains the tape file and is held onto the hub with a push-tab locking mechanism. Both hub assemblies are secured on their respective motor shafts with taper-lock fittings. The lock ring in these fittings can be easily released to align the hub (and reel) position in the tape path. However, correct positioning of the hubs on the motor shafts requires careful alignment to ensure that tape is handled safely. This should not be attempted without proper gauges and tightening torque specifications.

The hub mounted on the lower reel motor has a push-lock mechanism on which a supply reel of magnetic tape is mounted. The upper hub holds a 10.5 inch plastic take up reel.

NOTE *Should the transport-mounted take up reel break, it can be replaced by an operator. The procedure is described in section K of DGC Technical Reference 014-000055 for the 6020 series tape subsystem.*

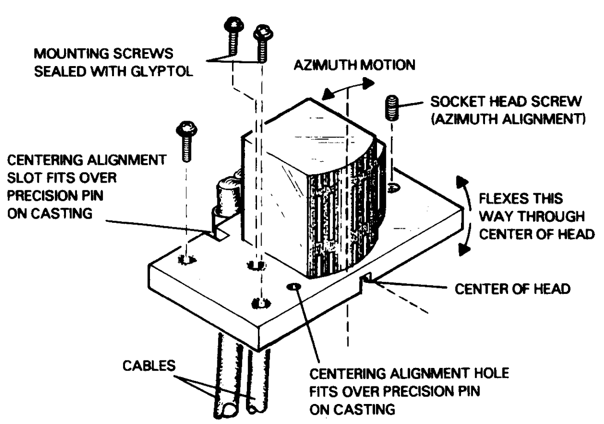
TRANSCRIPTION HEAD ASSEMBLY

The transcription head assembly is a 7- or 9-track read-after-write magnetic head, mounted so that it can be positioned correctly for accurate tape processing. The head assembly is shown below. The head is attached to an epoxy-composition block that attaches over guide pins in the casting and is secured with three screws. The dimensions of the head mounting plate and its mating surface on the casting are carefully controlled within tolerances that assure interchangeability of head modules from transport to transport without the need for shims.

Azimuth alignment is accomplished with a single screw which flexes the head mounting plate along a line through the center of the head. A spring washer places the azimuth adjustment under tension to eliminate creep.

NOTE *To prevent scoring of the transcription head use only soft cotton applicators against its surface. "Paper Towels", in general, have much too abrasive a surface and can damage both the head and eventually any tape that passes over it.*

TRANSCRIPTION HEAD



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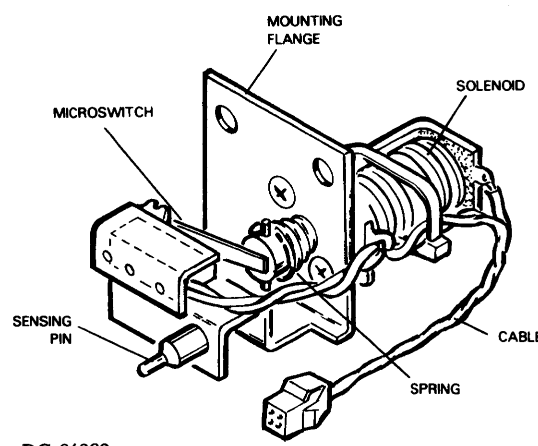
WRITE LOCK SWITCH ASSEMBLY

The write lock switch is a sensing assembly that determines whether or not a tape file mounted on the transport is write protected. The assembly is shown below. It consists of a sensing pin, a micro-switch, a solenoid, and a spring. The sensing pin is aligned with the write lock groove on the back of tape reels. When an enabling ring is mounted in the groove, the solenoid pin is depressed, opening a switch with two effects: first the solenoid is energized to retract the sensing pin and to prevent scraping; then the write heads' center taps are connected to the dc voltage supply. (Write current does not actually flow through the heads unless the write current drivers are enabled, viz. during an erase or data writing operation.) To prevent undue scraping of the sensing pin against a write enabling ring, the pin is retracted at the beginning of a tape LOAD operation, whenever the ring is detected.

WRITE LOCK SWITCH



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II

MISCELLANEOUS TAPE PATH ELEMENTS

The BOT/EOT sensor, tape guides and the suction tape cleaner attach directly to the transport casting. The surface of the suction tape cleaner (and the transcription head) is all that touches the recording surface of the tape.

BOT/EOT Sensor

The beginning and end of tape sensor contains two light emitting diodes (LED's) and two phototransistors in a sealed assembly. Each LED is paired with a phototransistor and scans half the width of tape for reflective markers that mark the Beginning of Tape (BOT) and End of Tape (EOT). Light from an LED reflects back to a phototransistor when the appropriate reflective tab passes the sensing assembly. The transport control logic sets and clears the BOT and EOT flags in the transport and tape subsystem status registers in response to the phototransistor signals. The correct positions for the BOT and EOT reflectors on the tape are shown below.

Tape Guides

There are two types of tape guides, nonroller head guides (2) and the roller guides (4). The head guides align the tape with the read and write surface of the transcription head; the roller guides stabilize the tape as it enters the vacuum columns.

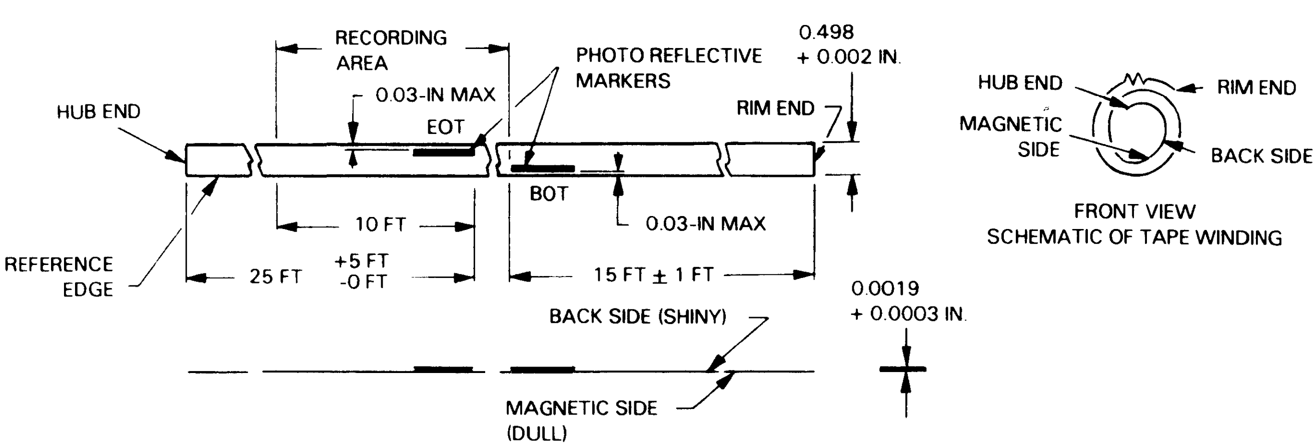
The head guides are two ceramic washers mounted on chrome-plated posts over which the tape passes. The upper washer (away from the casting surface) is fixed in position, and is in contact with the certified reference edge of the tape. The lower washer is lightly spring loaded to maintain slight pressure against the tape. (Industry standard magnetic tape can vary in width up to 0.002 inches relative to the true, straight, reference edge.) The tape guides' spacings from the head and capstan are those which have been found to give optimum long and short term dynamic tracking over the head. The guides are precision machined parts and normally do not require alignment or shimming.

There are four molded plastic roller guides. They provide large radius, low friction guides for abrupt direction changes in the tape path - particularly at the vacuum column openings.

Suction Tape Cleaner

Just before the tape passes over the head (in the forward direction), it passes over a suction tape cleaner that removes loose dust and tape debris. The cleaner is connected into the vacuum system, and the collected debris is vented out the back of the transport through one of the cooling fans. The surface of the cleaner is highly polished and the edges of the holes over which the tape passes are carefully chamfered to prevent abrasion of the tape's recording surface. Like the surface of the head, the suction tape cleaner should be cleaned only with soft cotton applicators.

LOCATING BOT/EOT REFLECTORS



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PRINTED CIRCUIT BOARDS

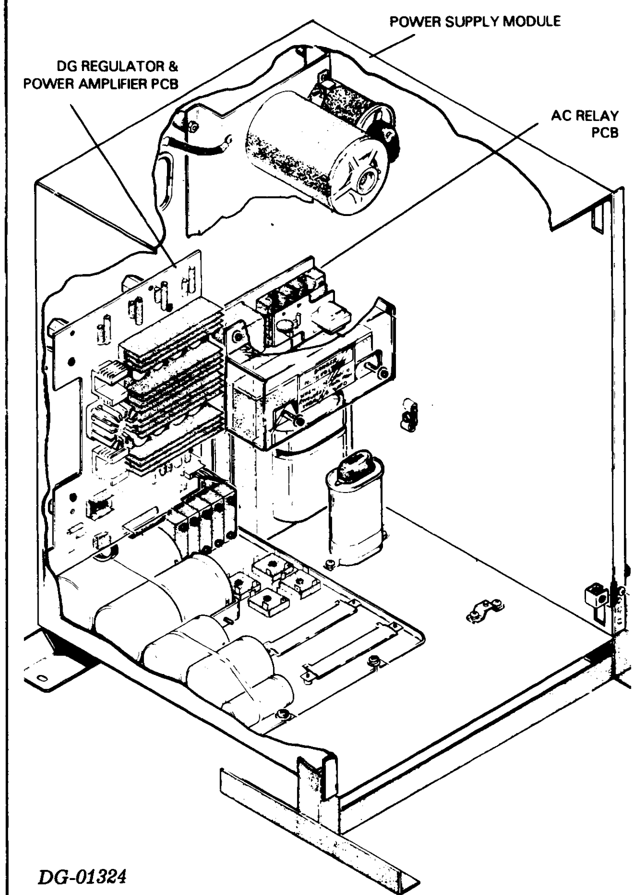
There are four printed circuit boards in the transport. Two of them mount to the transport enclosure, and the remaining two attach to the back of the recording deck casting.

The figure to the right shows the enclosure mounted boards. The small board at the back contains the ac relay circuits that switch ac power to the drive. The larger board next to it contains the dc regulator and power control circuits, as well as the power amplifiers that drive the reel motors.

The largest circuit board mounts vertically on two brackets attached to the casting and measures approximately 15" x 23". It contains the data handling electronics, the capstan servo system, part of the control circuitry and part of the reel servos system (less power amplifiers). A smaller circuit board containing most of the control logic associated with the operator's panel mounts horizontally behind the casting. The control board plugs directly into the main board without a cable. Rocker switches, indicators and the thumbwheel switch for the operator's panel mount directly on the control board. All of the operator's panel switches and indicators can be removed at once by removing the control logic board. These two boards and their mounting positions are shown below.

NOTE *See Printed Circuit Boards in Appendix B if you have an early version of the tape drive.*

ENCLOSURE-MOUNTED BOARDS



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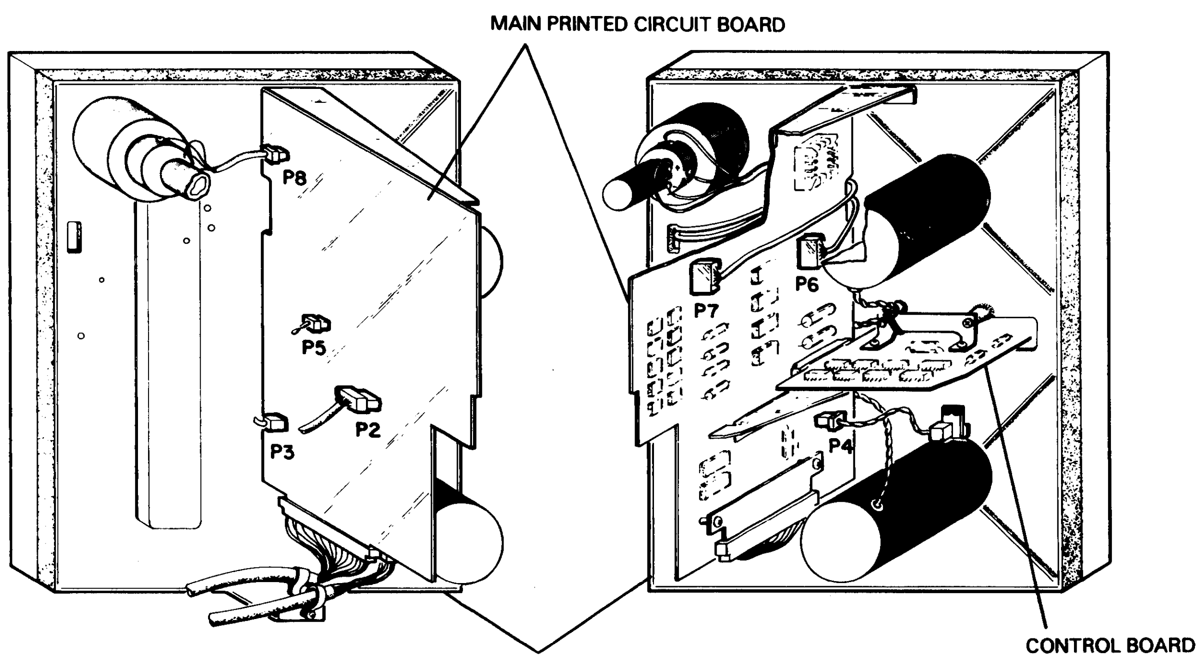
CASTING-MOUNTED BOARDS



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II

AIR FLOW AND VENTILATION IN THE TRANSPORT

One compact fan provides ventilation for the transport as shown in the illustration below. It draws air into the enclosure around the edges of the recording deck casting, and exhausts it out the left side.

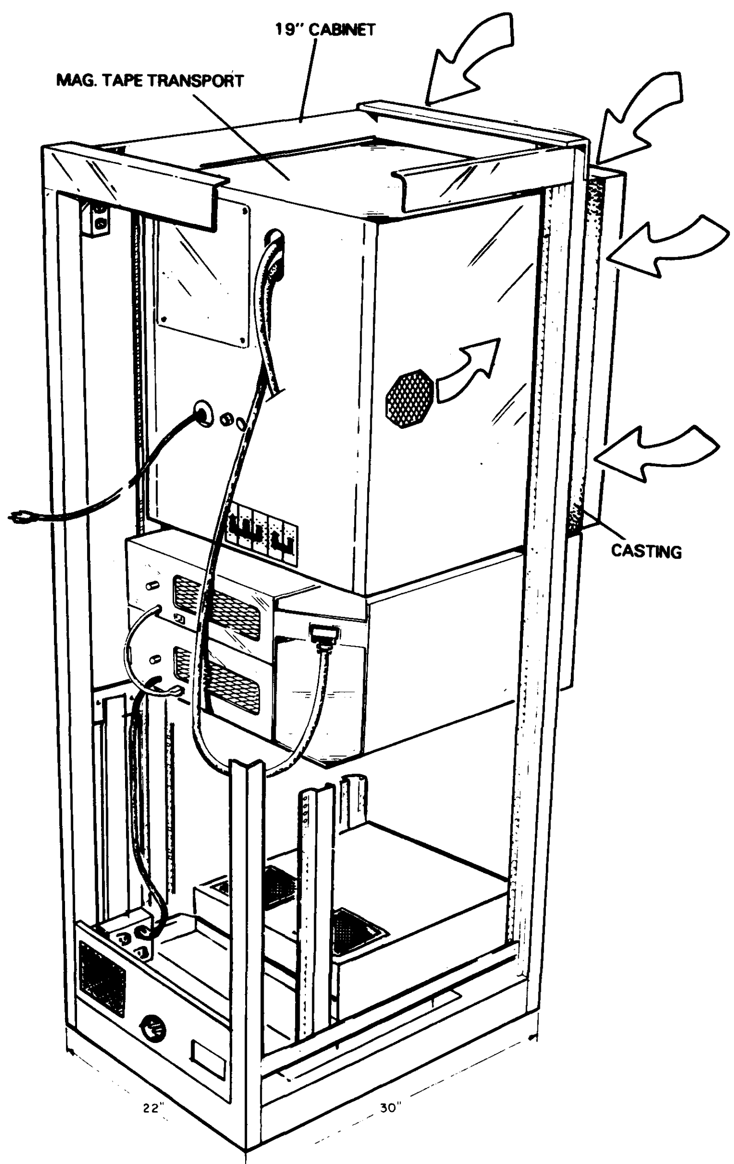
NOTE *See Air Flow and Ventilation in the Transport in Appendix B if you have an early version of the tape drive.*

REFERENCE

DGC print:

016-000491

VENTILATION OF THE TRANSPORT



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CHAPTER III
TRANSPORT CONTROL LOGIC

INTRODUCTION

The transport control logic performs basic housekeeping for the magnetic tape transport whenever it is operating - whether under local, operator direction or under computer control. These housekeeping chores are implemented in sequences initiated by the computer or an operator, and they assure that all operations are carried out in a logically sound and orderly manner. Additionally, a failsafe system protects the tape from becoming damaged by failures in the transport. For example, when an operator mounts a reel of tape on the transport and presses Load, a distinct series of circuit-level events take place to load the vacuum columns while several tests verify that the sequence is proceeding correctly.

Operator-initiated sequences include powering up, loading and unloading the tape buffers (vacuum columns), rewinding, resetting, and placing the transport On Line with the computer. Computer-directed operations include moving forward (for a read, write, erase or space forward command), and rewinding. When the transport is On Line, command and status information is exchanged through a signal network between the transport and the tape subsystem controller to prevent a large number of erroneous or meaningless operations. The failsafe or interlock system monitors certain key parameters in the transport such as the vacuum levels and power supply interruptions to protect the magnetic tape from physical damage in the event of a failure in the servo systems. All but the last of these control functions are discussed under separate headings in this section. The interlock system is intimately related to the operation of the analog servo systems; so it is described in Chapter V.

OPERATIONS INITIATED AT THE OPERATORS CONSOLE

The operations which are initiated at the operators console are: Power On, Load,, Unload, Unwind, On Line, Reset and Rewind. Associated with each of these operations is a sequence of logical steps and tests that is carried out to verify the transport is functioning correctly. Pressing one of the switches on the operators console initiates a sequence which is carried to completion automatically, but only if all tests for transport integrity are met. The control sequences are described below. Three of them are described in two ways - with a short description and with flowcharts presenting in some detail the circuit-level events in the sequence.

Flowchart Conventions

The logic flowcharts are, generally speaking, self-explanatory. However, certain conventions have been followed in constructing them so that the reader can conveniently use them as an introduction to the schematic circuit diagrams, (DGC NO.'s 001-000566, 001-000508, 001-001128 and 001-001160.) The flowchart conventions are:

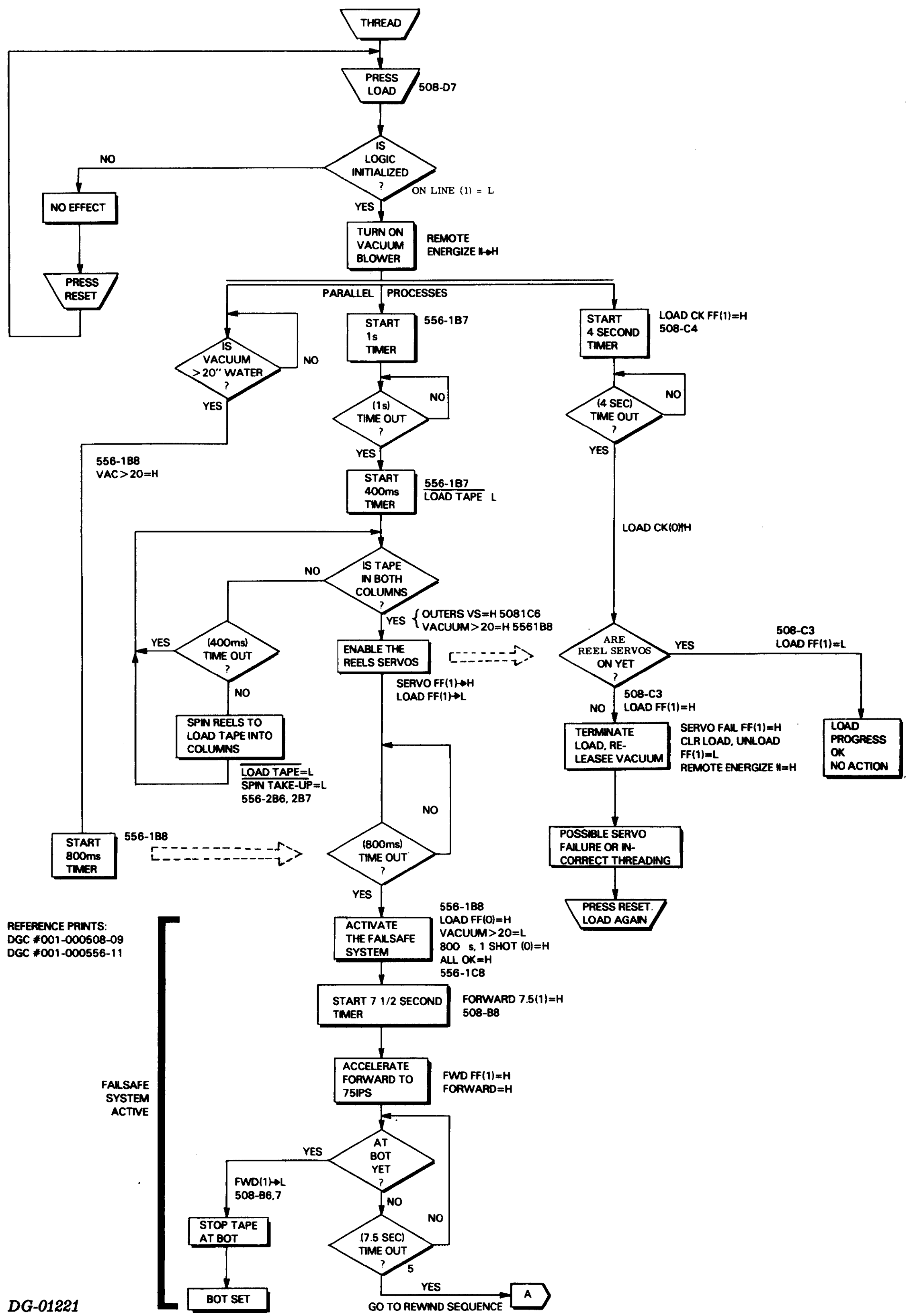
1. The number designated "Reference" at the bottom of the flowchart refers to the engineering schematic and revision level from which the flowchart was constructed.
2. The statement contained in any box of the flowchart describes a logic event or decision.
3. Where appropriate, actual logic values of certain signals are stated outside a box to show how the logic event is implemented.
4. In certain cases, parallel events are indicated in the logical flow. This occurs, for example, where a timer in one path can override and disable the action of a parallel path.

Load Sequence

To load the tape drive the operator mounts a reel of tape, threads it around a simple tape path, around the take up reel, and presses Load to initiate the load sequence. First, the vacuum system is turned on and its proper operation is verified. Both tape reels are then momentarily spun so that tape is fed into each vacuum column. (Injecting tape into the columns eliminates the irksome squeel characteristic of vacuum column transports.) If the tape equilibrates inside the columns within the proper time interval, the first half of the load sequence is considered successful and the servo failsafe system is placed in operation. A forward search is then made down the tape for a reflective tab marking the logical Beginning of Tape (BOT), or loadpoint. The tape stops at the loadpoint with the BOT indicator illuminated at the operators console.

Should the loadpoint marker not be found within 7 to 8 seconds (about 40 to 50 feet of tape will be searched), the transport will rewind the tape at high speed, searching backwards for the reflective tab. If the tab is not located during rewinding, the tape will simply spool off the take up reel and the failsafe system will terminate the load sequence. (This failure requires that the transport be reset. The Reset operation is discussed below.)

LOAD



THREAD
PRESS LOAD
508-D7
IS LOGIC INITIALIZED ?
ON LINE (1) = L
NO
NO EFFECT
PRESS RESET
YES
TURN ON VACUUM BLOWER
REMOTE ENERGIZE II→H
PARALLEL PROCESSES
IS VACUUM >20" WATER ?
NO
YES
START 1s TIMER
556-1B7
START 4 SECOND TIMER
LOAD CK FF(1)=H
508-C4
(1s) TIME OUT ?
(4 SEC) TIME OUT ?
556-1B8
VAC>20=H
START 400ms TIMER
556-1B7
LOAD TAPE L
LOAD CK(0)↑H
IS TAPE IN BOTH COLUMNS ?
OUTERS VS=H 5081C6
VACUUM>20=H 5561B8
(400ms) TIME OUT ?
ENABLE THE REELS SERVOS
ARE REEL SERVOS ON YET ?
508-C3
LOAD FF(1)=L
SERVO FF(1)→H
LOAD FF(1)→L
508-C3
LOAD FF(1)=H
SPIN REELS TO LOAD TAPE INTO COLUMNS
TERMINATE LOAD, RE-LEASEE VACUUM
SERVO FAIL FF(1)=H
CLR LOAD, UNLOAD FF(1)=L
REMOTE ENERGIZE II=H
LOAD PROGRESS OK NO ACTION
LOAD TAPE=L
SPIN TAKE-UP=L
556-2B6, 2B7
START 800ms TIMER
556-1B8
(800ms) TIME OUT ?
POSSIBLE SERVO FAILURE OR IN-CORRECT THREADING
PRESS RESET. LOAD AGAIN
REFERENCE PRINTS:
DGC #001-000508-09
DGC #001-000556-11
ACTIVATE THE FAILSAFE SYSTEM
556-1B8
LOAD FF(0)=H
VACUUM>20=L
800 s, 1 SHOT (0)=H
ALL OK=H
556-1C8
START 7 1/2 SECOND TIMER
FORWARD 7.5(1)=H
508-B8
FAILSAFE SYSTEM ACTIVE
ACCELERATE FORWARD TO 75IPS
FWD FF(1)=H
FORWARD=H
AT BOT YET ?
FWD(1)→L
508-B6,7
STOP TAPE AT BOT
(7.5 SEC) TIME OUT ?
5
GO TO REWIND SEQUENCE
A
BOT SET
DG-01221

III

Unload (and Unwind) Sequence

Pressing the Unload switch can cause two distinctly different operations to take place depending on whether or not the vacuum columns are loaded. (The transport must be off line.) The two possible effects are called "unloading" and "unwinding". The Unload sequence is initiated by momentarily pressing Unload when the vacuum column buffers are operating. The unwind operation is performed by pressing and holding Unload when the vacuum columns are not operating. Releasing the switch causes the unwind operation to stop.

Unload

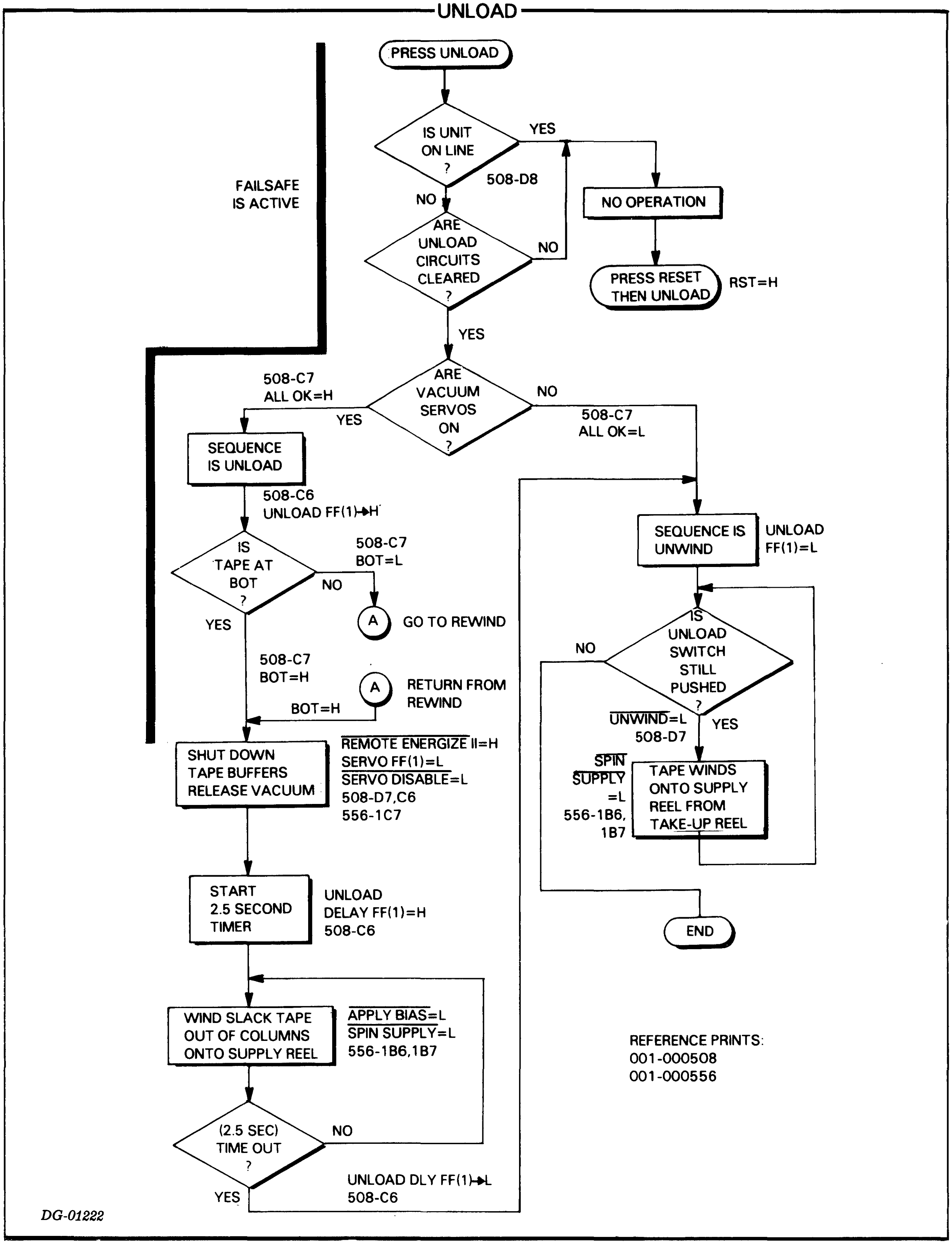
When the unload sequence is initiated, the transport rewinds tape to the loadpoint if it is not already there. The servos and servo failsafe system are disabled and then the vacuum in the tape buffers is released. Finally, the supply reel is spun momentarily to pull tape out of the columns.

Unwind

Pressing and holding Unload on a transport with the tape buffers shut down causes the supply and take up reels to slowly spin while the switch is held down. This slowly winds tape onto the supply reel. The spin rates of the two reels are adjusted so that a full, 10.5 inch supply reel spools tape at about the same rate as a nearly empty take up reel. If the unwind operation is used to slowly rewind an entire tape the spooling rates will not always match and some care must be taken to keep tape from spilling onto the floor. Light pressure should be applied to the HUB (not the flange) to slow the take up reel.

The slow reel-to-reel rewind can be used for recovering a tape stranded on a malfunctioning tape drive.

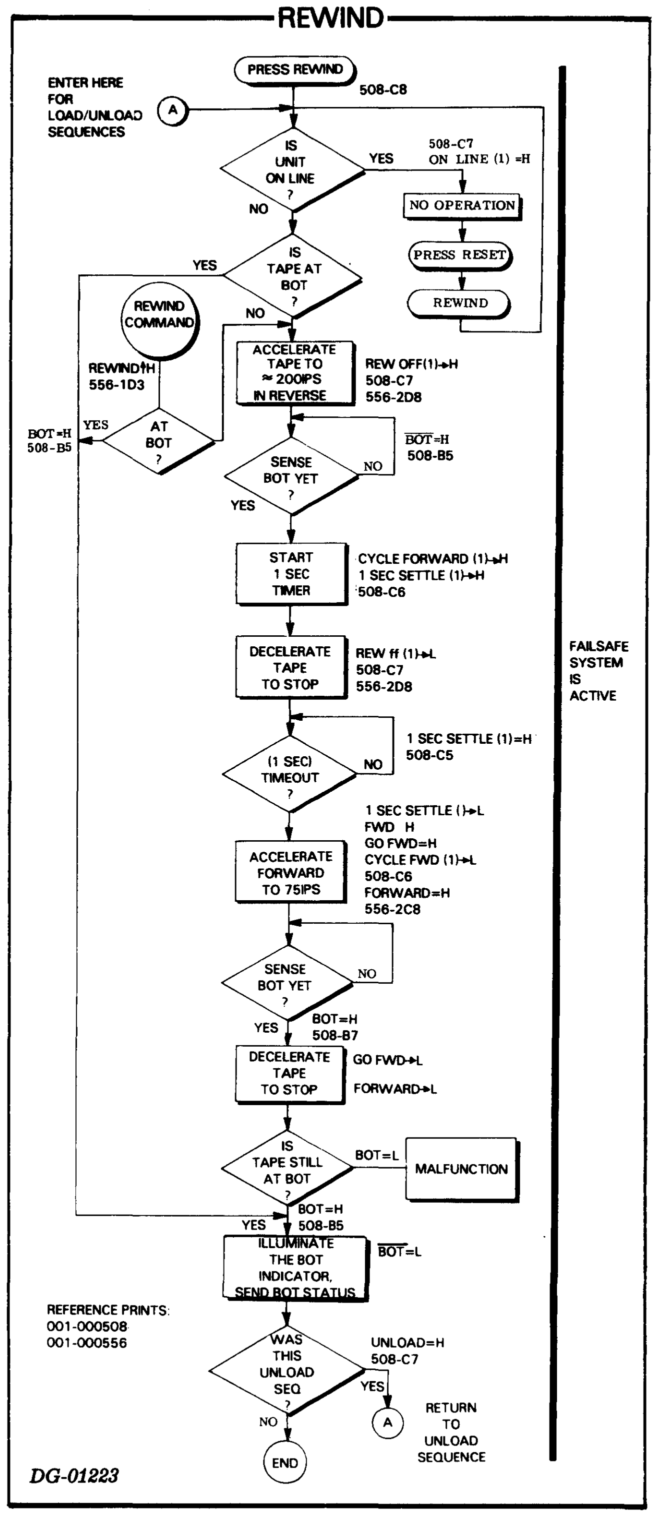
UNLOAD


PRESS UNLOAD
IS UNIT ON LINE ?
YES
508-D8
NO
NO OPERATION
PRESS RESET THEN UNLOAD
RST=H
FAILSAFE IS ACTIVE
ARE UNLOAD CIRCUITS CLEARED ?
NO
YES
ARE VACUUM SERVOS ON ?
508-C7
ALL OK=H
YES
NO
508-C7
ALL OK=L
SEQUENCE IS UNLOAD
508-C6
UNLOAD FF(1)→H
IS TAPE AT BOT ?
508-C7
BOT=L
NO
A
GO TO REWIND
YES
508-C7
BOT=H
A
RETURN FROM REWIND
BOT=H
SHUT DOWN TAPE BUFFERS RELEASE VACUUM
REMOTE ENERGIZE II=H
SERVO FF(1)=L
SERVO DISABLE=L
508-D7,C6
556-1C7
START 2.5 SECOND TIMER
UNLOAD DELAY FF(1)=H
508-C6
WIND SLACK TAPE OUT OF COLUMNS ONTO SUPPLY REEL
APPLY BIAS=L
SPIN SUPPLY=L
556-1B6,1B7
(2.5 SEC) TIME OUT ?
NO
YES
UNLOAD DLY FF(1)→L
508-C6
SEQUENCE IS UNWIND
UNLOAD FF(1)=L
IS UNLOAD SWITCH STILL PUSHED ?
NO
UNWIND=L
508-D7
YES
SPIN SUPPLY =L
556-1B6, 1B7
TAPE WINDS ONTO SUPPLY REEL FROM TAKE-UP REEL
END
REFERENCE PRINTS:
001-000508
001-000556
DG-01222

III

Rewind Sequence

There are three ways a rewind sequence can be initiated: via the operators console when the unit is off line and not under program or computer control, when the transport is On Line, and when a BOT reflector is not located during the forward search of the load sequence. In all cases the rewind sequence is identical. If the tape is at the loadpoint, there is no effect. If the tape is not already at the loadpoint, it accelerates to 200ips (nominal) in reverse until the loadpoint tab is detected (or until the tape unwinds from the take up reel). If a loadpoint marker is detected, the tape decelerates, reverses direction, and hunts forward to stop there.



On Line Sequence

Pressing the On Line switch on the operators panel enables the transport select logic, allowing the transport to respond to commands issued by the tape subsystem controller. The identity of the transport within its subsystem is assigned by the position of the Unit Select switch on the operators panel.

NOTE *Indeterminate logical and status conditions can be encountered by the computer software if more than one transport in a tape subsystem is assigned the same unit number - even if only momentarily. Therefore the Unit Select switch should not be changed while the unit is On Line. Reset the transport before changing the Unit Select number.*

When the unit is placed On Line, the unit ready logic is also enabled, and the READY indicator on the operators panel should illuminate. The load, unload, and rewind switches on the operators panel are disabled while the unit remains On Line.

Reset Sequence

Pressing Reset can have two different effects: the first is to take a transport off line, placing it under local, operator control; the other is to reinitialize the control circuits after an unsuccessful load attempt, after a servo failure, or when some other undetermined state occurs in the control circuits.

CONTROL SIGNALS EXCHANGED WITH THE TAPE CONTROLLER

The following table lists the signals that are exchanged between the tape transport and the tape subsystem controller when the unit is On Line. The signal RUN initiates tape motion forward or backward at 75ips as selected by the signal: FORWARD/REVERSE. Tape motion at 75ips continues while RUN asserts. The select lines are decoded to select units 0 through 7, inclusive. For example, if SEL 1 and SEL 2 assert, then unit number "3" is indicated.

SIGNAL NAME	LOCATION AT THE BACK PANEL OF A DATA GENERAL COMPUTER (THE TAPE CONTROLLER SLOT)	LOCATION AT THE I/O CONNECTOR OF A DGC 6020 SERIES TRANSPORT
	MOTION CONTROL SIGNALS TO THE TRANSPORT	
RUN	A73	8
FWD/REV	B67	48
TC REWIND	B69	49
SEL 1	A75	1
SEL 2	A78	4
SEL 4	A79	19
	STATUS SIGNALS FROM THE TRANSPORT	
TUR (Unit READY)	B54	47
BOT	B53	46
EOT	B48	42
9 CH	A71	9
HI DENSITY	B49	43
REWINDING	B11	30
W.L. (Write Protected)	B36	39
	CLOCK AND COUNTER SIGNALS	
SEND CLOCK	A63	13
IRG	A47	17
DELAY 1	A81	20
	DATA WRITING SIGNALS	
WB (P thru 7) (9 lines)	A59(P); A87(0); A85(1); A89(2); A84(3); A91(4); A86(5); B34(6); A83(7);	15(P); 26(0); 24(1); 27(2); 21(3); 3(4); 23(5); 38(6); 22(7);
WRITE STROBE	A77	5
WRITE RESET	A57	16
WRITE T (Enable)	A61	14
	DATA READING SIGNALS	
RB (P thru 7) (9 lines)	B38(P); B31(0); B40(1); B25(2); B27(3); B13(4); B15(5); B19(6); B23(7);	40(P); 37(0); 41(1); 35(2); 36(3); 31(4); 32(5); 33(6); 34(7);
RD EN (Enable)	A76	6
READ STROBE	A49	18

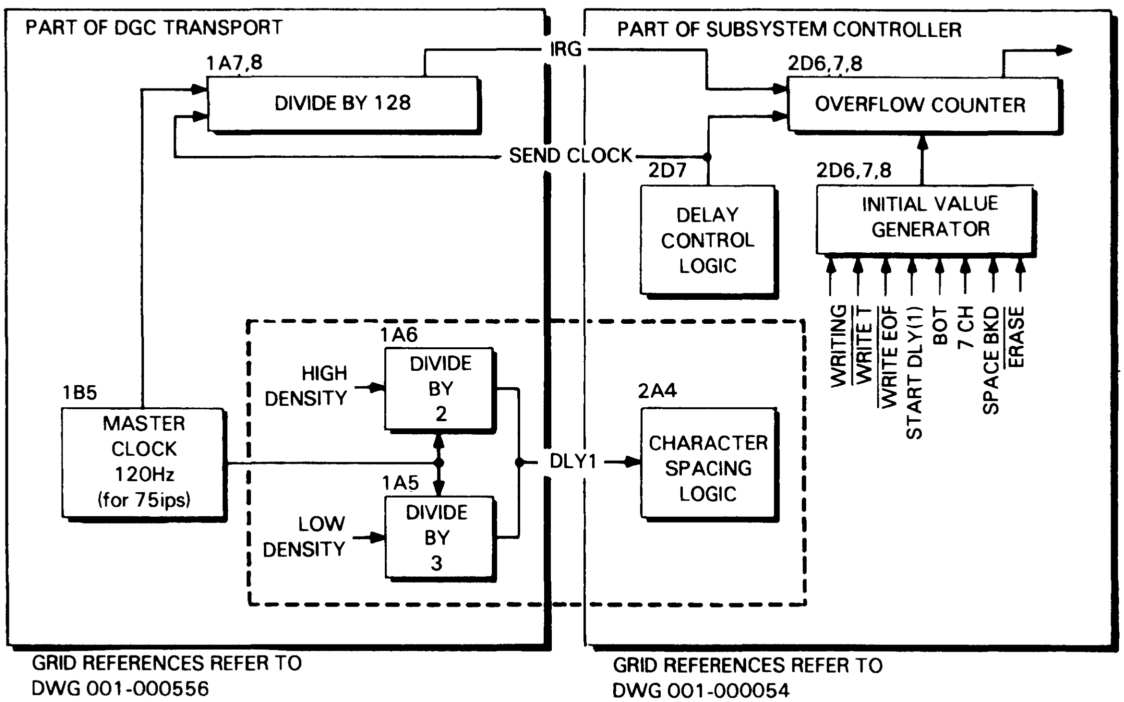
DG-01310

TRANSPORT AND SUBSYSTEM TIMING

A clock and counter scheme using components in both the transport and the controller provides basic timing for tape operations when the transport is operating under computer control. There are two timing networks: one provides timing signals to generate and correctly identify the Interrecord Gap (IRG) that separates adjacent data records on tape; the other provides timing signals for correct character spacing and formatting within a data record.

The timing circuits are divided between the controller and the transport so that transports with differing tape speeds, data densities and number of tracks can be connected in the same subsystem. The components which are indigenous to the operating characteristics of the transport are located in the transport; those that perform generalized functions in the timing chain are located in the controller and shared by all transports in the subsystem. The organization of the timing circuits and their location are shown below. The grid references for the controller logic refer to the schematic prints for DGC's tape subsystem controller (DGC No. 001-000054).

FRAME AND GAP TIMING



DG-01224

Start and Stop Delays

The functions of the delay generating network are threefold:

1. To delay the start of reading and writing operations while the transport accelerates to 75ips.
2. To control the length of tape to be erased at the end of a writing operation. The delay is calculated to include the distance traveled while the transport decelerates. This is one half the Interrecord Gap.
3. To control the length of tape to be erased during an erase command.

The delay network is activated at the start and end of every tape operation. The delay generated by the network is a function of the current operation, the transport parameters and whether the operation is beginning or ending.

The transport-resident portion of the delay network includes a divide by 128 counter and the transport's master clock which runs at a frequency determined by the tape speed of the transport. (For 75ips transports this frequency is 120kHz.) The controller-resident portion of the network includes an overflow counter that is initialized to give the desired delay interval at the time it overflows.

The controller asserts the signal SEND CLOCK to first clear and then enable the transport counter at the start and conclusion of each tape operation. This also initializes the overflow counter with the appropriate value. When the counter overflows, the delay interval is over; and the delay network is disabled. The controller then continues with appropriate action to implement or finish the current command.

Character Spacing

The functions of the character spacing signals are twofold:

1. To define the spacing between characters or "frames" on tape.
2. To define the format of a data record by inserting the necessary spacing for the error checking characters at the end of a data record.

The distance between centers of adjacent data frames on tape is a function of both the tape speed and the data density. The transport-resident portion of the frame interval timer is a free-running clock signal derived from the transport master clock. The frame-width signal has a frequency of 60kHz for 800bpi data density and 40kHz for 556bpi data density.

The controller-resident portion of the frame interval timer includes the logic circuits that clock data onto the tape during writing operations, as well as those that generate the end of record gaps (EOR Gaps). These gaps are three character-frames wide and they serve to separate the LPCC and the CRCC (9-track only) at the end of a data record. During reading and spacing operations, the interval signal is used to determine if a character is missing, and to identify the end of record gaps. (A more complete description of industry standard tape formats is included in the Data General *Programmer's Reference Manual for Peripherals* - DGC 015-000021.)

REFERENCES

DGC Prints:

001-000054
001-000508
001-000556

CHAPTER IV
DATA TRANSFER AND TRANSCRIPTION SYSTEMS

INTRODUCTION

Digital data is transferred from the computer memory via the Data Channel in sixteen bit words and written on magnetic tape in seven or nine parallel tracks. Data read from the tape is assembled into sixteen bit words and transferred to the computer memory. (When the transport transcribes data in seven tracks, four bits of the memory word are ignored during writing; these same bits are cleared to zero during reading.)

This section describes the circuits that receive data from the tape subsystem controller and transcribes it to tape; as well as those that read data from tape, and send it to the controller. The beginning of this section presents a brief review of data transcription principles.

REVIEW OF DATA TRANSCRIPTION PRINCIPLES

There have been numerous coding schemes contrived for transcribing data to and from magnetic media, but the NRZI * technique is perhaps the most commonly used method for multi-channel magnetic tape equipment operating in the low to medium density range. For data densities below about 1000 bits per inch (bpi), NRZI coding provides highly reliable data storage and retrieval yet requires relatively simple analog circuitry for the drivers and amplifiers associated with the read and write heads.

The 6020 series transports use the NRZI technique for recording data. In this technique, the bit value "1" is explicitly coded as a magnetic "event" or flux reversal, while the bit "0" is implicitly coded as the absence of a flux reversal. The following discussion is a simple introduction to a basic understanding of magnetic heads (both read and write) and the nature of digital magnetic recording.

Conceptually, reading and writing digital data on magnetic tape are straightforward processes; although to efficiently implement them is a sophisticated art. It is important to realize that the reading process is a transition-detecting process. The construction of the read head and the laws of physics dictate that the head can sense only the transitions between magnetic levels, not the levels that result from such transitions. This is directly analogous to the action of edge triggered logic commonly used throughout the digital industry (e.g., the clock input of a D-flip-flop). Consequently, the important considerations regarding the write head are those which directly relate to causing a magnetic transition-event at the read head.

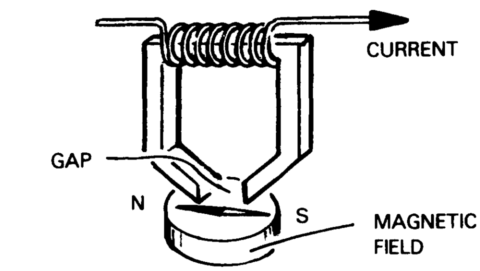
First consider how magnetic transitions are written on tape.

* NRZI is an acronym for Non Return to Zero for ones (I's); but this is of questionable importance even in an historical sense ...

Writing Data

The write head is an electromagnet shaped like the letter "C". Whenever current flows through the coil, a magnetic field is set up in the region named the gap. If the head or electromagnet were large enough, the direction of its field could be detected with a compass. The behavior of this imaginary compass illustrates how the field in a head behaves.

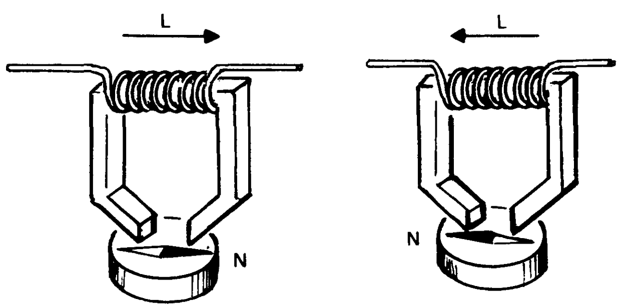
WRITE HEAD



DG-01263

If the compass were placed in the gap while current was flowing through the coil, the compass would orient itself across the gap with its North pointer directed toward one side of the gap. Now, if the current in the coil is reversed, the compass would suddenly swing around with "north" pointing to the opposite direction. This is because the direction of the magnetic field across the gap depends on the direction of current in the magnetizing coil.

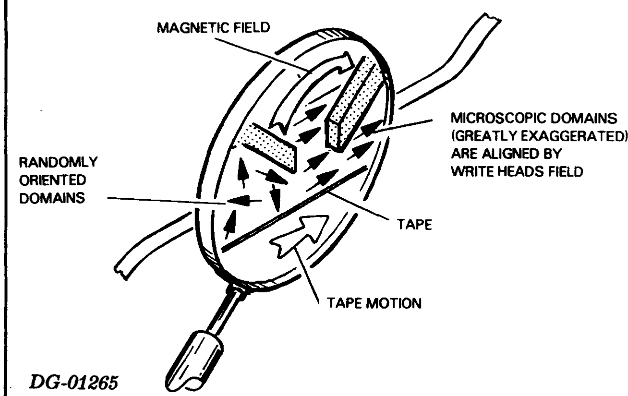
CURRENT REVERSED



DG-01264

The recording surface of magnetic tape is a thin layer of magnetic particles that behave like tiny compasses. Clusters of these particles, called domains, will tend to align with a strong magnetic field, and remain so aligned, indefinitely, after the field is removed. (Of course a subsequent field can realign the position of these magnetic domains.)

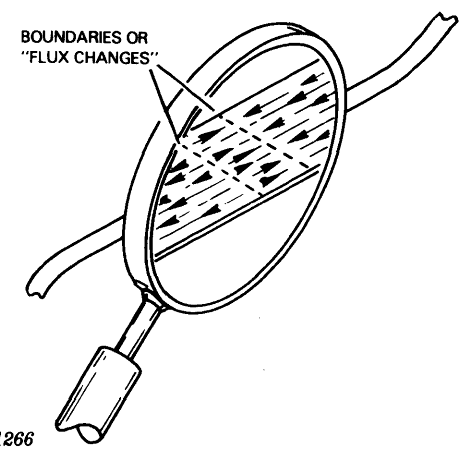
RANDOM DOMAINS



DG-01265

As tape moves over the write head, the domains align themselves with the magnetic field as they pass across the gap. Each time the write current reverses, the resultant field will reverse and a boundary will be produced on tape with the domains on either side of the boundary pointing in opposite directions. The boundary is often called a flux reversal.

ALIGNED DOMAINS



DG-01266

This flux reversal is the magnetic "event" which translates to a bit value of 1 whenever it is detected by the read head. For the bit value 0, the write current drivers do not reverse the current through the write head; no flux reversal is recorded on tape; and consequently, no electrical pulses are produced by the read head when that section of tape is read.

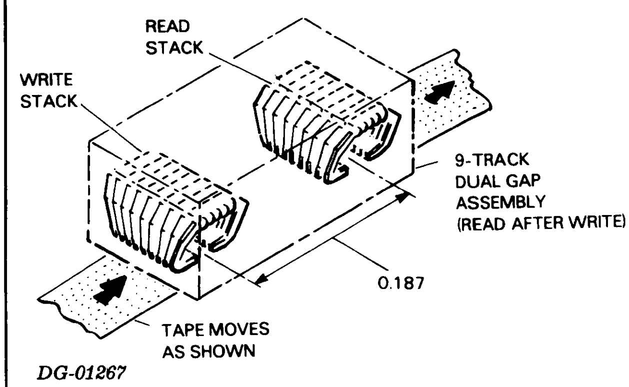
Reading Data

The read head is made just like the write head except the coil is connected to an amplifier instead of a current driver. A low amplitude pulse is produced by the read head whenever a flux reversal recorded on tape crosses the gap. The amplified pulses are interpreted as the binary value of 1.

It is possible to use the same "electromagnet" for both reading and writing by switching coil connections between a current driver and an amplifier to first write and then read the tape. If, however, separate heads are used, with the read head positioned "downstream" from the write head, data can be verified almost immediately, as it is written, without having to back up the tape to reread that section. This capability is called "read after write" or "dual gap" and is standard with Data General magnetic tape equipment.

In practice, the read and write heads are quite small, and positioned 0.187 inches apart. Seven or nine read after write heads are stacked side by side to provide multi-track recording.

DUAL GAP



DG-01267

IV

TERMINOLOGY CONVENTIONS

The terms "bit", "byte", "character", and "record" are described below to perhaps reduce industry-wide ambiguity in their use. These descriptions conform with the most generally accepted common usage.

Bits

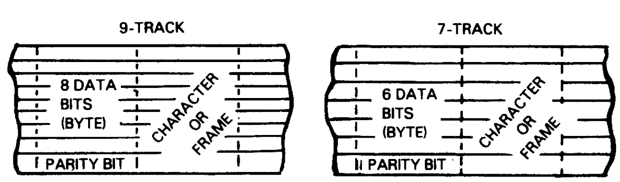
Data is stored as a "magnetic event" on the tape by the write head in the transport. As the tape moves past the write head, a sequence of data bits are written along the length of the tape. The number of data bits per inch (bpi) determines the data density for that transport. 6020 series transports can be selected to operate at two densities, 800bpi and 556bpi.

Industry compatible tape transports contain either 7 or 9 write heads, allowing simultaneous recording of a number of parallel tracks along the length of the tape. The data bits written simultaneously by a number of heads, one bit in each track, define a character on the tape. Each character, therefore, appears across the width of the tape.

Characters and Bytes

A character is generally composed of a number of data bits and one parity bit. The data bits in a character are collectively called a byte. Seven track magnetic tape contains a 6-bit byte of data and a parity bit in each character; nine track tape contains an 8-bit byte of data and a parity bit.

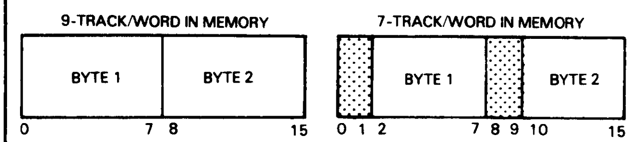
MAGNETIC TAPES



DG-00975

Since DGC computers utilize a 16-bit word length, two bytes from the tape form one computer word as shown below. When a 9-track tape is used, the two 8-bit bytes fill one computer word. However, 7-track tapes provide only 12 data bits for each computer word. The remaining four bits are ignored during data transfers between tape and memory. This means that all the 16-bit data words have to be reformatted when writing a 7-track tape to avoid losing the contents of those four bits.

DATA TRANSFER

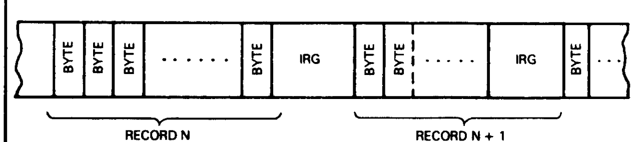


DG-00976

Records or Blocks

Because the amount of data stored on magnetic tape usually contains several related computer words, the pairs of bytes on the tape for each word are grouped together to form records. Successive records are separated from each other by gaps on the tape. The tape transport can only stop the tape in one of these interrecord gaps (IRG). The record is the smallest possible unit of addressable information on the tape.

RECORDS

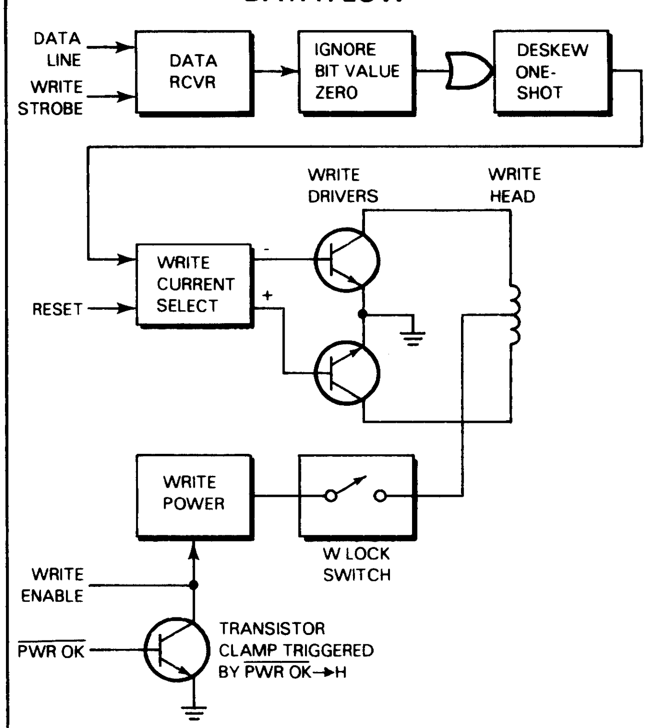


DG-00977

DATA WRITING PATH

The data writing path consists of a nine bit wide data bus receiver (character plus parity), a deskew register and the write current drivers. Data flows from left to right in the simple diagram shown below. Only one channel is shown.

DATA FLOW



DG-01268

Data Receivers and Write Drivers

The data lines are sampled on the leading edge of the data strobing signal from the controller. In channels where the data bit value is 1, the current through the write head will reverse (in accordance with the NRZI technique) and a flux reversal will be recorded on tape. In order to ensure that the flux reversal on tape will be as sharp as possible (to reduce spurious noise), the write current drivers operate at 50mA, or 150% of the write head saturation current.

When power is first turned on at the transport, the current drivers are initialized to a specific current direction (even though the windings are not actually energized until a writing operation occurs). This initial condition can be arbitrarily called the plus (+) current direction with the resulting magnetic field on the tape being called +O. The reversed current and field are then called - and +O, respectively.

At the conclusion of a data transfer to tape, any number of the write windings may be in the negative or reversed condition, depending whether the number of flux reversals recorded in that track was odd or even. All of the windings are forced back to the initial, or positive, current direction when the write reset signal from the tape controller asserts.

The flux reversal resulting from any write winding going from negative to positive on the write reset strobe is recorded on tape. Since resetting the write channels means that the number of flux reversals in every track must be an even number, the character recorded is a parity character with each bit completing an even parity condition for its track. This character is often called the longitudinal parity check character or LPCC.

In keeping with industry-wide formats for both 7- and 9-track data recording, the tape controller sends the reset signal to write the LPCC on tape as the last character of a data record, separated by three character-periods from the previous character. (A complete description of 7- and 9-track data formats is included in Section S of the tape subsystem Technical Reference DGC No. 014-000055 and in the *Peripherals Programming Reference Manual* DGC No. 015-000021.)

IV

Deskew Register (Static Deskew)

Ideally, the nine (or seven) individual segments in the write head are aligned in a straight line perpendicular to the tape, so that data characters are written without skew. In practice, manufacturing tolerances preclude such ideal heads, and a small but perceptible skew pattern is usually present. An adjustable monostable multivibrator (or "one shot") in each channel can be used to insert short delays, where appropriate, to compensate for the static skew of the head.

While the leading edge of the write strobe signal clocks the data character transferred between the tape controller and the transport, the trailing edge of the deskew one shot initiates the start of a current-reversal in a write head. The effects of static or geometric skew on the write head can be nearly eliminated, so that the data character is written on tape in a straight line across the tape.

The write deskew register is adjusted using a master skew tape, which is a precision standard, recorded using special equipment. A master skew tape contains successive frames of flux reversals, or ones, written perpendicularly across the tape without skew, and with precise timing or spacing between frames. Master skew tapes of exceptional quality are available from several manufacturers.

Write Protection

The transport is equipped with write protection facilities that are controlled by the position of its write lock sensing pin, located behind the supply tape reel near its hub. A groove is molded on the back of most reels of computer-grade tape, and a plastic ring called an enabling ring can be inserted into that groove. When the ring is removed, the transport is write protected and data cannot be written. The write lock sensing pin checks whether or not an enabling ring is present on a tape reel. The write lock sensing pin and its companion assembly are described in Chapter II.

At the circuit level, write protection means that dc power is not supplied to the write drivers (an opened switch physically disconnects the write power supply line) and the signal W.L. asserts to notify the subsystem controller that the transport is write protected.

The heads are disconnected from their dc supply voltage whenever the sensing pin extends into the write lock groove of a tape supply reel. When a write protected reel is mounted on the transport, even a failure in the write circuits cannot destroy data. The solenoid is de-energized and releases the sensing pin whenever the vacuum columns are turned off so that the presence of an enabling ring is always checked at the beginning of a tape loading operation.

Write Current Ground Isolation

DC ground for the write drivers is kept strictly isolated from other dc ground on the read/write circuit board. The return path is cabled directly back to the power supply and connected with dc common ground at one and only one point. (The capstan motor's return line is similarly isolated.) This is consistent with good practice in analog circuit design: to eliminate ground-loop and noise interaction that could be caused by a shared, distributed, grounding system.

Write Disabling on Failing Power

In later units, the write circuits incorporate an additional feature to protect the transport from writing faulty data during a power failure. A transistor clamp circuit immediately disables the signal WRITE EN, effectively shutting off the write current drivers. The clamp circuit is activated by the signal PWR OK which goes false several milliseconds before the transport circuit performance can degrade during failing power. The "early" shut down of the write drivers prevents them from glitching unreliable data to tape during power failure.

DATA READING PATH

Flux reversal pulses detected by the read head are first amplified by a two stage analog amplifier, then rectified and amplified again. A delay line network in conjunction with a threshold detection network converts the analog pulses to TTL logic levels. A data register and bus line drivers send the data values to the tape subsystem controller along with appropriate synchronizing signals.

Analog Amplifier

Analog signals from the center tapped read windings are presented to a differential analog amplifier and then to a second, single-ended, analog amplifier. Flux reversal pulses from the head windings are 10mV (+10%) single-ended, or 20mV, peak to peak.

A trimpot in the feedback loop of the second stage provides gain adjustment for each head amplifier. Gain is normally adjusted to provide 5.0V, positive-going, pulses at test points further along the read chain.

The Full Wave Rectifier

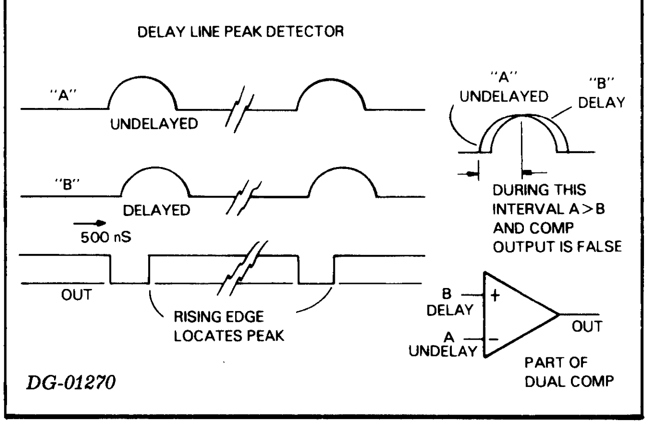
The flux reversal pulses from the read windings are bipolar, and depend whether the write current that wrote the flux change went from +0 to -0 or from -0 to +0. A full wave rectifier converts all the data pulses to positive-going pulses, which are amplified again through a low gain differential amplifier and then a common emitter transistor amplifier. A test point (at the transistor emitter) in each read chain provides for convenient gain monitoring and adjustment. Correct adjustment of the signal amplitude at each test point ensures that the proper clipping levels will be obtained in the threshold detection circuit.

Delay Line Peak Detector

The timing diagram below shows how the delay line is used in conjunction with the clipping network to convert analog read pulses to binary logic levels. The signal from the transistor amplifier is presented to the reference network of a voltage comparator, and also through a 400ns delay line to the sense input of the same comparator. Four hundred nanoseconds after the signal to the reference input peaks, the delay comparator will switch to its true state since the delayed signal at that point in time will be greater than the undelayed signal. The delay comparator remains asserted until the next data pulse arrives.

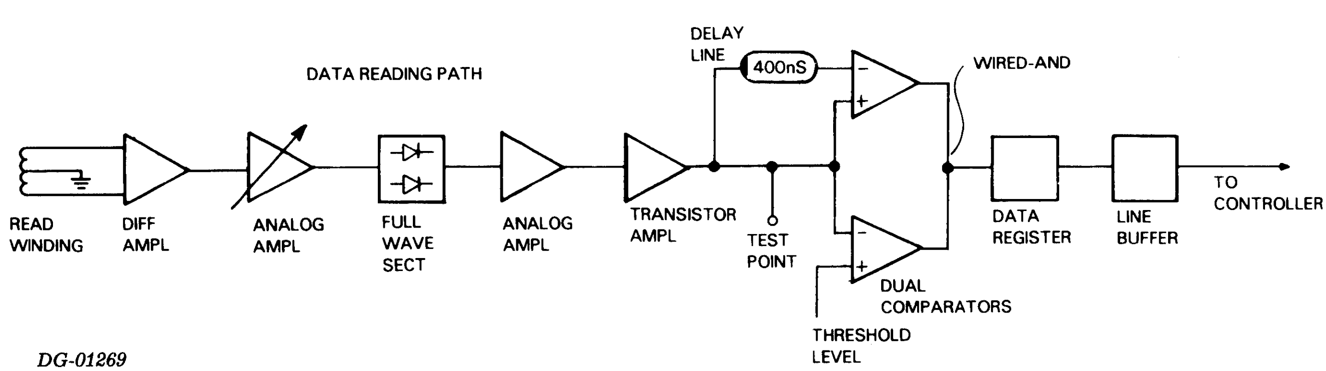
The delay comparator is internally connected in a wired-AND configuration with another comparator, the threshold comparator. The reference input of the threshold comparator is connected to a selectable threshold signal and the sense input is connected to the undelayed analog read signal. As a result, the dual comparator's output signal asserts only when two conditions are met: a) the amplified signal from the read head has reached its peak level and b) its amplitude is greater than the selected threshold level.

DELAY LINE TIMING DIAGRAM



DG-01270

FLUX PULSE PATH



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IV

Threshold Selection

The threshold reference voltage applied to the threshold comparator can be one of three values. Two of the values are used only during data reading operations; the other value is used only during writing. The read thresholds are operator-selectable using a small toggle switch inside the transport. The read thresholds (normal: 1.25V; and low clip: 0.75V) represent clipping levels of about 25 and 15 percent, respectively, of the analog signal from the read head. The write threshold (2.0V) gives 40 percent clipping.

NOTE *The threshold voltages are fixed and determined by a resistive network; the clipping value (in percent) is stated relative to the amplitude of the analog read signal. Accurate clipping levels are obtained only when the read amplifiers have been adjusted to 5.0V amplitude at the read test pads for each track.*

While the normal level is adequate for noise rejection and signal detection in most reading operations with computer-quality tape, the low clip level provides greater sensitivity for reading tapes with poor signal quality or those which have been damaged. However, the low clip level should not be used for routine tape operations since it provides less noise protection and might degrade overall tape subsystem performance.

A third threshold level, 2.0 volts, is automatically selected while writing to allow read after write data verification. This level represents 40 percent clipping of the read signal. A high clipping level provides a more stringent verification of data being written than would the reading levels. It ensures that a strong flux reversal signal has been written on tape.

Data Register and Line Drivers

When a bit value of "1" is detected in any track during reading, writing, or spacing, the value "1" is loaded into the appropriate cell of the transport data register. The bit values of all cells in this register are placed on the data reading lines, RD P,0-7, which connect with the tape subsystem controller.

When the leading "1" for a character is detected in any track, a delay timer is activated whose duration is one-half a data character time appropriate to the selected data density (800bpi or 556bpi).

This delay provides a "window" with enough time for all the bits of a character to be detected, and for the data register and bus lines to settle. A 1μs (microsecond) strobing signal then transfers data to the controller. Finally, the trailing edge of the strobe signals clears the transport data register and prepares it for the next character to be detected.

NOTES *Since all NRZI timing is determined by successfully detecting at least one 1 in each frame on tape, some care must be taken to assure that an all zeros character is not written on tape. The odd parity condition on standard 9-track format assures at least one 1 in every character. However, since no such safeguard exists when using even parity with 7-track recording, that data should be checked for null characters.*

Data General's 4030 and 6020 series tape subsystem controllers require that at least three characters be read during a reading, writing or spacing operation. This guards the subsystem from reading spurious noise signals and trying to interpret them as data. At least two 16-bit words should be written (4 characters) using Data General equipment. Tape records written on other equipment must contain at least three characters to be read.

Erase Function

A full width, noncontact erase head is positioned "upstream" from the read after write head. The erase head is energized during all writing and erasing operations. The erase head is disabled whenever the write lock sensing pin is activated. The erase current is 50mA, or 150% of the saturation current for the erase winding. This value of erase current gives -40dB erasure, minimum, as tape passes near the energized erase head. The tape does not touch the erase head, but passes within 0.003 to 0.005 inches of it.

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No. 001-000556

CHAPTER V
ANALOG AND SERVO FUNCTIONS

INTRODUCTION

There are several self-contained electromechanical systems within the tape transport that use analog signals. As such, they present different operating principles than those that relate to most digital logic circuits. These analog systems include the capstan servo system and two vacuum column, tape reel servos. (There are two independent reel systems, one for each column and reel pair.) This chapter describes these analog systems. It also describes a small section of the transport's digital control logic that monitors the servos' operation. These logic circuits form an interlock, or failsafe, system that protects the tape from damage if there is a servo failure. The circuits that transcribe data to and from magnetic tape also use analog signals; they are discussed in Chapter IV.

The first part of this chapter will present some basic principles of servo systems and of the analog circuits used to realize them. The operation of the failsafe system is then presented, followed by detailed descriptions of the reel servos and the capstan servo.

WHAT IS A SERVO?

A servo is any closed-loop, electromechanical, feedback control system. The most important characteristic of a servo is its ability to measure some condition, determine the variation or "error" of that condition from what is desired, and then take the necessary action to reduce the error. All servos contain four basic elements in one form or another.

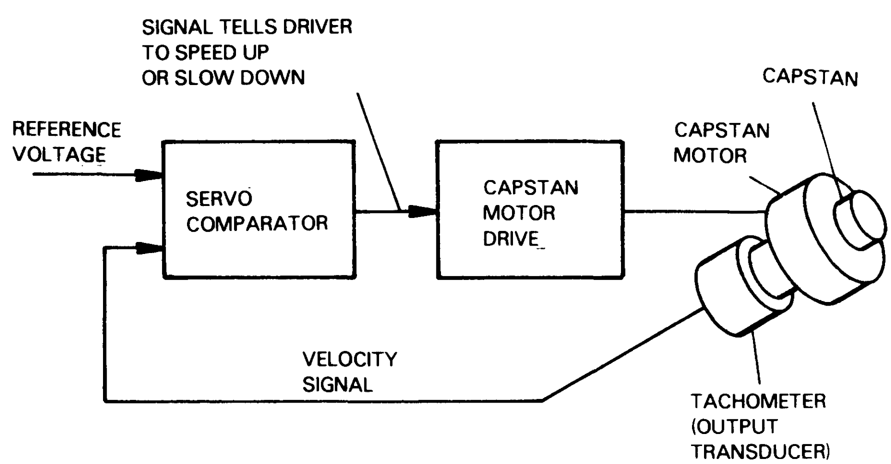
- A reference input that defines the desired output
- An output sensor
- A method for comparing the output with what is desired
- An actuator or driver which changes the output

For instance, the capstan is controlled by a servo. The simplified block drawing below shows how the four basic elements of a servo work together to control the capstan speed.

Power to rotate the capstan is provided by the driver circuit. A tachometer connected to that motor produces an analog signal that is proportional to how fast the capstan is spinning. This analog signal is compared to a reference input that represents the desired capstan speed. By comparing these two voltages, it can be determined if the capstan is spinning at the correct speed, or whether it's running faster or slower than desired.

If the measured speed is too high, the capstan driving circuit supplies less power and the capstan slows down. If the measured speed is too low, more power is provided to speed the capstan up. The servo continually measures the output speed and continually corrects the current supplied to the motor to maintain precise speed.

GENERALIZED SERVO



DG-01225

OPERATIONAL AMPLIFIERS AS ANALOG BUILDING BLOCKS

The operational amplifiers used in the 6020 series transport servo systems control certain mechanical systems by performing electrical analogs of mathematical operations like addition, inversion, integration, differentiation, and scalar multiplication. Each of these functions can be implemented by connecting an "ideal" operational amplifier in a unique configuration. This provides a set of building blocks with each circuit representing a single mathematical function.

Ideal Operational Amplifier

The symbol for the ideal operational amplifier is a triangle, pointing to the right to conform with the commonly accepted direction of causality flow.

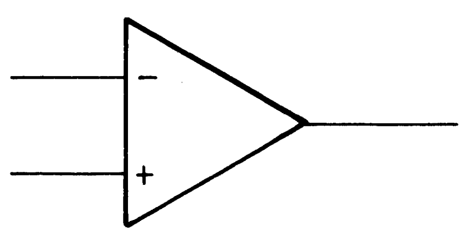
The gain of this amplifier is extremely high and its output signal will quickly reach a maximum (saturate) when there is merely a few millivolts or so difference between the input terminals (- and +).

Yet, the amplifier can be connected in certain configurations where:

a) the allowable input signal is not restricted to an amplitude of a few millivolts maximum, and

b) the amplifier circuit performs the mathematical functions scalar multiplication, differentiation, integration, and summation.

OPERATIONAL AMPLIFIER



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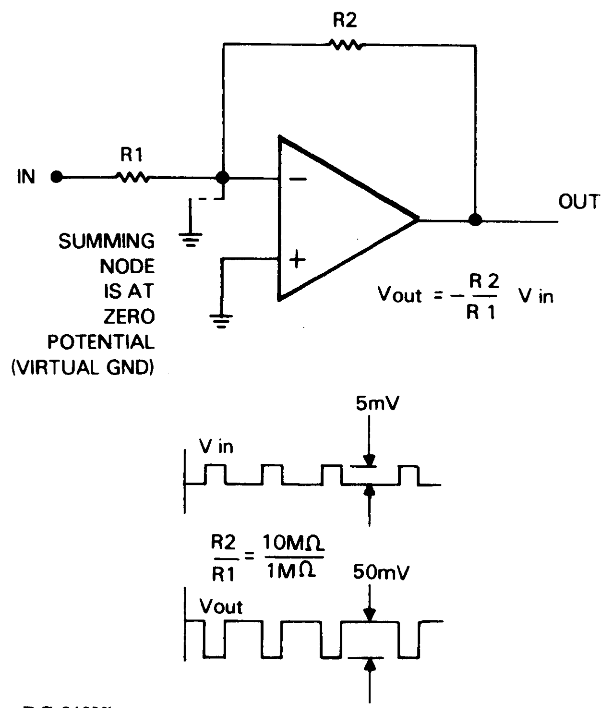
Scalar Multiplier

An operational amplifier can be connected to multiply a given input voltage by a constant scale factor. The output is usually inverted from the input signal. The inverting multiplier looks like this:

INVERTING MULTIPLIER



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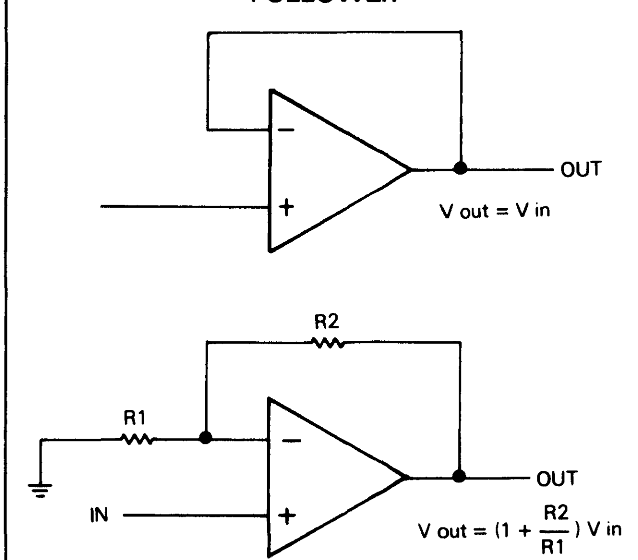
In this case, the gain is given by -R2/R1. If R2 is 10 megohm, and R1 is 1 megohm, and the input signal to the scalar is a series of positive pulses 5mV in amplitude, the output would be negative pulses of 50mV amplitude.

The summing node is shown at virtual ground only because the voltage between the two inputs of an operational amplifier must be very nearly zero to prevent the amplifier from saturating. In this case, the noninverting (+) input is grounded. (If the noninverting input (+) were held at 2 volts, the inverting node (-) would be 2 volts also.)

Followers

A noninverting version of the scalar multiplier, called a follower, can be used for isolating various amplifier stages and for drivers. There are two versions of the follower, the gain-of-one follower, and the follower-with-gain. This drawing shows how the followers are formed.

FOLLOWER



DG-01228

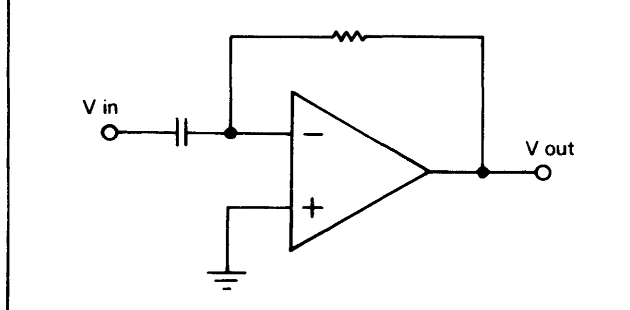
An important characteristic of the unity gain follower is that the output signal is independent of the values of input series resistors. (In the scalar amplifier, the input resistance and its component tolerance directly affect the output signal.) This characteristic makes the follower useful as an inexpensive, and precise, isolation or driver amplifier that doesn't require precision components.

This independence from input series resistance is equally true for followers constructed around a single operational amplifier as well as for ensembles of operational amplifiers which, as a group, behave like a follower. (An example of such an ensemble is the 75ips ramp generator in the capstan servo.)

Differentiator

One of the analog building blocks performs the mathematical function differentiation. Differentiation of a signal yields a value that represents how fast that signal is changing. The differentiator is shown below.

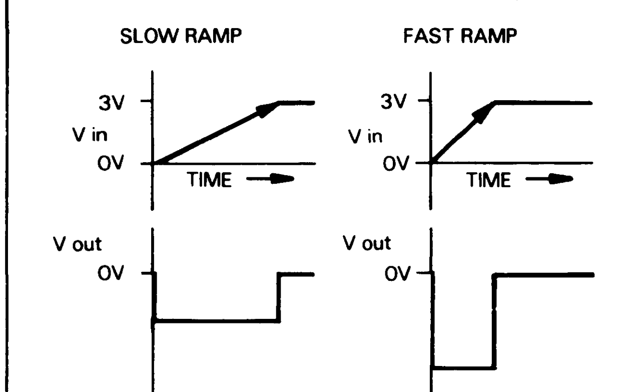
DIFFERENTIATOR



DG-01229

The waveforms below show how the differentiator's output might change for two similar (zero to three volt) voltage ramps that differ in rise time.

DIFFERENTIATOR WAVEFORMS



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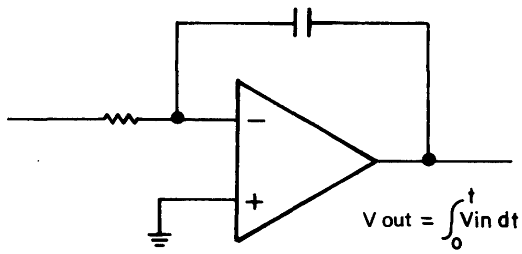
Integrator

Another "building" block in the operational amplifier family used for analog functions is the integrator. In this configuration, too, the output is inverted with respect to input. The basic form of the integrator is this:

INTEGRATOR



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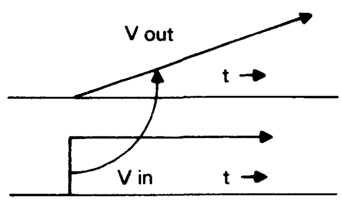
Assuming, for the moment, that the output voltage of this circuit is initially 0 volts, the output of the integrator for a constant voltage input looks like this:

INTEGRATOR WAVEFORMS



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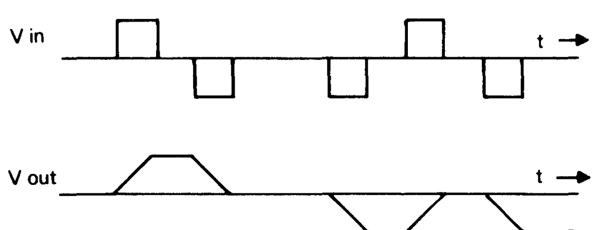
And if the input signal is a square wave, the output of the integrator looks like this:

INTEGRATOR WAVEFORMS



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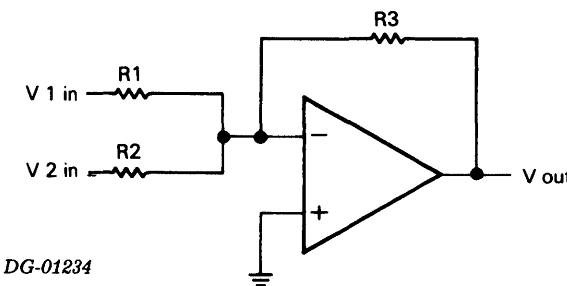
Summing Amplifier

The analog building blocks may have several inputs connected in parallel to the summing node. Each signal must be applied through its own input component (usually a resistor, but it may be a capacitor). The output signal of an amplifier with several input signals is the sum of the output signals that would occur for each input signal considered alone. Any analog building block with multiple, parallel inputs, is a summing amplifier.

For example, this scalar multiplier has two inputs:

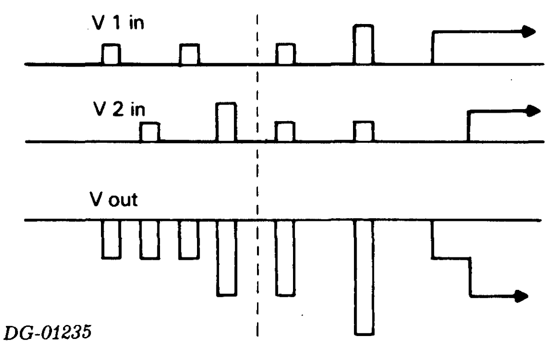
SUMMING AMPLIFIER



DG-01234

The waveforms below show what the output signal for this amplifier would be for the input signals shown. To the left of the vertical dashed line, one input signal is always zero so that the output for each input can be seen. To the right of the dashed line the input signals occur simultaneously and the combined output signal is shown accordingly.

SUMMING AMPLIFIER WAVEFORMS



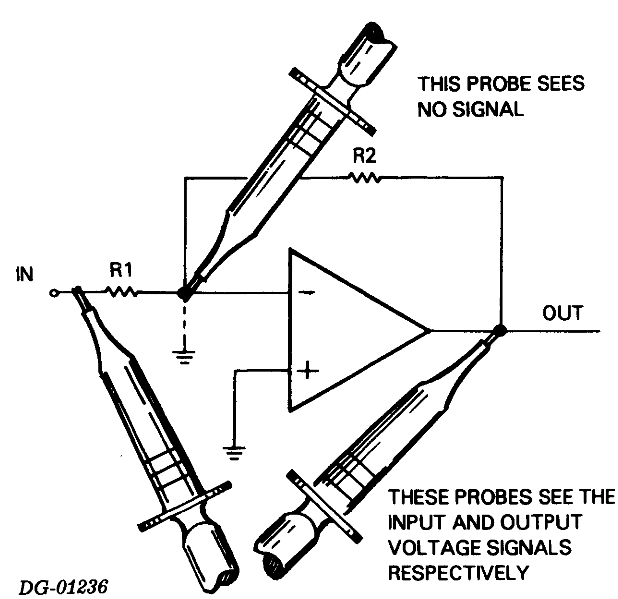
DG-01235

IMPORTANT CONSIDERATIONS

There are certain important considerations that apply to operational amplifier circuits:

1. The input node (sometimes called the summing node) of any of the operational amplifiers described here is, by necessity, at very nearly the same potential as the noninverting (+) terminal. In many cases the amplifier is connected single-ended, that is, with the noninverting input (+) grounded. (For example, the oscilloscope probe connected to the summing node in the example below would show negligible voltage at that point.) However, the virtual ground, when shown in a drawing, implies an OPERATING constraint and NOT an actual electrical connection.

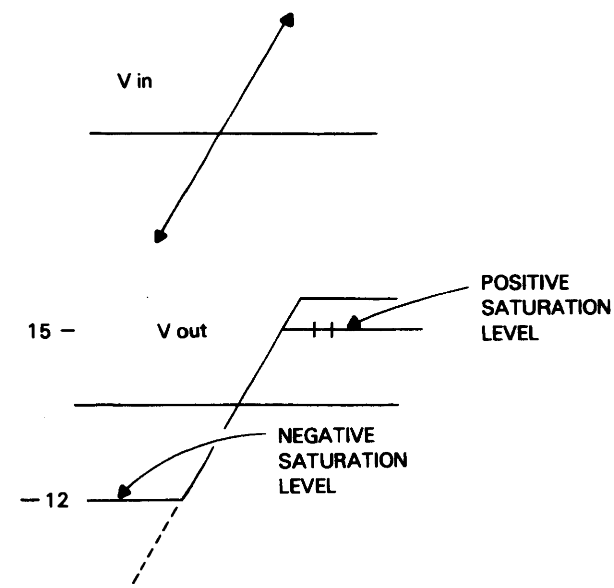
VIRTUAL GROUND



DG-01236

2. The output signal of an operational amplifier cannot exceed a saturation value. That value usually approximates the supply voltage from which the amplifier operates. (For example, an amplifier connected to +15Vdc and to -12Vdc will follow its predicted output response only in the range from -12 to +15 volts, as shown below.)

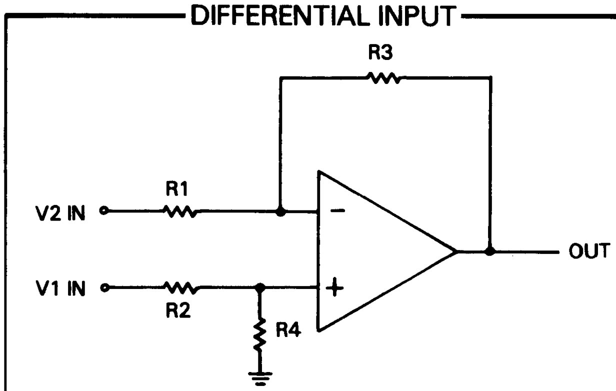
AMPLIFIER SATURATION



DG-01237

3. Input signals to all of the building blocks described to here have been shown single-ended, that is, the input and output signals have all been stated relative to ground, or zero volts. It is possible and often useful to combine the use of the noninverting and the inverting inputs of an amplifier to perform a mathematical function on a signal not referred to ground. (The differential input is particularly well suited for minimizing the effects of spurious pickup in cables.) A building block with differential input is shown below; it is basically an inverting multiplier and a noninverting amplifier combined in one circuit.

DIFFERENTIAL INPUT



WHEN R1 = R2 AND R3 = R4, THEN;
V OUT = R3/R1 (V2-V1).

DG-01238

AMPLIFIER STABILITY

Analog circuits can become unstable under certain conditions. The analog blocks previously described use feedback signals to realize their mathematical functions, and control of that feedback is necessary to preserve the amplifier's stability. The irritating, ear-piercing, squeal that often occurs in public address systems is an example of what can happen when feedback becomes uncontrolled.

While the descriptions of the various analog building blocks presented in the previous sections are sound, they do not reflect the difficulties encountered when such a circuit is built using real components. There are two areas where departures from the simplified descriptions can - and often do - cause instabilities. These areas are:

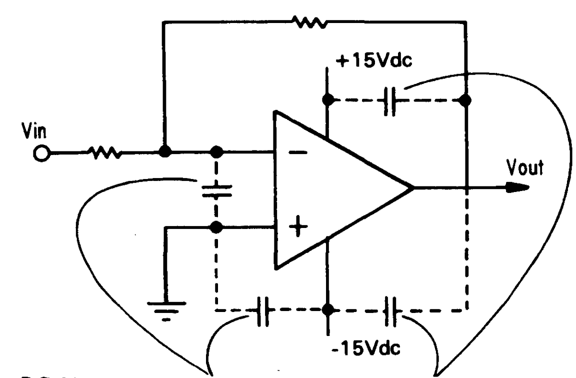
1. The environment: The circuits described do not show the small amount of capacitive pickup that always exists between the etched conductors (including power leads) on a printed circuit board.
2. Inside the integrated operational amplifier chip: There is no "ideal" operational amplifier. Manufacturers usually design such amplifiers for general purpose applications. These amplifiers are optimized to approach "ideal" operation only over a certain range of signal conditions.

Compensation techniques are available to prevent feedback instabilities from originating in either of these two areas. External compensation reduces the likelihood of instabilities arising in an amplifier because of stray pickup in the circuit environment. Internal compensation matches the integrated circuit's "ideal" range most closely with the signal conditions of the servo.

External Compensation

Stray capacitance among the etched conductors on a printed circuit board can effect circuit performance by coupling part of the output signal of an amplifier back to the noninverting input (+) of the same amplifier. If at any frequency, the amount of stray coupling to the noninverting input exceeds the feedback to the inverting (-) input, the amplifier will oscillate or ring. This illustration shows some possible paths of capacitive pickup in a typical analog block. Clearly, the magnitude of the capacitively-coupled signal through any stray pickup path increases with frequency. For this reason, amplifier instability is usually recognized as spurious ringing.

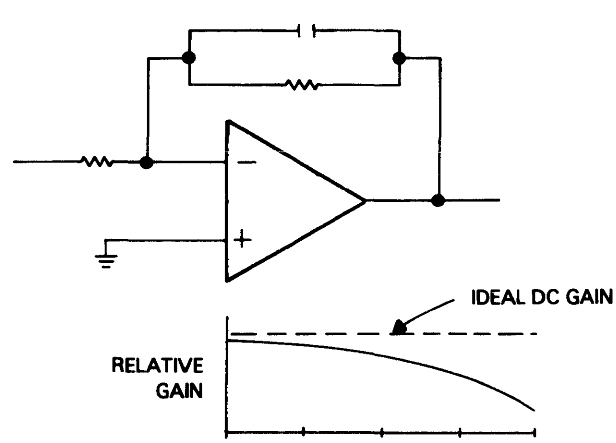
STRAY CAPACITANCE



DG-01239

External compensation consists, therefore, of increasing the coupling for high frequency signals to the inverting input so that it will always dominate the positive feedback that may be spuriously coupled to the noninverting (+) input. This can easily be done by adding a high pass filter in the negative feedback loop of the multiplying, differentiating, and summing blocks. (In effect, the high pass filter already exists in an integrator.) A side effect of this compensation is somewhat reduced gain at high frequency, but this is usually ignored.

COMPENSATED AMPLIFIER



DG-01240

V

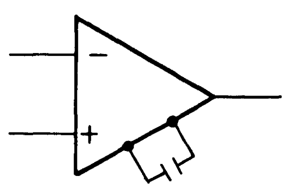
Internal Compensation

A pair of terminals are provided on most integrated operational amplifiers for compensating internally-caused instability. General purpose integrated operational amplifiers consist of several micro circuit amplifiers, internally connected so that the overall amplifier performance best approaches the ideal operational amplifier described in the previous section.

These internal connections can cause instability under certain operating configurations. The special terminals allow a compensating network or component to be added that optimizes the operation of the amplifier for the configuration in which it is being used. However, for the analog building blocks discussed here, a single capacitor, usually about 33pF, provides adequate compensation.

The value and tolerance of compensation components are important to the stability of analog circuits. Occasionally, servo failures can be traced to a compensating component whose value has shifted outside its specified tolerances.

AMPLIFIER COMPENSATION

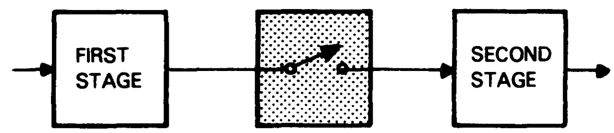


DG-01241

ANALOG SWITCHES

While the transistor can often be used as a switch, two special semiconductor devices provide superior switching for handling analog signals. These devices are the P-channel and the N-channel Field Effect Transistors (FET's) or analog switches. Analog switches are used in the transport failsafe system to disable the servo systems when a failure in the system is detected. The switch acts like this:

ANALOG SWITCH



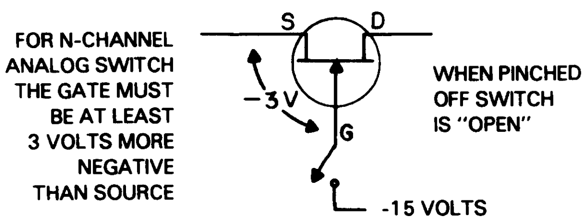
DG-01242

When the switch is open, the signal from the first stage is disconnected from the input to the second stage.

N-Channel Analog Switch

The important parameter in the N-channel analog switch is the "pinch-off" voltage. This is the minimum voltage that must be applied between the source and gate terminals of the FET to force the switch fully OFF, as shown below.

N-CHANNEL ANALOG SWITCH



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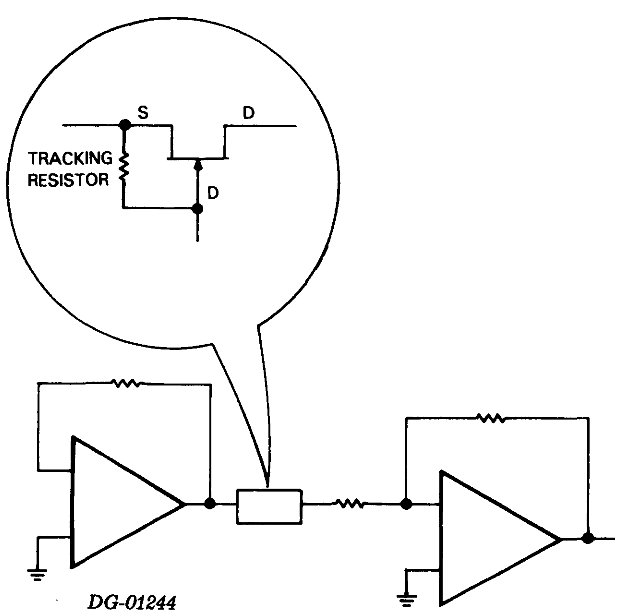
The analog switch is fully on whenever the voltage from source to gate is 0 volts (or some more negative voltage). When that voltage swings into an intermediate range (i.e., between 0 and 3V), the switch is in an indeterminate state which generally varies from device to device. A reference resistor (like a pull-up resistor in open collector logic circuits) is often used to force the switch's gate to track with its source. The tracking resistor forces the source-gate voltage to remain at precisely zero volts whenever the gate's driving circuit is not forcing the switch fully off.

N-CHANNEL SWITCH



DG-01244

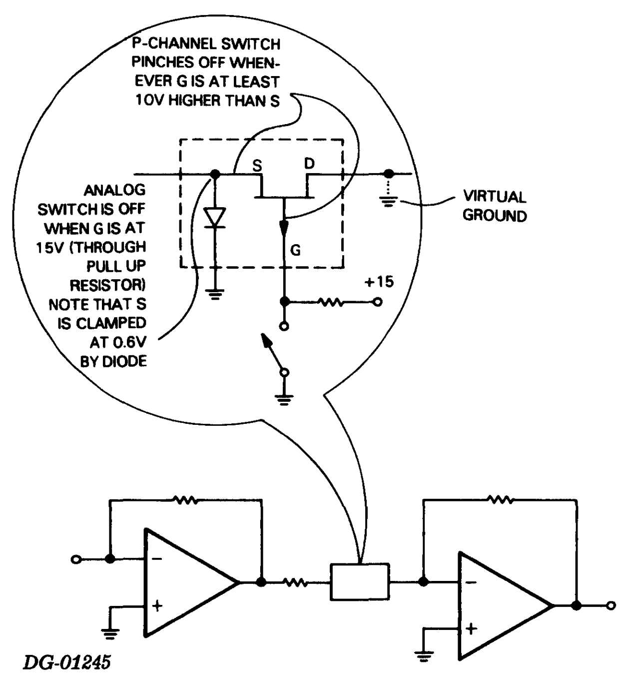
P-Channel Analog Switch

The equivalent pinch-off voltage in P-channel analog switches is on the order of 10 volts. Because of their polarity requirements, they are ideally suited for use with TTL logic circuits since they can be driven directly by a single open collector gate. The commonly used four terminal package is shown below.

The virtual ground shown at the inverting (-) input of the figure above is a reminder that, in this example, the summing node is at nearly zero potential. The switch in this example will be forced fully off whenever the gate terminal is held at a positive voltage greater than pinch-off. (+15V is usually convenient.) In this state, any positive-going signal from the previous stage will be grounded through the input diode and any negative-going signal will simply pinch the switch off even harder.

However, when the open collector driver forces the switch's gate to zero volts, the switch will be fully on. All of the terminals of the switch will remain near zero volts because the switch is at the summing node of the single-ended amplifier.

P-CHANNEL SWITCH



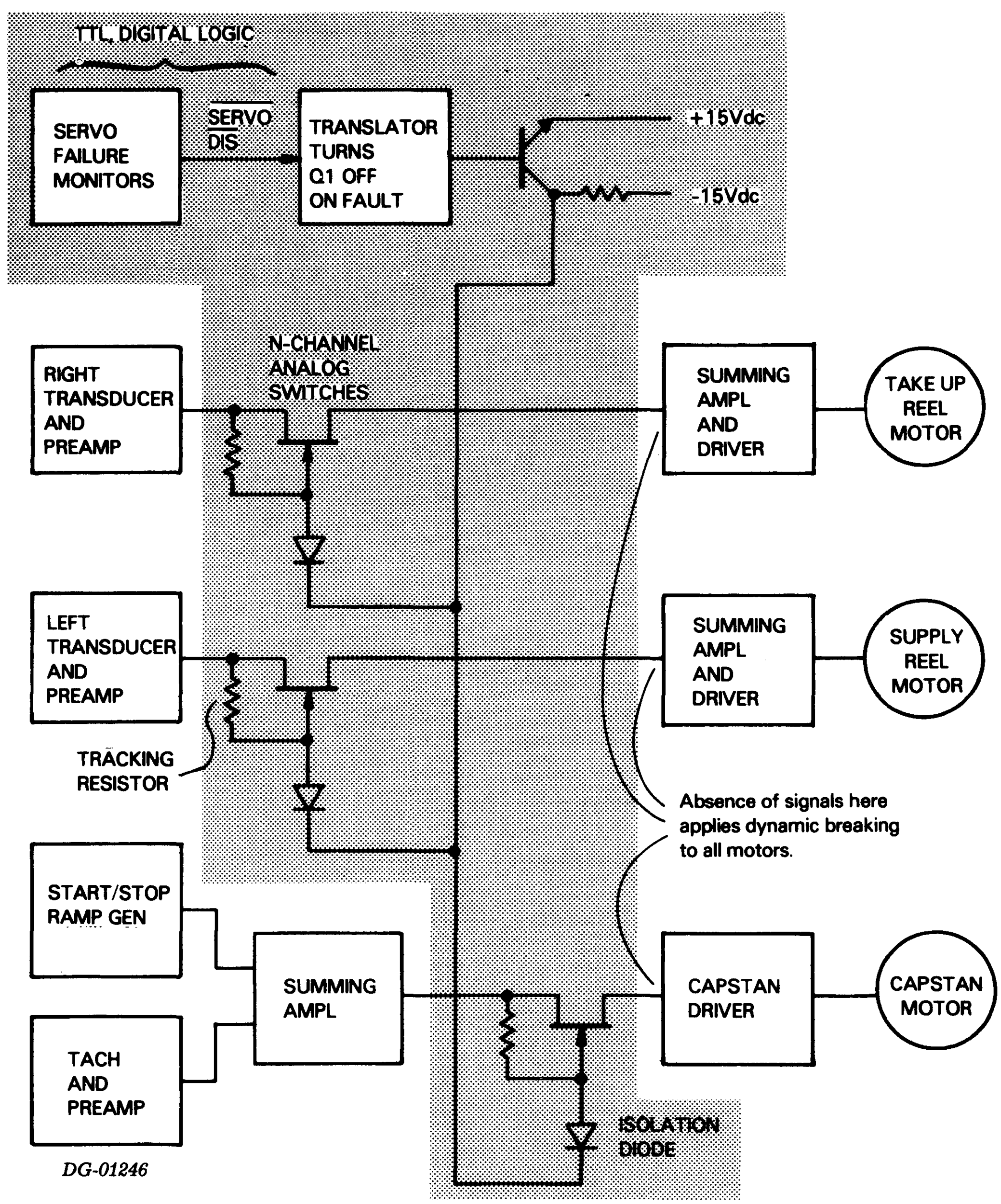
DG-01245

V

SERVO DISABLING INTERLOCKS

The transport servo interlocks monitor certain parameters in the servo systems and, in the event of a failure, they affect an orderly shut down of the systems in a manner that presents the least possible damage to the magnetic tape. If there is an incorrect voltage in any of the dc power supplies, an ac power interruption, a leak in the vacuum system or a failure in the servo amplifiers, the servo disabling system begins to shut down the servos. The vacuum is released, and the capstan and reel motors are dynamically braked (0 voltage is applied to each) to quickly stop all rotation. This leaves the tape slack and undamaged. A functional diagram of the interlock scheme is shown below.

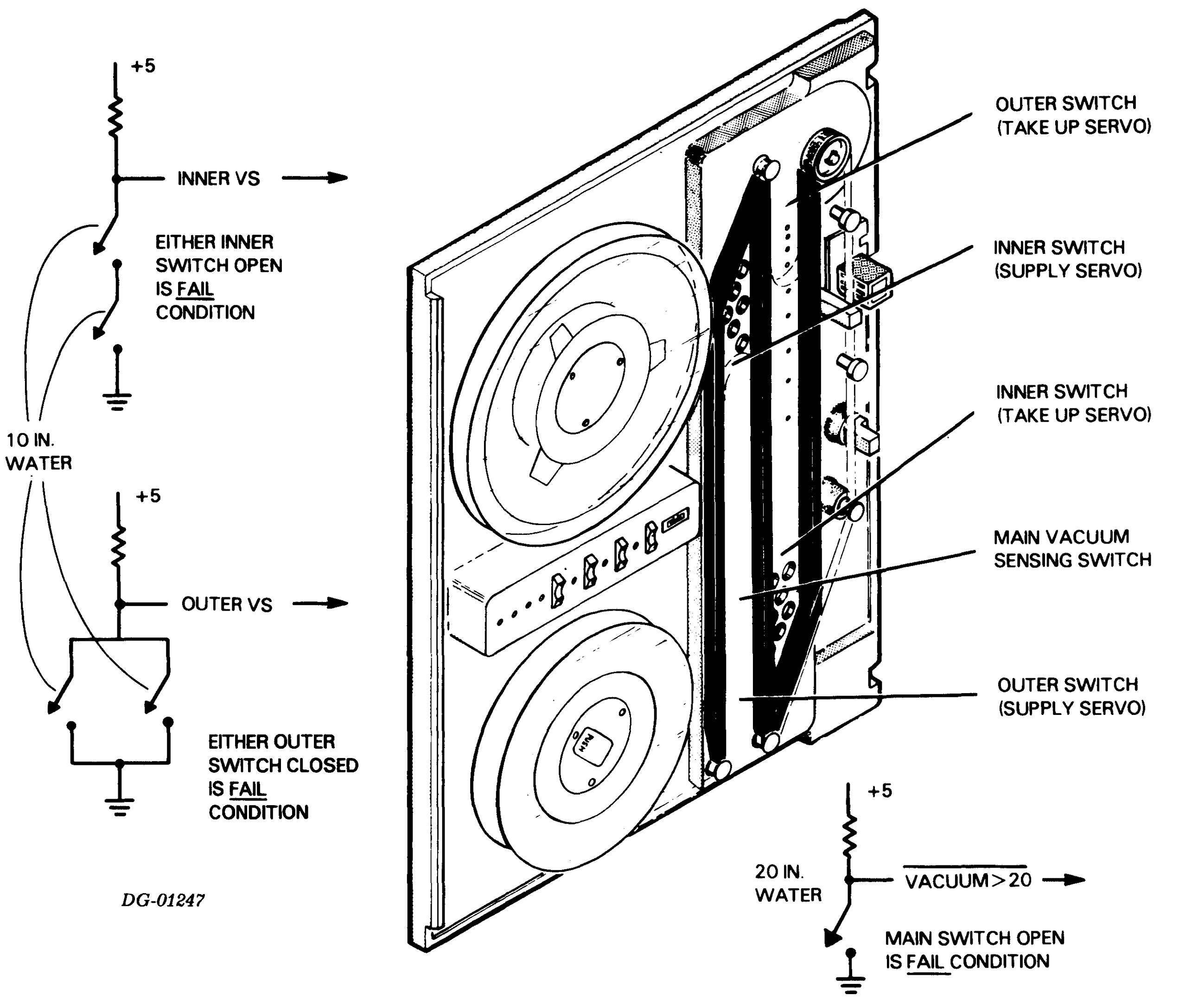
DISABLING NETWORK



DG-01246

There are five vacuum-sensing switches which are part of the servo disabling system. Four of the switches close at a vacuum of ten inches water; these switches detect excursion of the tape past the inner or outer extremities of the two vacuum columns. A fifth switch, closing at twenty inches of water, monitors the vacuum level in the primary vacuum manifold. The placement of the switches and their electrical configuration are shown below.

LIMIT SWITCHES



V

VACUUM COLUMN, TAPE BUFFER SERVO SYSTEM

There are two vacuum column servo systems, one for each vacuum column and reel motor combination. Each system consists of a vacuum-sensing transducer, a preamplifier, a summing amplifier, a power amplifier, a reel motor, a vacuum column, and bias circuits. The servos operate independently of each other, and independently of the capstan servo.

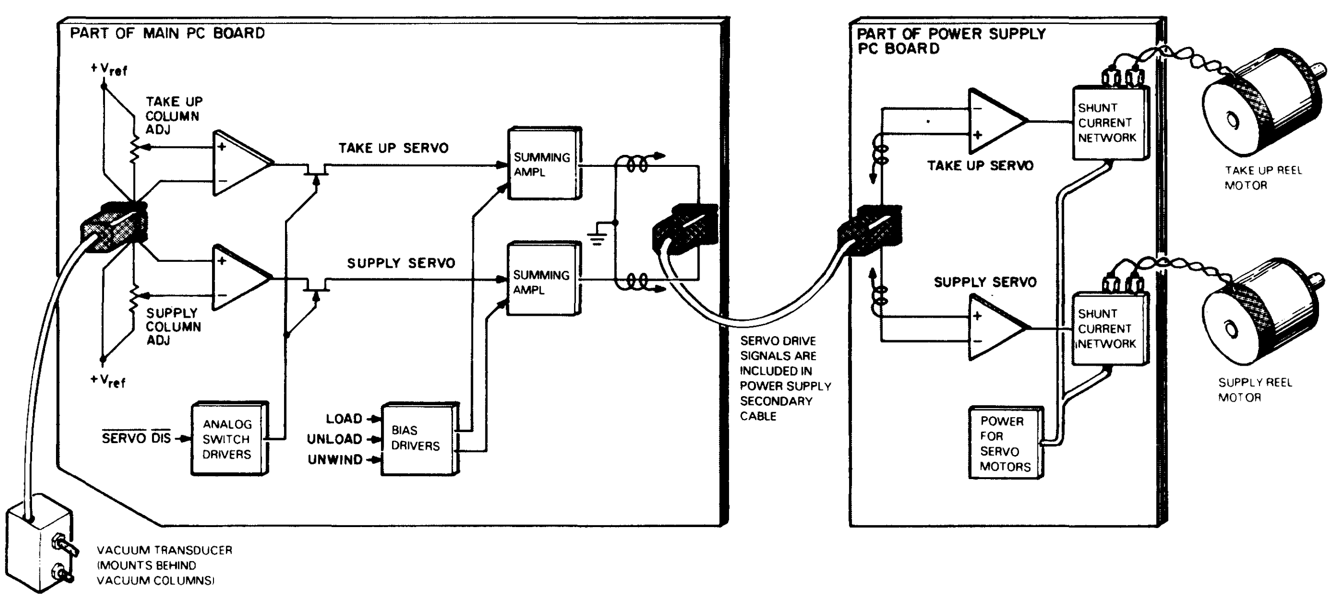
The two tape buffer servos operate in the same manner. Their organization is shown on this page. (The vacuum columns are omitted.) Since the servo components are located on several different subassemblies, the diagram also shows where the servo elements are located inside the transport.

The description that follows briefly summarizes the operation of the reel servos. Each major element in the servo is then described in detail. When the tape buffers are operating, a loop of tape is positioned in each vacuum column. One end of the tape loop goes around the capstan; for the purpose of this discussion it can be considered securely held and motionless.

The other end of the tape loop goes to a tape reel which can be rotated forward and backward by its reel motor.

An error signal, proportional to the tape's position above or below an equilibrium point near mid column is generated in the transducer. Preamplifier and an amplifier in each reel-column servo system conditions the signals from the pressure transducers and applies them to the input of the reel drivers. The reel driver controls servo power to the reel motor so it spins in the correct direction to reduce the error signal until the tape is at the equilibrium position. A single adjustment is provided to set the location of the equilibrium point within each column.

REEL SERVOS



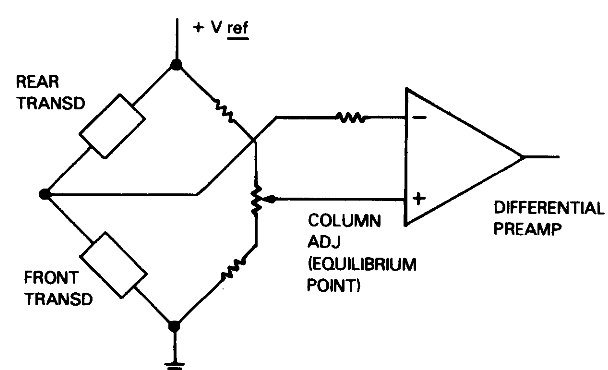
DG-01256

Vacuum Transducer

The pressure transducer generates an error signal that is proportional to how far the tape loop is above or below an equilibrium point in the vacuum column. Several small sensing holes, drilled in a row within the vacuum column, connect to a manifold machined into the casting behind the column. When the tape loop is in the column it divides the sensing holes into two groups - those that "see" atmospheric pressure and those that "see" vacuum. The average pressure in the servo manifold will change in steps as the tape moves up and down over the sensing holes inside the column. The illustration at right shows how this is done.

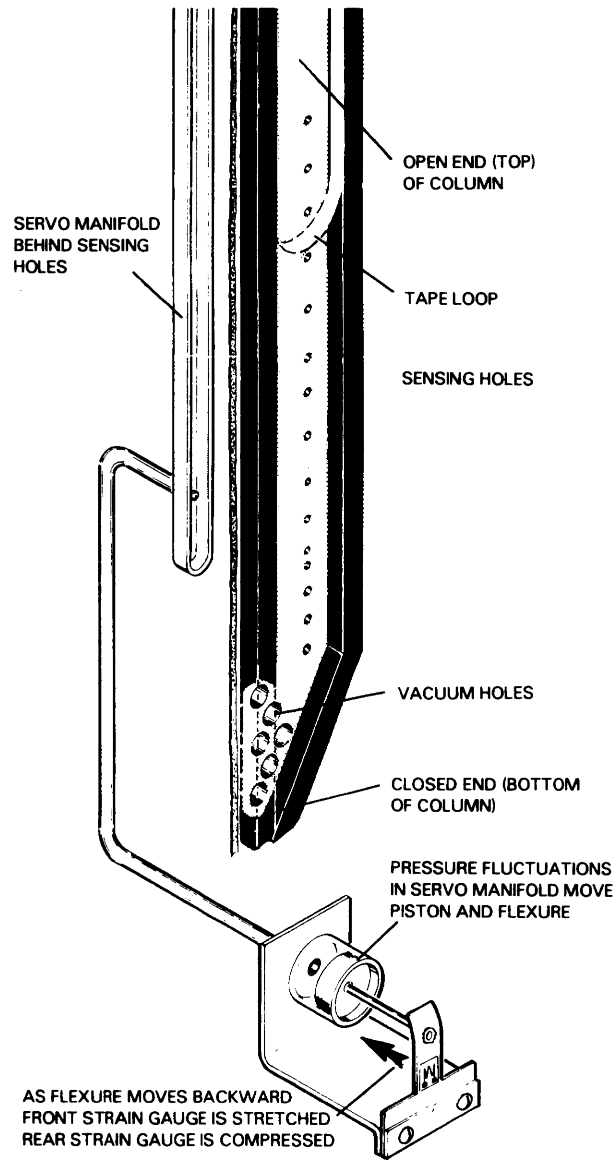
A small, spring-loaded pneumatic piston is connected through a short tube to the manifold. The piston moves within its cylinder in response to pressure fluctuations in the servo manifold, and flexes a spring arm on which two strain gauges are mounted. (A strain gauge is an electromechanical transducer whose resistance increases when it is stretched and decreases when it is compressed.) As the spring arm flexes, one strain gauge is compressed and the other is stretched. The two strain gauges are connected in series, operating in push-pull, so the effects of temperature fluctuations are minimized. A highly regulated reference voltage is placed across the strain gauge pair, as shown below.

TRANSDUCER



DG-01249

MANIFOLD AND TRANSDUCER



DG-01248

V

The two series-connected strain gauges along with a resistor network form a bridge circuit that includes an adjustment to set the equilibrium point for the tape loop within each vacuum column. The equilibrium point adjustment establishes what pressure in the servo manifold will nearly balance the bridge circuit. If the tape loop rises above the equilibrium point, the pressure in the transducer will increase and the bridge will go out of balance, applying a low amplitude error signal to the servo preamplifier. If the tape loop falls below the equilibrium point, the vacuum in the transducer will decrease and an error signal of opposite polarity will be presented to the preamplifier.

NOTE *"Above" and "below" the equilibrium point are not reckoned relative to the ceiling and floor of the computer room, but to the open end (top) and closed end (bottom) of the vacuum columns.*

The output of the bridge, measured to ground with an oscilloscope, is nearly half of the reference voltage, or 5.3 volts, regardless of flexure position. The magnitude of the differential input signal to the transducer preamplifier is of the order of a few millivolts - even for large flexure movement. The preamplifier gain is extremely high, and it can saturate when the column adjustment is badly misaligned. When the column adjustment is correct, the error signal measured at the output test pad of a preamplifier will remain less than a volt (plus or minus) while the tape is at equilibrium and can swing from about -3 volts to +3 volts as the capstan accelerates and decelerates.

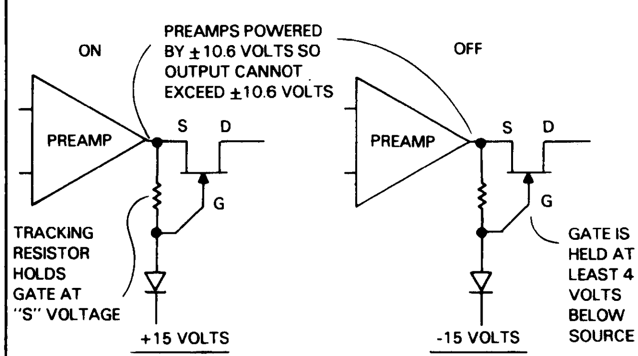
Servo Preamplifiers

The preamplifiers in both servo loops are identical. They are differential, scalar amplifiers which amplify the low level signal from the transducers. Power for the preamplifiers is taken from a special reference supply, which provides highly regulated dc voltages of +10.6 and -10.6 volts. These reference supplies are located adjacent to the amplifiers to reduce spurious noise pickup in the power conductors. The preamplifiers use precise voltage supplies to ensure exceptional noise immunity in the high-gain circuits.

An N-channel analog switch is used to enable and disable the output of each preamplifier. When the servos are enabled, the gate of the analog switch is connected to +15 volts through a small, back-biased diode. (The preamplifier output at full saturation is limited by its supply voltage to 10.6Vdc.) Since the gate is allowed to float by the back-biased diode, a tracking resistor is inserted between the source and the gate of the analog switch to ensure that they remain at the same potential. This is the fully ON condition for an N-channel switch, and it is shown on the left in the figure below.

When the servos are disabled, the gate is connected to -15 volts as shown on the right of the same figure. Now the diode is forward biased. Since the downward saturation of the preamplifier is limited to -10.6 volts by its supply voltage, there will always be at least 4 volts from gate to source on the analog switch (pinch off is 3 volts), to hold it fully off.

TRANSDUCER PREAMPLIFIERS

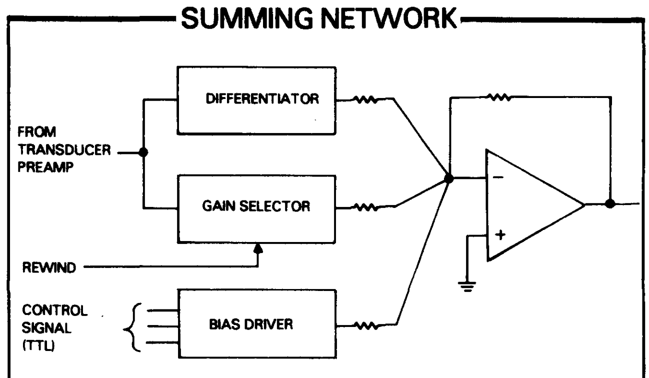


DG-01250

Summing Amplifier and Biasing Circuits

The second servo amplifier stage in the two reel servo systems are nearly identical. Each amplifier contains three gain selectors which change the degree of amplification performed on the signal from the first amplifier in response to certain operating conditions. Each contains a differentiator, so that not only the error signal from the transducer, but also its rate of change affect the response of the reel motors. Also, each amplifier contains certain bias-supplying circuits which are used during load, unload and unwind sequences.

The gain selectors, differentiators, and the bias circuits operate independently within each summing amplifier and will be described separately below.



DG-01251

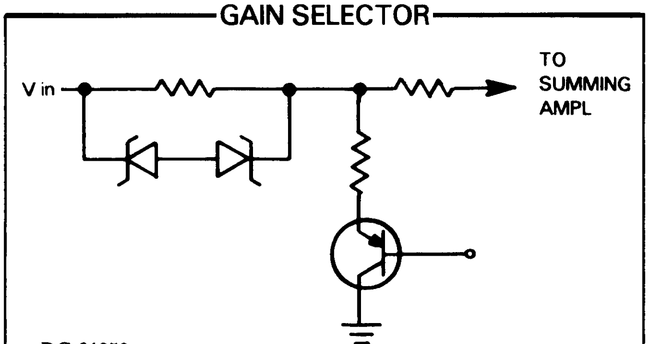
Gain Selectors

The three gain selectors change the amplification of the error signal from the first amplifier stage of both reel servos. There is a full gain condition and three reduced gain conditions. Full gain is realized whenever the tape loop within a servo's vacuum column is not in the immediate vicinity of that column's equilibrium point and the transport is not rewinding the tape. One of the reduced gain selectors is active whenever the transport is not rewinding and the other is active when the tape is in the immediate vicinity of a vacuum column's equilibrium point. Both reduced gain selectors may be active simultaneously, producing even more attenuation.

The equilibrium point gain reduction establishes a "dead zone" near the center of a column so that power consumption by the servos will be reduced when the tape buffers are idle. (The buffers can be considered idle whenever the capstan is motionless.) This significantly reduces the amount of heat generated in the reel motors, the power amplifier and the power supply, and is a principal reason why no external source of ventilation is required to cool the transport casting or enclosure.

The near-equilibrium gain reduction is implemented by the switching action of two back to back, series-connected, zener diodes which shunt part of the input resistance of the summing amplifier as shown.

GAIN SELECTOR



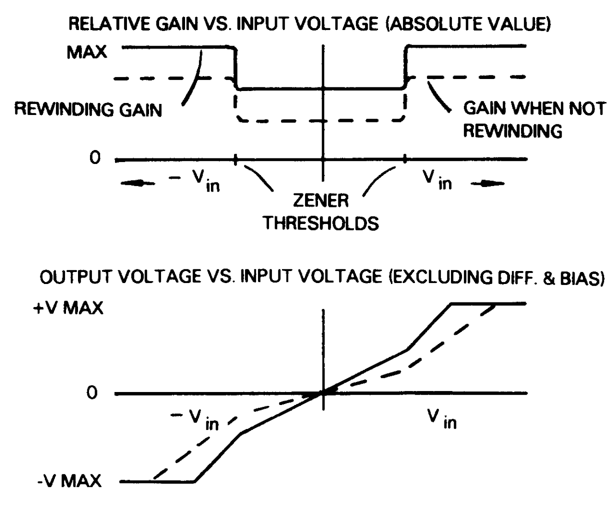
DG-01252

As long as the voltage across the shunted resistor, R1, does not exceed the zener breakdown voltage, the gain of the amplifier remains the ratio of the op amp's feedback resistance to the total input resistance. This is the reduced gain condition. When the voltage across the shunted resistor exceeds breakdown, the apparent input resistance to the op amp is reduced and the gain increases to its "full gain" condition.

An additional reduction of the summing amplifier gain is in effect whenever the transport is not rewinding. The transistor in the figure above shows how this is implemented. This gives the servo higher gain during rewinding. This higher gain is needed to accurately control the tape position in a column during high speed rewinding.

The combined effect of the gain selectors on the dc gain characteristics of the summing amplifier is summarized in the two graphs below. Only relative values of gain and voltage are shown.

RELATIVE GAIN VALUES



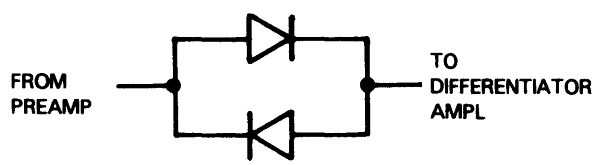
DG-01253

Differentiator

The output signal from the transducer is differentiated and the result is also applied to the summing node of the summing amplifier. This differentiated value represents how fast, and in which direction, the error signal is changing. As the error signal's rate of change increases from the equilibrium value, so does the corrective action taken by the servo to bring the tape loop back near mid column.

Because differentiators are sensitive to noise, a glitch filter is included in the circuit to prevent spurious spike transients from overloading the servo. The glitch filter is simply two diodes, connected in parallel (with opposite polarity) as shown below.

GLITCH FILTER



DG-01254

If the output of the summing amplifier is monitored with an oscilloscope, the interpretation of the waveforms must take into consideration the presence of the differentiated component. The behavior of a differentiator is not generally intuitive, and presence of the signal within the amplifier output can be confusing.

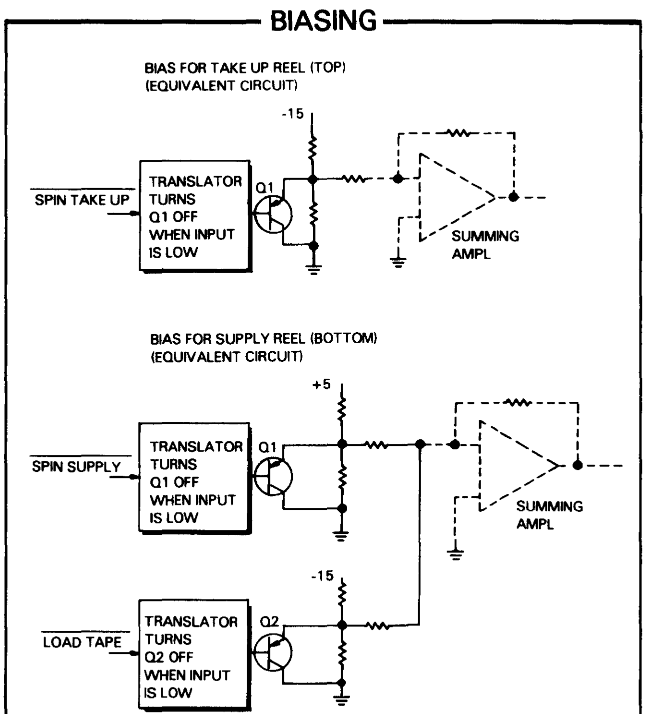
When the transport is rewinding, the relative weight or proportion of differentiated component in the amplifier output signal decreases because the gain of the undifferentiated component increases during rewind.

Bias Circuits

Certain dc bias signals can be applied to the summing node of each summing amplifier. These signals cause the reel motors to spin forward or backward at appropriate, fixed rates; they are used during the load, unload, and unwind operations. Three digital signals apply these signals to the summing amplifiers. The signals, their functions, and the magnitude of the applied bias levels are tabulated below.

Supply Servo Only		
LOAD TAPE	-3.6Vdc	Load sequence only; spins supply reel CW.
SPIN SUPPLY	3.7Vdc	Supply load and unwind; spins take up CCW.
Take Up Servo Only		
SPIN TAKE UP	-3.6Vdc	Load and unwind; spins take up CCW.

The following diagram shows the organization of the bias circuits and translators in the summing amplifiers. The translators convert TTL-level logic transitions to other, often higher, signal levels.



DG-01323

During the load sequence, LOAD TAPE, and SPIN TAKE UP assert for 400 milliseconds shortly after the vacuum blower is energized. Both reel motors then spin in the direction that feeds tape into the vacuum columns. Injecting tape into the vacuum columns in this manner reduces the annoying squeal that is typical of vacuum columns as they first load tape. (The squeal is caused by the resonance of vibrating tape stretched across the mouth of the vacuum column.)

During an unload sequence, SPIN SUPPLY asserts for about 2.5 seconds shortly after the vacuum blower is turned off, and the vacuum columns have vented. This causes the supply reel motor (the bottom motor) to slowly spin counterclockwise (looking from the front) and gently wind onto the supply reel the tape that had been looped in the columns.

When the vacuum columns are already unloaded and an operator pushes and holds the unload switch (this is called the unwind function), two signals, SPIN SUPPLY and SPIN TAKE UP assert while the switch is held down. This causes the supply reel to slowly spin counterclockwise, unwinding the tape from the take up reel and winding it onto the supply reel. The bias voltages applied to the two summing amplifiers are adjusted so that a nearly full 10.5 inch supply reel spools the tape at the same rate the nearly empty take up reel unwinds it. This minimizes tension on the tape. For any other conditions such as when tape is on a small supply reel or when there is a sizable length of tape wrapped on the take up reel, the take up reel will unwind tape faster than the supply reel can spool it up. When this happens, as it might in an emergency rewind, care should be taken to prevent tape from cascading onto the floor.

Reel Motor Drivers

The output of the summing amplifiers is carried through twisted-pair cables to the reel motor drivers located within the power supply module. The driver for each reel motor is similar to the scalar multiplier building block previously described. There are, however, two exceptions:

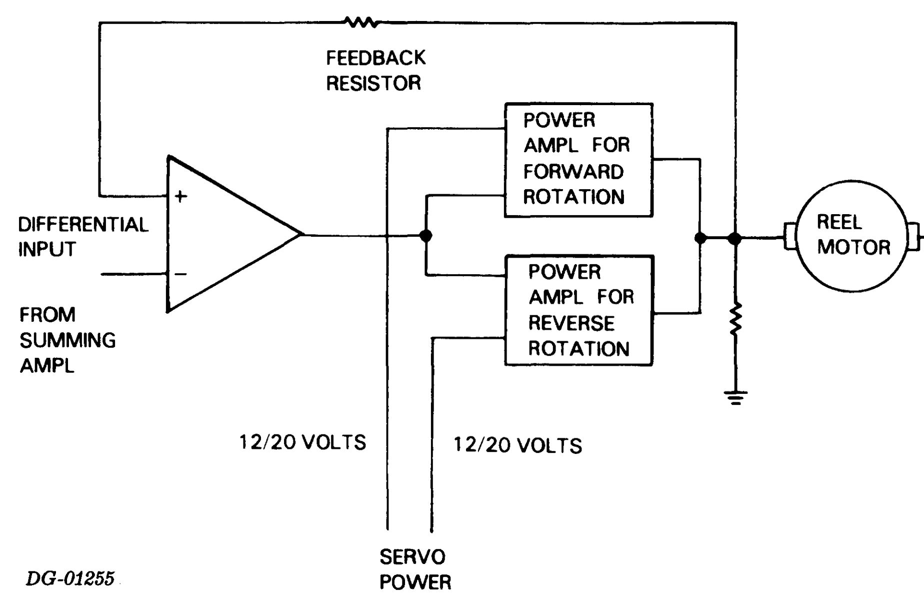
1. Input to the driver is differential rather than single-ended;
2. A power amplifier provides the output signal rather than the operational amplifier itself.

The differential input to the reel driver is used to cancel spurious noise pickup in the cable between a summing amplifier and a reel driver. The shunt current is used because a reel motor can momentarily draw over 20 amps, far exceeding the direct sourcing capabilities of a single integrated operational amplifier. The current shunt circuits in each reel driver provide current to drive a reel motor from the +12/20 volt and -12/20 volt (dc) servo power supplies.

Each reel driver has two mirror-image current amplifiers. One amplifier provides current from the positive voltage when the motor rotates in one direction; the other provides current from the negative supply for the opposite motor rotation. The feedback resistor that determines the gain for the entire driver circuit connects "downstream" from the current source to ensure that the voltage signal applied to the reel motor accurately follows the input signal to the reel driver.

The servo power supplies (+12/20Vdc and -12/20Vdc) operate at the 12 volt level whenever the transport is not rewinding. When the transport rewinds, the servo supply voltages are increased.

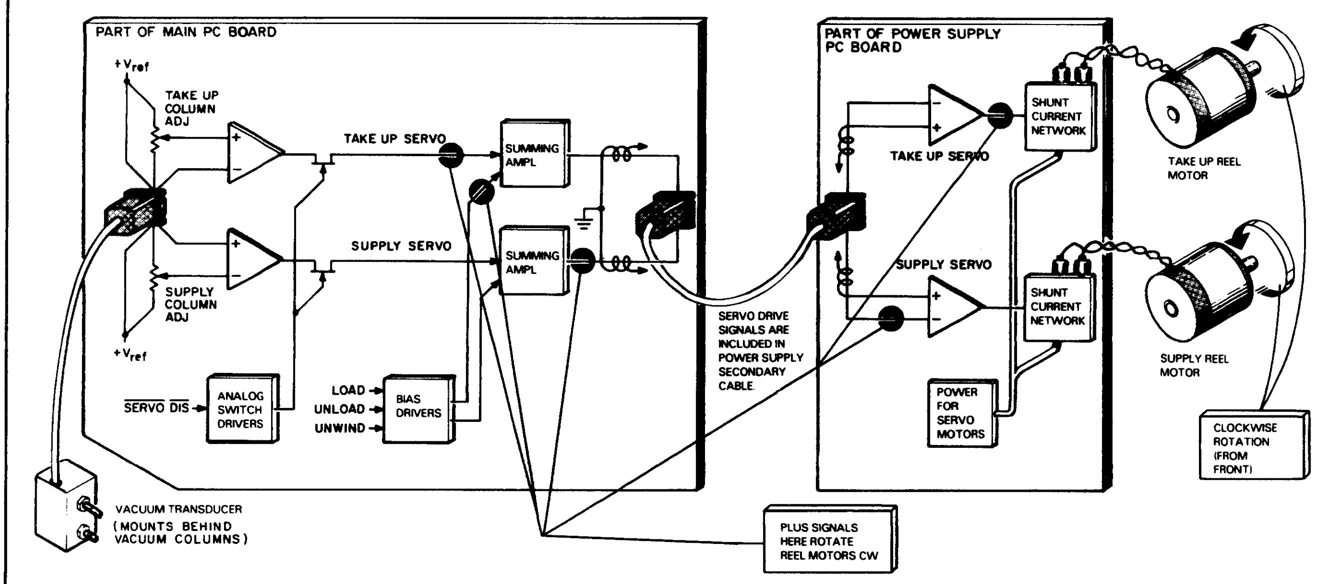
REEL DRIVER



SIGNAL POLARITY AND MOTOR ROTATION

The diagram on this page shows the direction a reel motor rotates for the signal polarity at various locations in the reel servos.

REEL MOTOR



DG-01257

CAPSTAN SERVO SYSTEM

The capstan servo system contains a capstan motor and its summing/driver amplifier, a tachometer, tachometer preamplifier, and motion and ramp generators. There are separate ramp generators for rewinding and for 75ips tape movement.

On this page, there is a functional diagram of the capstan servo system. The diagram also indicates the location of the servo elements within the transport. Servo operation is briefly described in the next few paragraphs; then each of the major servo elements is described in more detail within the sections that follow.

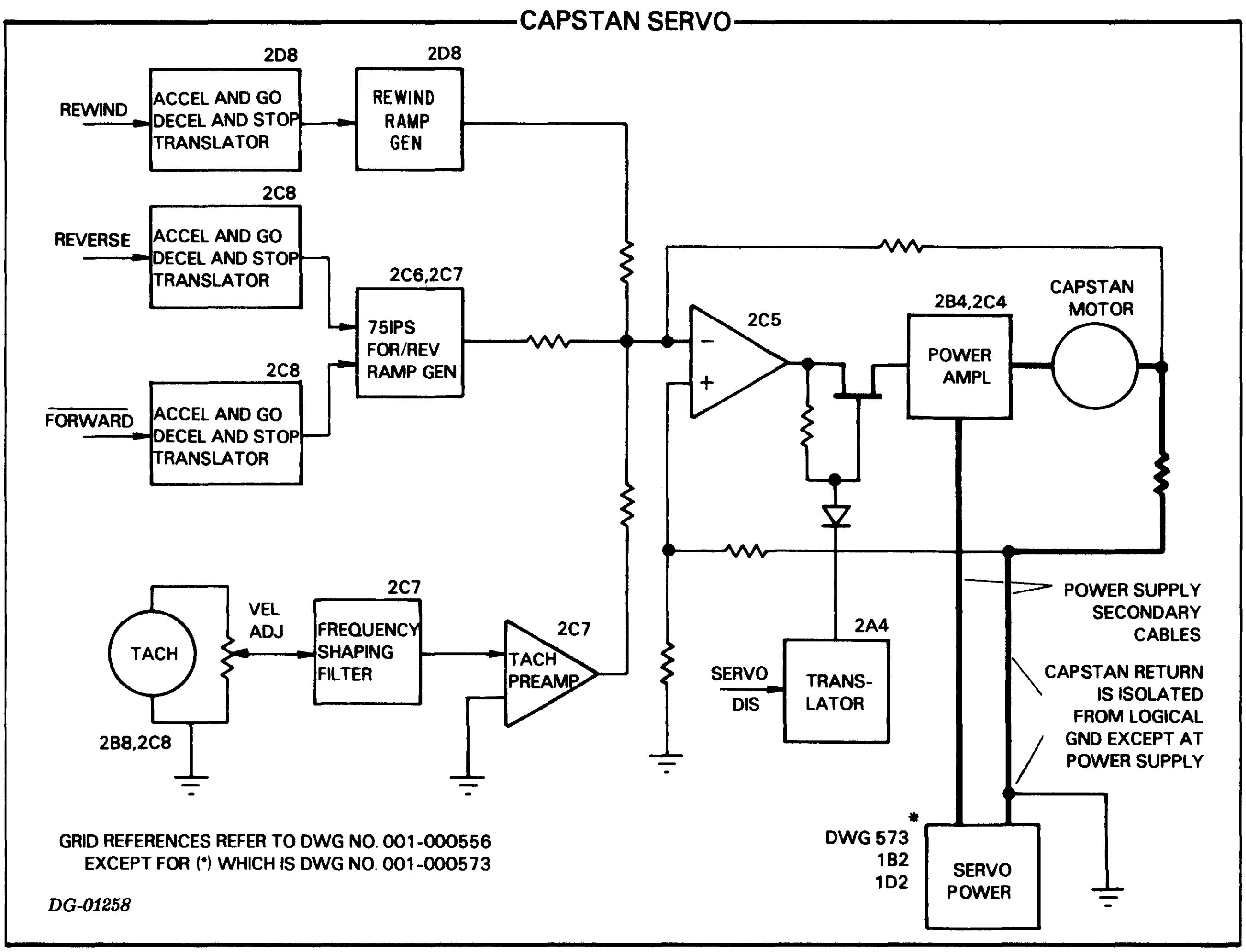
All motion of the tape past the transcription head is initiated and controlled by the capstan servo. Tape wraps 180 degrees around the no-slip surface of the capstan, and whenever the capstan motor turns, the tape moves accordingly.

TTL signals within the transport assert and initiate forward and reverse motion at 75ips or initiate rewinding at 200ips. The binary signals act through translators to apply certain voltage levels to the ramp generators. The ramp generators use these voltages to precisely control the acceleration and deceleration of the capstan.

There are two ramp generators. One ramp generator controls acceleration to and deceleration from 75ips, while another performs the same functions for rewinding.

An error signal from the tachometer, proportional in magnitude to the velocity of the capstan, is used to accurately control the speed of the capstan motor. The error signal is subtracted from the output signal of the ramp generator in the summing/driver amplifier. The resultant servo signal is amplified through a current amplifier to spin the capstan motor.

An analog switch in the summing/driver amplifier disables the capstan servo and stops the capstan motor if there is a failure in the transport servo-mechanisms.



Motion Selection and Ramping, 75ips

Acceleration and deceleration for all 75ips tape movements are initiated within the transport's local control logic through the action of two signals: FORWARD and REVERSE. When either signal asserts, a translator applies an appropriate reference voltage to the input of the 75ips ramp generator. When the reference voltage is positive, the capstan accelerates the tape forward and continues moving while the reference voltage is present. A negative signal causes reverse motion.

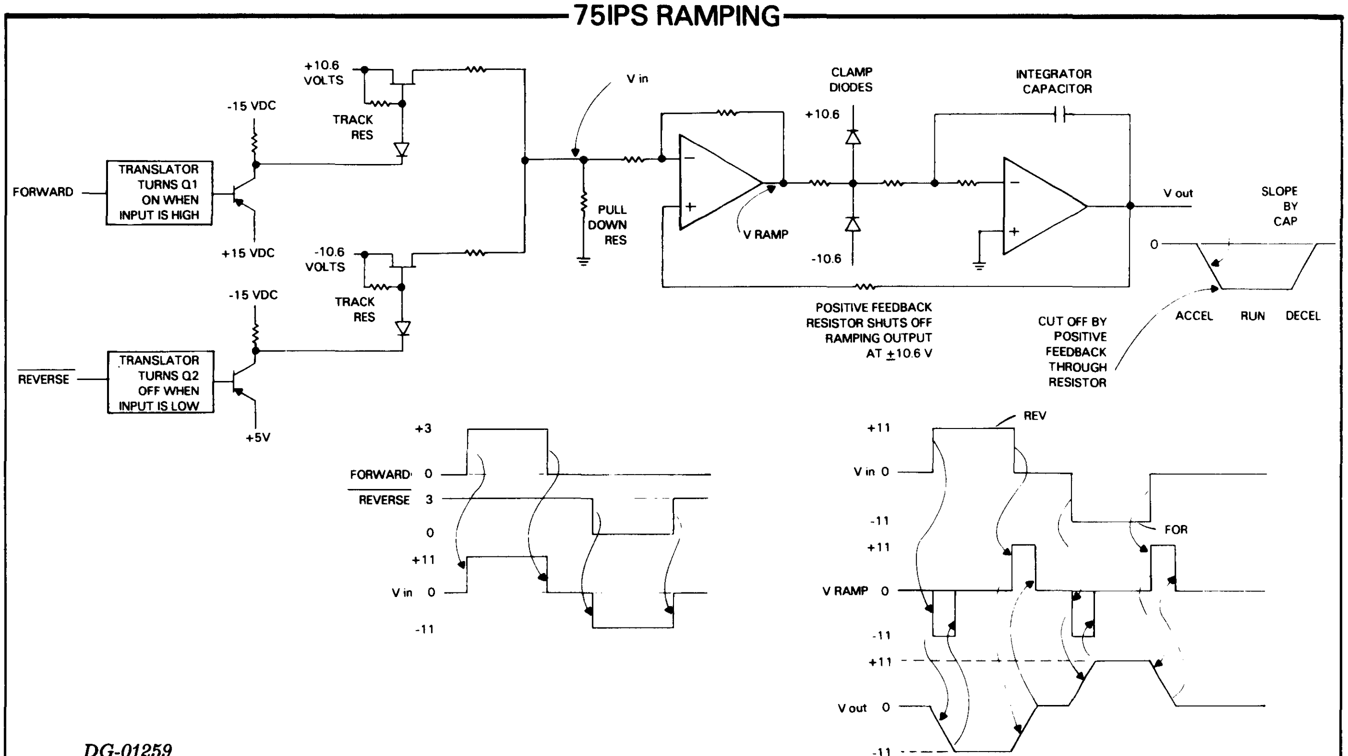
When a motion control signal asserts for any 75ips tape motion, its leading edge causes the ramp generator to begin a precisely controlled voltage ramp from zero volts to the value of the reference voltage. The transition of the asserted signal to its false condition removes the reference voltage from the ramp generator, initiating a deceleration ramp to zero volts. Logical interlocks prevent control signals for both forward and reverse motion from asserting simultaneously.

The illustration on this page shows the functional organization of the motion selectors and the ramp generator for 75ips movements. The accompanying waveforms show the signals throughout the network and how they change in response to motion commands.

The ramp generator is a two stage, gain-of-one, amplifier with a precisely limited slew rate that converts the step-transition signal from the translators to a straight-line ramping transition. For accelerating and decelerating the capstan, the ramp-time is 5.0 + 0.25ms.

The first stage of the two stage ramp generator has an approximate gain of 1000. Because of this, a voltage signal from the translator drives the first stage into saturation and the clamping diodes hold the signal V ramp at plus or minus 11.2 volts. Positive feedback is applied to the first stage from the output of the ramp generator through a resistor as shown. When the ramp reaches 11.2 volts, the positive feedback will "turn off" the first stage operational amplifier (the inverting and non-inverting inputs will be the same, V ref voltage). The signal V ramp is initiated. (A configuration wherein an amplifier swings sharply between zero and saturation voltage is sometimes called a hysteresis amplifier.)

75IPS RAMPING



DG-01259

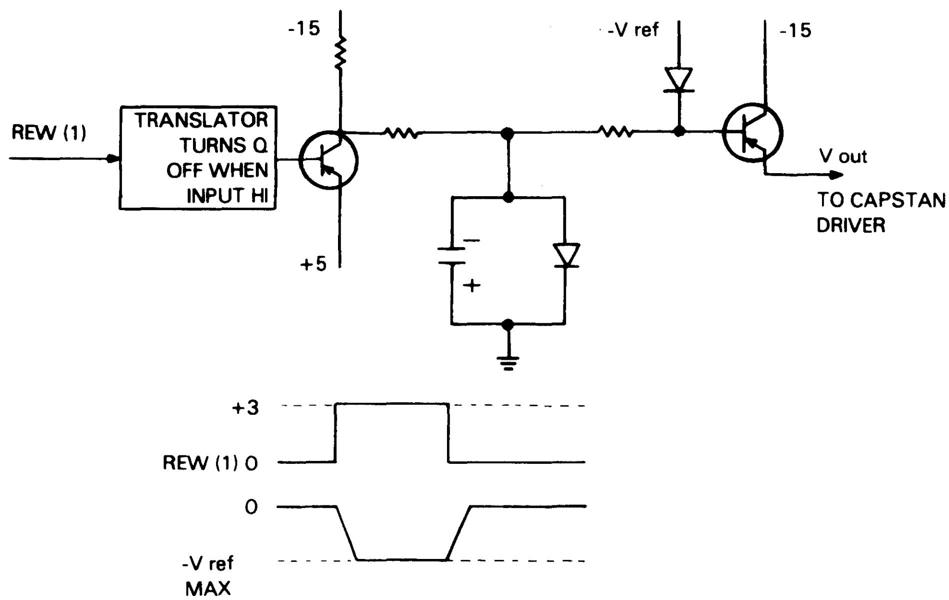
Motion Selection and Ramping, Rewind

Acceleration and deceleration for rewinding is initiated by the binary signal REW(1). When the signal asserts, a negative reference signal is applied to the ramp generator. The reference voltage is removed when the control signal goes false.

The ramp generator changes the step-transition output signal from the translator to an exponential ramp of about 500ms duration.

A functional diagram of the rewind selecting and ramping circuits is shown below with appropriate waveforms. The organization and operation is similar to that used for 75ips. However, the tolerances for rewinding are less stringent than for tape processing, and consequently, the feedback-controlled ramp circuits used for 75ips are not needed.

REWIND RAMPING



DG-01260

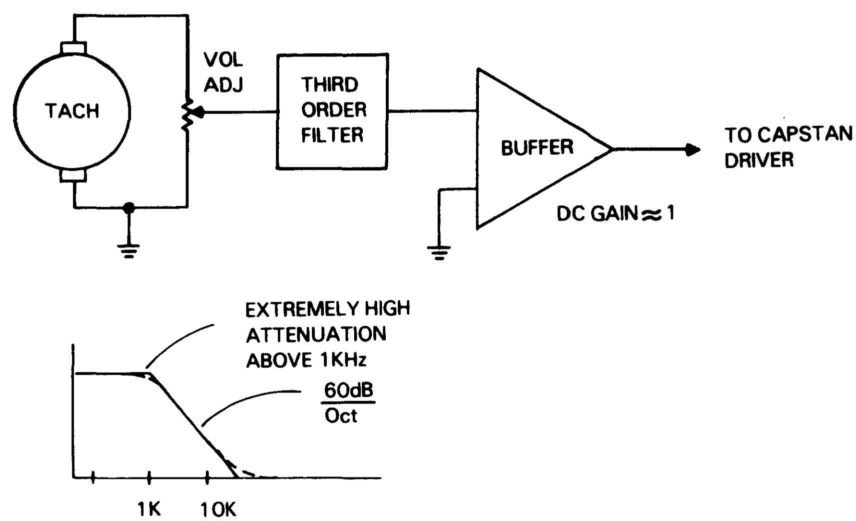
Velocity Control Tachometer

The tachometer, piggy back mounted with the capstan motor, generates an analog signal whose magnitude is proportional to the capstan's rotational velocity. This signal is used to calculate a servo error signal that controls the acceleration and deceleration of the capstan motor.

In effect, the tachometer signal is subtracted from the reference signal of the ramp generator. When the capstan is initially at rest, the error signal that starts its motion is nearly the full output of the ramp generator. As the capstan begins to accelerate, the tachometer output increases and the error signal calculated in the servo diminishes. Eventually, the error signal will reach a minimum with the capstan rotating at the desired speed. (The error signal will never reach zero volts since some small amount of torque will be required by the motor to overcome friction.

The organization of the tachometer and its preamplifier is shown below. The tachometer output is divided through a trimpot that provides an adjustment for setting the capstan velocity. The filter is needed to eliminate high frequency resonance between the capstan servo and the tachometer. The combination preamplifier and third order filter has a dc gain near -1 with flat response to 1kHz. Above 1kHz, the filter cuts off sharply (-60dB/decade), and effectively blocks all signals above 2kHz.

TACHOMETER FEEDBACK



DG-01261

Capstan Summing/Driver Amplifier

The output signals from the ramp generator and from the tachometer are combined (summed) in the capstan summing/driver amplifier. The amplifier also controls the power supplied to the capstan motor. A functional diagram of the summing/driver amplifier is shown below.

Feedback to the inverting (-) input of the amplifier is taken from across a small resistor in series with the capstan motor. This signal represents the current through the capstan motor. That CURRENT feedback, rather than VOLTAGE feedback, used in this servo system is an important characteristic that distinguishes the operation of the capstan servo from the reel servos. Principally, it means that the error signal developed in the capstan servo represents how much the capstan motor must accelerate or decelerate; whereas the error signals in the reel servos represent the velocity and direction the motor must rotate.

(In a dc motor, the rotational velocity is directly proportional to the voltage applied across the armature, while the torque developed in the motor is directly proportional to the current through the armature. For a low inertia motor of the type used to rotate the capstan, acceleration of the armature will be nearly proportional to the developed torque.)

Since velocity is simply the integral of acceleration, the capstan motor is, in effect, an electromechanical integrator; its output (velocity) is the integral of its input (the armature current supplied by the summing and driving amplifier).

An important characteristic of an integrator is that its output is relatively insensitive to noise; likewise, the rotational velocity of the capstan is relatively insensitive to noise in the capstan servo, and this contributes favorably to the precision of the transport's tape velocity control.

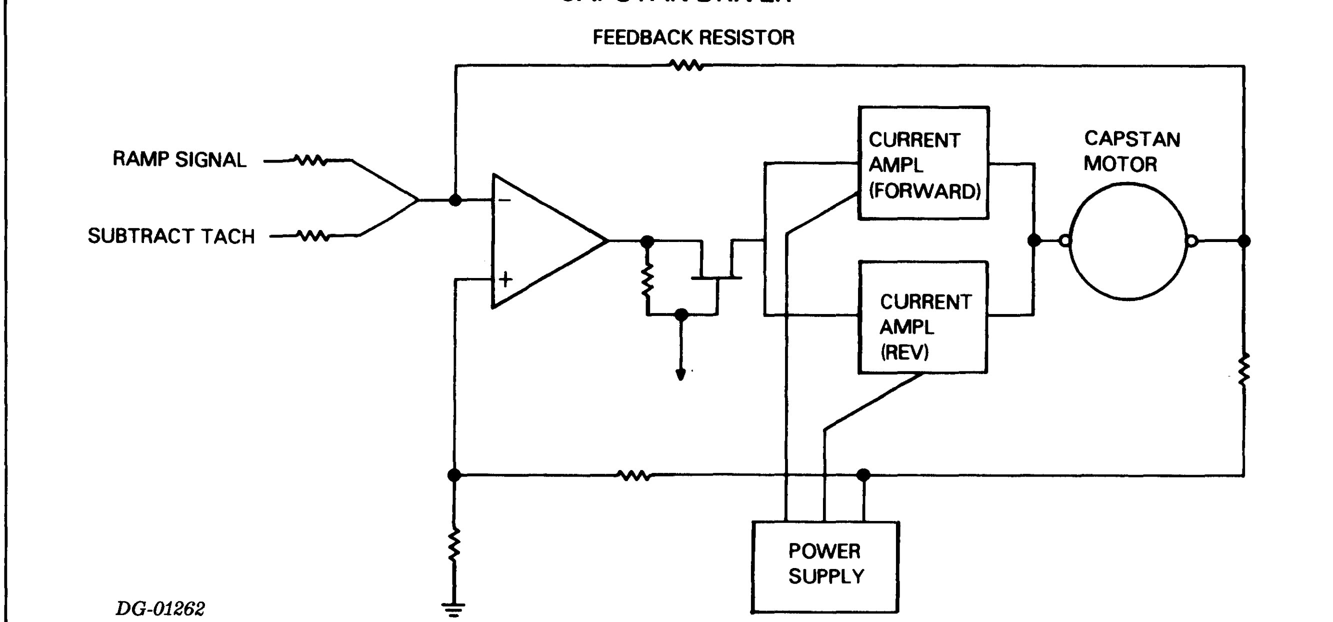
The feedback signal applied to the noninverting (+) input serves to cancel the effects of voltage drop and noise pickup in the cable between the power supply and the shunt current amplifiers.

The operation of an analog switch is described in detail within the section describing the reel servo preamplifiers. When the binary signal SERVO DIS asserts, the translator applies -15 volts to the gate of the analog switch, forcing it fully off. The circuit is then prevented from supplying current to the capstan motor. If the failsafe system disables the servos while the capstan is rotating, friction will quickly stop the motion.

There are two linear current amplifiers, identical in operation, that control current from the servo supply through the capstan. One amplifier controls positive current to the capstan; the other controls negative current.

The power supply delivers power to the servos at either high (+20Vdc) or low (+12Vdc) voltage depending on the present transport operation. Low voltage is supplied whenever the transport is not rewinding. High voltage power is supplied during a rewind to provide additional power for the high speed motion.

CAPSTAN DRIVER



DG-01262

Capstan Ground Isolation

DC ground for the capstan motor is cabled directly back to the power supply, and is kept strictly isolated from dc ground everywhere else in the transport except at the single point at the power supply where all grounds are tied together. This nearly eliminates any noise interaction that could occur between the capstan system and the write current drivers if they shared a common and distributed ground system. Single-point grounding is consistent with good practice in analog circuit design.

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CHAPTER VI
POWER SUPPLY AND DISTRIBUTION

INTRODUCTION

The 6020 series transport power supply controls and converts ac supply power to low voltage dc for the transport circuits and servo motors. It employs a ferro-resonant transformer to provide the coarse regulation needed for the servo circuits and motors; series pass regulators provide accurately regulated voltages for the more critical circuits. A remote energize circuit enhances operator safety and convenience. It uses a low level control voltage to electronically switch ac power to the supply and blower. Finally, overvoltage and overcurrent detectors protect the supply and transport circuits.

NOTE *See Appendix B instead of this chapter for power supply information if you have an early version of the tape drive.*

SUPPLY SPECIFICATION

AC Power				
Voltage +10/-15 %	Frequency +- 1 hz	Current Idle / Operating / Max		
100	60	3.5	5.5	6.5
120	60	3.5	5.5	6.5
100	50	3.5	5.5	6.5
220	50	3	4	4.5
240	50	3	4	4.5

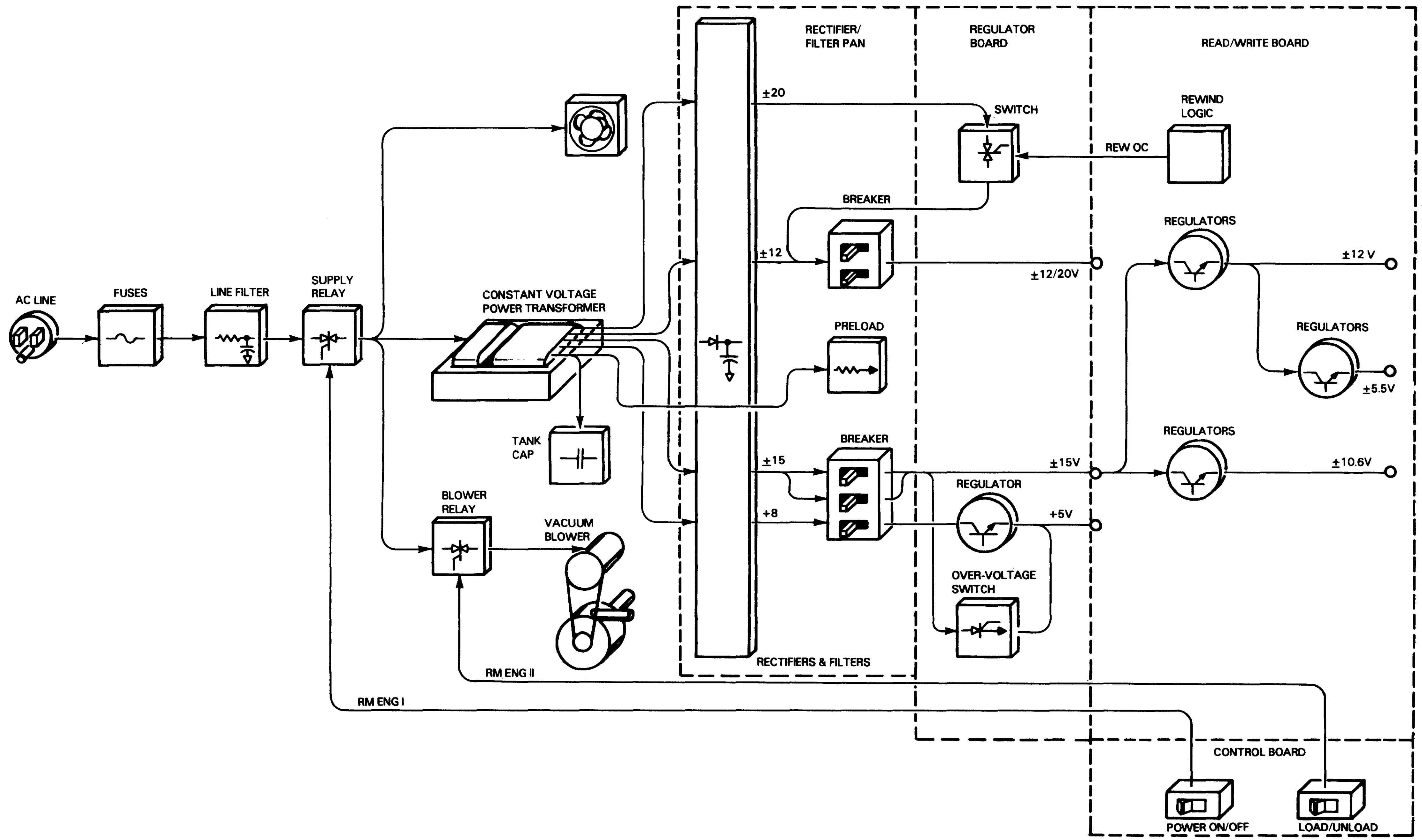
DC Power						
Voltage	Tolerance	Current Amps Max	Ripple Vpp	Regulator *	Source **	Destination
+12/20	11/18.5 to 13/21.5	17/4	1.5/0.5	xfmr	PS	servo motors
-12/20	-11/18.5 to -13/21.5	-17/4	1.5/0.5	xfmr	PS	servo motors
+15	13.9 to 16.1	2	0.8	xfmr	PS	servo ampls
-15	-13.9 to -16.1	1	0.5	xfmr	PS	servo ampls
+5	4.75 to 5.4	4	0.2	LS	PS (+8)	control logic
+12	± 5%	0.35	0.15	LS	R/W (+15)	read ampls
-12	± 5%	0.35	--	LS	R/W (-15)	read ampls
+10.6	± 5%	--	--	LS	R/W (+15)	servo preamps capstan servo
-10.6	± 5%	--	0.03	LS	R/W (-15)	servo preamps capstan servo
+5.5	± 5%	0.15	0.03	LS	R/W (+12)	read preamps
-5.5	± 5%	0.15	--	LS	R/W (-12)	read preamps
+V	7.3 to 24	--		none	PS	remote energ.

* refers to the regulation method
xfmr = ferroresonant transformer
LS = linear series pass regulator

** locates the source
PS = enclosure mounted power supply
R/W = read/write board
(the number in parenthesis indicates bulk supply voltage)

DG-04672

SUPPLY AND DISTRIBUTION BLOCK DIAGRAM



DG-04659

OVERVIEW

The block diagram shows the major components of the power supply and distribution system. The ac input is shown at the left, and the regulated dc outputs appear at the right. AC power is fused and filtered, and connected to the ac relay module. The module produces a low level dc control voltage for the panel mounted power switch. The switched control voltage energizes a solid state relay that connects ac power to the constant voltage transformer (CVT) and cooling fan. A second remote energize module routes power to the vacuum pump. (It derives its control voltage from the +5 VDC regulated output.)

The CVT outputs are rectified and filtered, and provide seven coarsely regulated dc voltages. The rewind logic controls a switch that allows the +- 20 volt outputs to override the +- 12 volt outputs; this provides increased voltage to the capstan and reel motors during a rewind operation. Preload resistors stabilize the CVT under light load conditions. A five pole dc circuit breaker prevents excessive current flow on the +12/20 volt outputs, and a three pole breaker protects the +15 and +8 volt outputs. Four linear series pass regulators provide additional operating voltages for the drive circuits, and an overvoltage crowbar opens the three pole breaker if the +5 volt output exceeds a preset limit.

VI

FUSES

The following table summarizes the fuse configurations;

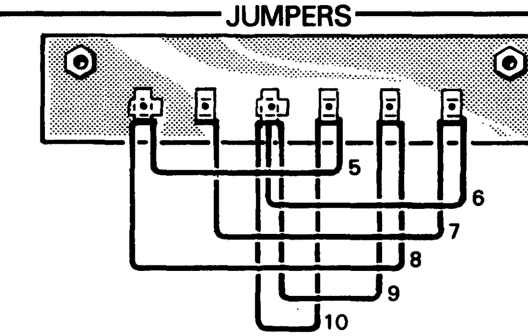
Line Voltage	Frequency	Number of Fuses	Rating (amps)
100	60	1	8
120	60	1	8
100	50	2	8
220	50	2	5
240	50	2	5

The fuse(s) are accessible at the rear of the transport enclosure.

REMOTE ENERGIZER

In the interest of operator convenience and safety, the ac circuits are energized from the operators panel using a low level dc control voltage. The remote energizer circuits are shown in the following schematic diagram. The control transformer is energized whenever the transport is connected to the ac power line; it operates over the full range of line voltages. The transformer output is rectified and filtered to provide a low level dc control voltage. The power switch connects the control voltage to a solid state switch that energizes the CVT and cooling fan. The primary windings of the CVT are connected in series for 220/240 volt operation. In this configuration, the lower winding acts as an auto-transformer to provide 110/120 volts for the fan and vacuum pump. A second solid state switch energizes the vacuum pump when a tape is loaded.

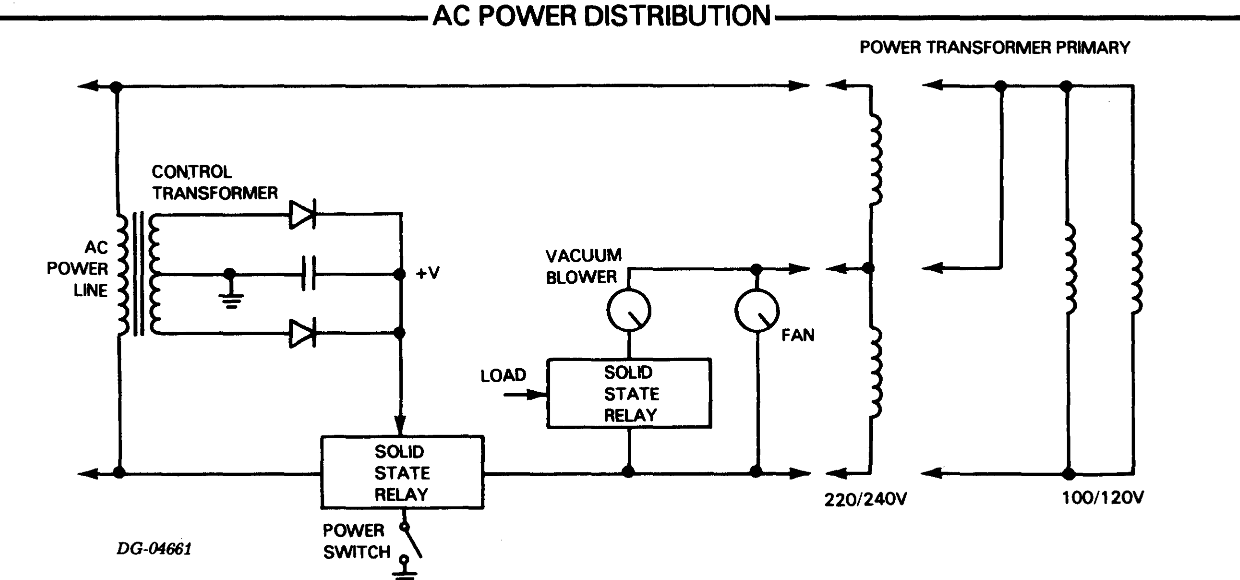
POWER TRANSFORMER JUMPERS



NOTE:
1. FOR 120 VAC 60Hz, ADD JUMPERS 5 AND 6
2. FOR 100 VAC 60Hz, ADD JUMPERS 7 AND 8
3. FOR 100 VAC 50Hz, ADD JUMPERS 7 AND 8
4. FOR 220 VAC 50Hz, ADD JUMPER 9
5. FOR 240 VAC 50Hz, ADD JUMPER 10

DG-04660

AC POWER DISTRIBUTION

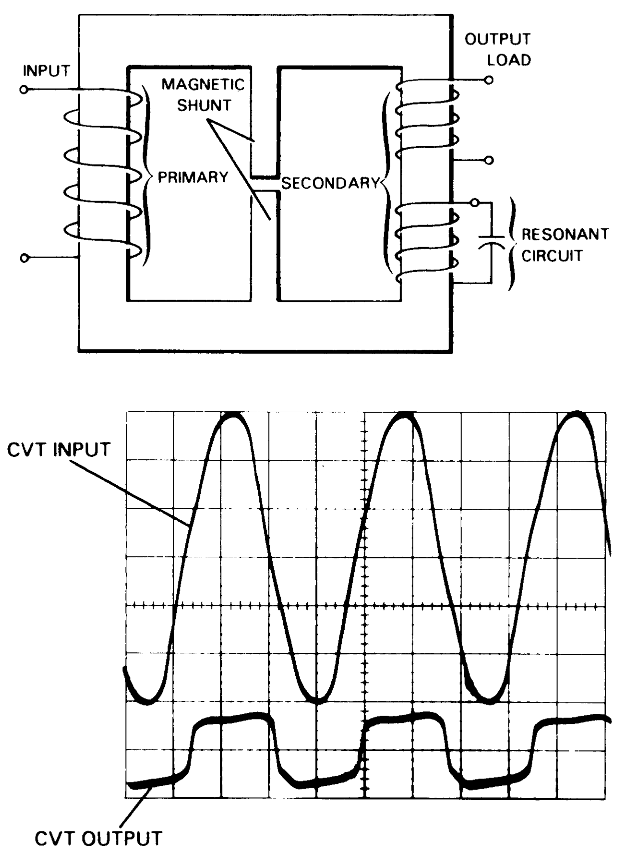


DG-04661

CONSTANT VOLTAGE TRANSFORMER

The structure of a constant voltage transformer differs from that of a conventional transformer. A magnetic shunt and resonant winding are added to control the flux linkage between the primary and secondary windings. When the primary voltage (and therefore the primary flux density) exceeds a minimum value, the resonant winding saturates the secondary half of the transformer core. This happens irrespective of the ammount of current flow in the secondary windings. As the primary current rises, the additional flux is short circuited through the magnetic shunt, and does not link the secondary windings. This mechanism maintains a fixed secondary flux density, and regulates the secondary voltages. Because the secondary core saturates at the onset of each half cycle of the primary voltage, the transformer inherently limits current in the secondary windings and provides square wave outputs.

CONSTANT VOLTAGE TRANSFORMER



DG-02345

DC GROUNDS ISOLATION

Certain major branches of the dc grounding circuit are kept strictly isolated, save the one location where they are brought together. The write current return (WRITE GROUND), the capstan motor return (CAPSTAN GROUND), and the reel motor returns are isolated from all other dc grounds that are distributed and common throughout the transport. This eliminates the possibility of ground loop and common mode errors that could affect particularly the write circuits if strict isolation were not maintained. The ground returns join at the filter capacitor bus bar, which in turn is grounded to the transport enclosure.

VI

VOLTAGE REGULATORS

The power supply includes seven voltage regulators. They are all variations of the linear series pass type, and are detailed below.

+5 Volt Regulator

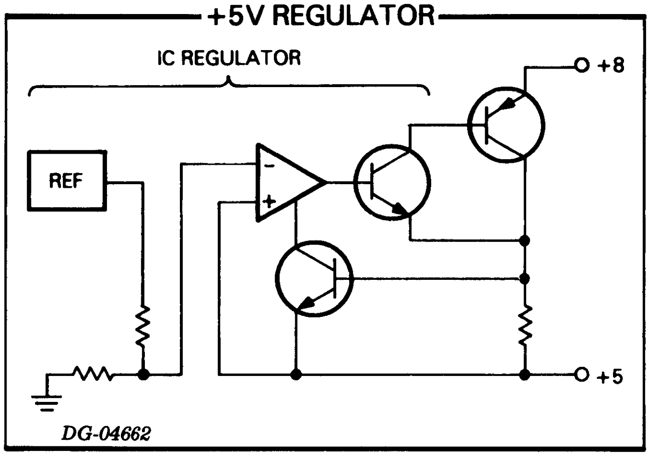
The +5 volt regulator employs an integrated circuit that includes a precision reference and a comparator. The reference voltage is divided down to provide a nominal 5.2 volt reference for the comparator. The drive transistor controls the series pass transistor, and feedback to the comparator stabilizes the output voltage. A current sense resistor and associated transistor limit the output current to a preset maximum to protect the pass transistor from excessive power dissipation.

±10.6 Volt Regulators

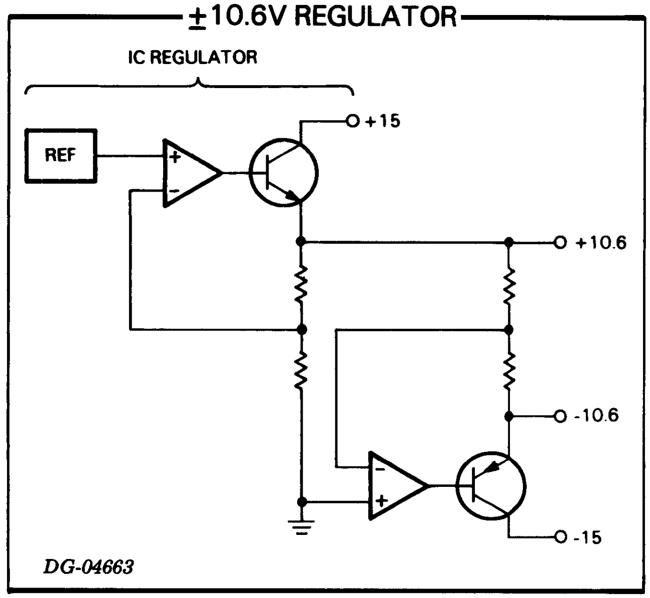
The +10.6 volt regulator is similar to the one described above. It dispenses with the external pass transistor and the current limiting circuit. The nominal 7.15 volt reference is applied directly to the comparator, and feedback from the output is divided to set the proper output voltage.

The -10.6 volt regulator employs an integrated circuit comparator and an external pass transistor. It derives its reference from the +10.6 volt supply. A resistive divider adds the reference and the output. The result is zero volts when the output is equal to but opposite from the reference. The comparator accepts a zero volt reference (ground) and stabilizes the output voltage. (The -10.6 volt regulator could be modeled as a unity gain inverting amplifier with a +10.6 volt input.)

+5V REGULATOR



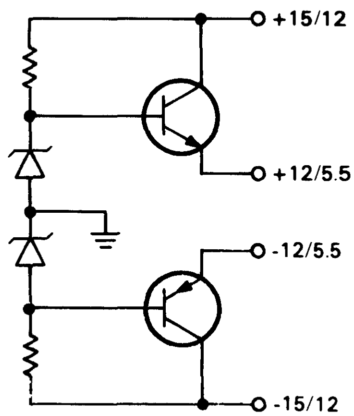
±10.6V REGULATOR



±12 Volt and ±5.5 Volt Regulators.

The remaining regulators employ zener diode shunt regulators and emitter followers. The zener provides a reference voltage, and the emitter follower acts as a current amplifier.

±12V OR ±5.5V REGULATORS



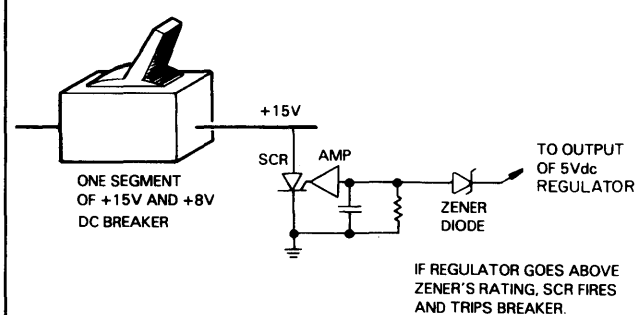
DG-04664

OVER VOLTAGE PROTECTION

Over voltage protection is applied to the +5 volt output to protect the logic circuits should the regulator fail. If the +5 volt output rises above approximately 6.8 volts, a zener diode forward biases an amplifier that fires a silicon controlled rectifier (SCR). The SCR short circuits the +15 volt output and trips the three pole circuit breaker, which disconnects ±15 volts and +8 volts, and thereby disables the +5 volt regulator.

As mentioned previously, the CVT transformer provides inherent over voltage protection on the ±12/20 and ±15 volt outputs.

CROWBAR CIRCUIT



DG-04665

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APPENDIX A
TECHNICAL SPECIFICATIONS

GENERAL

Tape Speed:	75ips
Data Density:	800bpi (9-track 6021 and 6023); 556 or 800bpi (7-track 6020 and 6022)
Start and Stop Time:	5msec (10%)
Speed Variation:	+4% maximum total
Start/Stop Distance:	0.187 (+0.019) in.
Rewind Speed:	200ips nominal
Dynamic Skew:	75 microinches, maximum
Static Skew:	100 microinches, maximum (READ); electronic skew compensation supplied for NRZI (WRITE)
Tape (Computer Grade):	0.5", 1.5mil mylar
Reel Size:	up to 10 1/2"
Recording Mode:	NRZI IBM compatible
Head Type:	dual gap
Power Requirements:	100/120Vac (+10%, -15%) 60Hz + 1Hz or 100/220/240Vac (+10%, -15%) 50Hz ± 1Hz, single phase, 900 watts maximum.
Heat Generated:	3800 Btu/hr maximum

MECHANICAL

Dimensions:	19"W x 24 1/2"H x 19"D, from mounting surface. (Control fits on a 15" square printed circuit board and occupies one computer slot.)
Weight:	150 lbs.
Mounting:	standard 19" rack.
Power Cable:	10' long

ENVIRONMENTAL

Temperature Range:	60 to 90°F room (60 to 100°F cabinet); -10° to 160°F storage
Relative Humidity Range:	20% to 80%, non-condensing, operating; 15% to 95%, non-condensing, storage
Altitude Range:	to 10,000 feet

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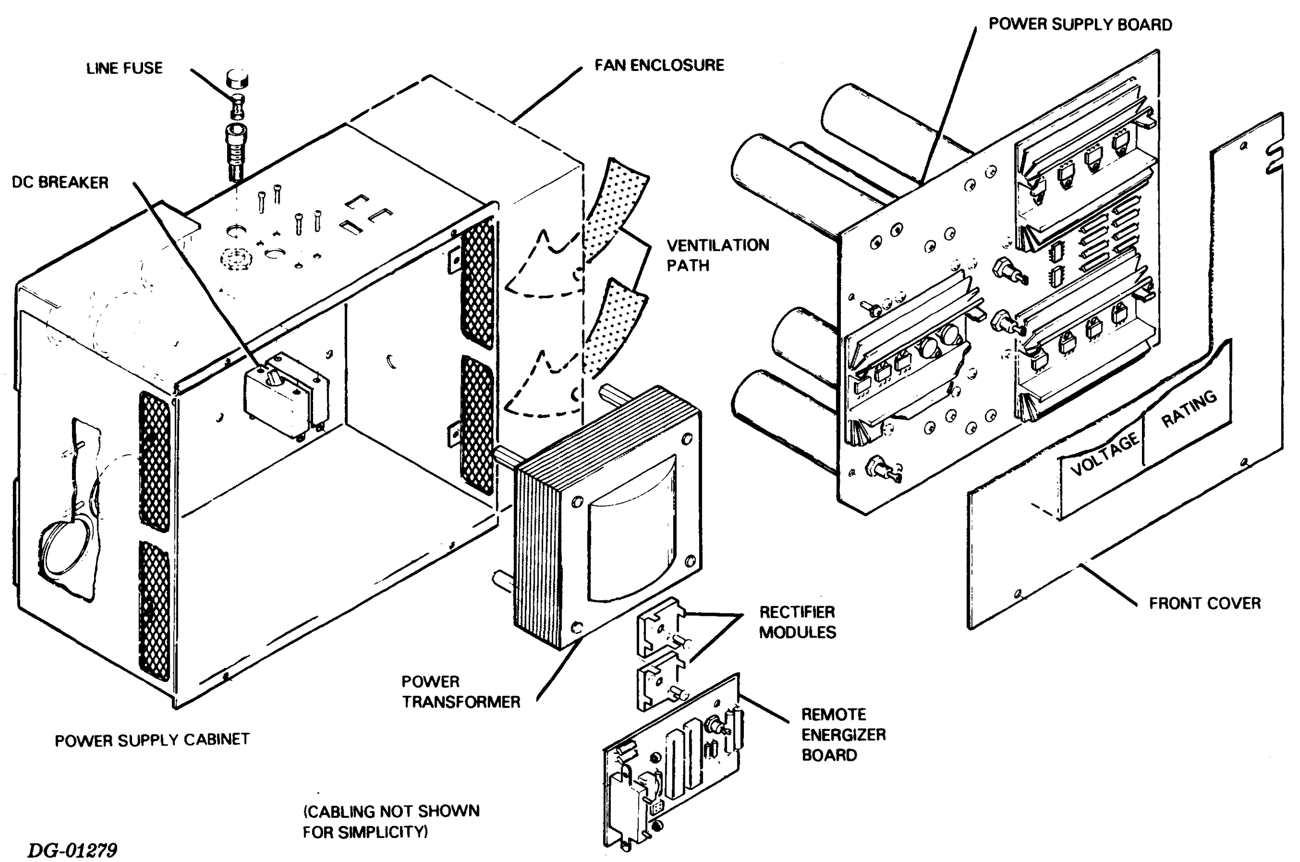
POWER SUPPLY MODULE



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APPENDIX B
POWER SUPPLY AND DISTRIBUTION
(EARLY VERSION, 6020 SERIES TAPE TRANSPORT)

INTRODUCTION

An early version of the 6020 tape transport has a power supply that differs from the one described in the main body of this manual. To determine which version you have, examine the interior of the transport enclosure. The early power supply is completely enclosed in a box at the back of the enclosure. (You may also examine the rear of the drive; the early version has no visible fuses or circuit breakers.)

The early power supply employs a conventional power transformer and a combination of linear and switching regulators. It is functionally equivalent to the current version in that it provides the same voltages and currents as well as the remote energize feature.

POWER SUPPLY MODULE

The power supply provides low voltage dc power at several levels to operate the transport servo and logic circuits. It is completely enclosed in a removable module that is bolted to the rear of the transport enclosure. The supply is shown in the illustration at the left. It contains two printed circuit boards, a transformer, a circuit breaker, two bridge rectifiers, internal cabling and two external cables. Four bolts, accessible from behind the transport enclosure, secure the module in position. The ac power cord extends through a hole in the rear of the enclosure.

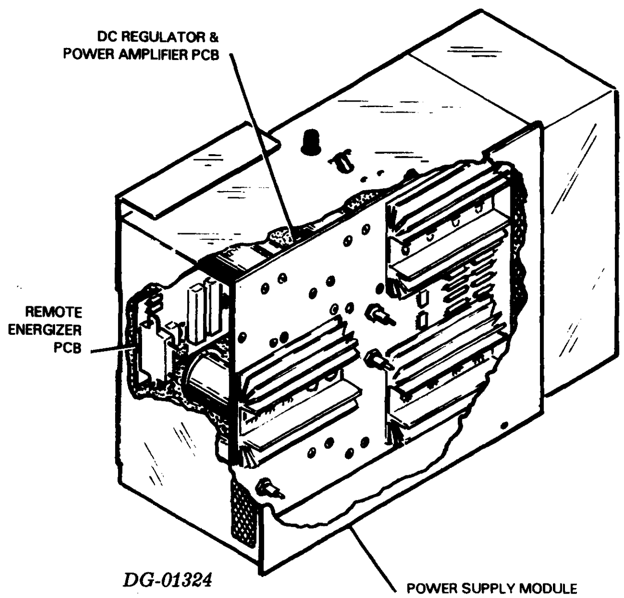
NOTE *The power supply module may be operated outside of the transport enclosure if required for servicing. However, complete cooling of the power supply is assured only when the module is inside the transport enclosure near its cooling fan. When operating the module outside the enclosure, remove its cover and maintain a low duty cycle on the servos to prevent overheating.*

CAUTION *AC power is ALWAYS present within the module whenever the transport is plugged into a live ac supply.*

PRINTED CIRCUIT BOARDS

The power supply-mounted boards are shown below. The small board mounted in the back of the power supply is the remote energizer circuit for powering up the transport. The large board at the front of the power supply contains the principal dc regulators and the reel servo power amplifiers.

POWER SUPPLY-MOUNTED BOARDS



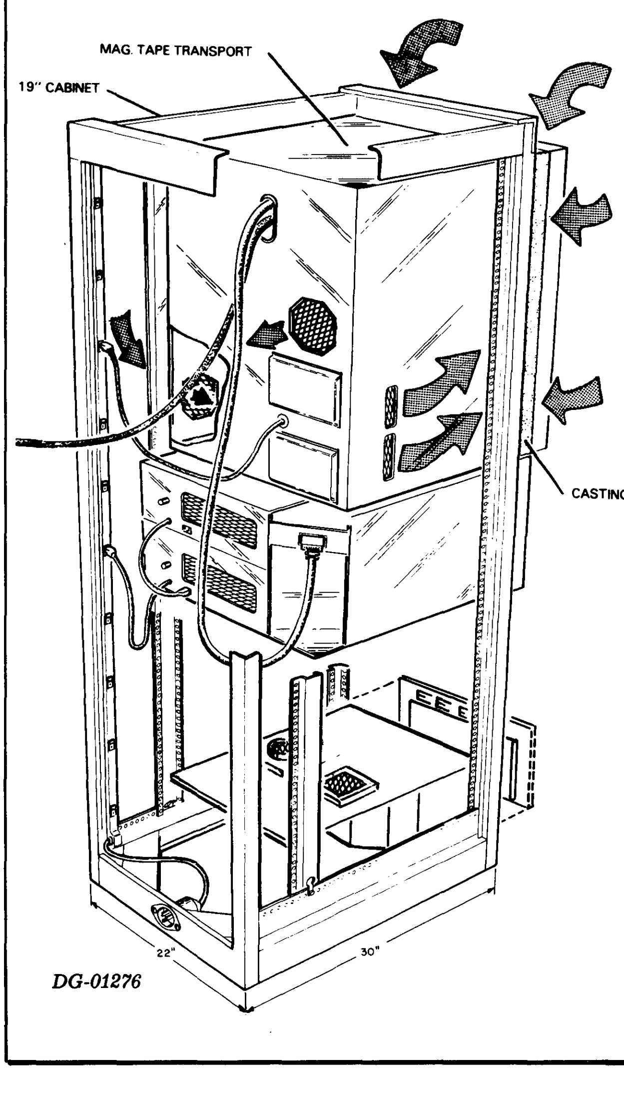
DG-01324

AIR FLOW AND VENTILATION IN THE TRANSPORT

The mechanical configuration of the power supply module, and its orientation in the enclosure, dictates the need for two ventilating fans. Air flow within the enclosure is therefore somewhat different from the current version.

Two compact fans provide ventilation for the transport as shown in the illustration below. The fan facing the rear of the enclosure draws air into the enclosure around the edges of the front casting. The side-directed fan draws air through the power supply module.

VENTILATION OF THE TRANSPORT



DG-01276

SUPPLY VOLTAGES

The 6020 series transport power supplies convert the ac supply power (120Vac or 220Vac; 50Hz or 60Hz) to the proper low voltage, direct current, power needed for the logic circuits and for the servos. There are 11 low voltage levels distributed throughout the transport, summarized in the following table:

+5Vdc	Used to power the logic circuits.
+15Vdc	Used for servos' op-ampls except as noted.
-15Vdc	Used for servos' op-ampls except as noted.
+12Vdc	Used for read amplifiers, 2nd stage.
-12Vdc	Used for read amplifiers, 2nd stage; also for capstan summing ampl.
+6Vdc	Used for read amplifiers, first stage.
-6Vdc	Used for read amplifiers, first stage.
+10.6Vdc (Vref)	Both reference supplies are used for servo preamplifiers and for ramp generator.
-10.6Vdc (Vref)	Both reference supplies are used for servo preamplifiers and for ramp generator.
+12/20Vdc (dual)	Both dual supplies drive the servo motors (capstan; 2 reels) with 20 volt level used during rewind.
-12/20Vdc (dual)	Both dual supplies drive the servo motors (capstan; 2 reels) with 20 volt level used during rewind.

CONFIGURATION

The diagram below shows the configuration of the transport low voltage system including the circuit board location of the various regulator circuits supplying each voltage level.

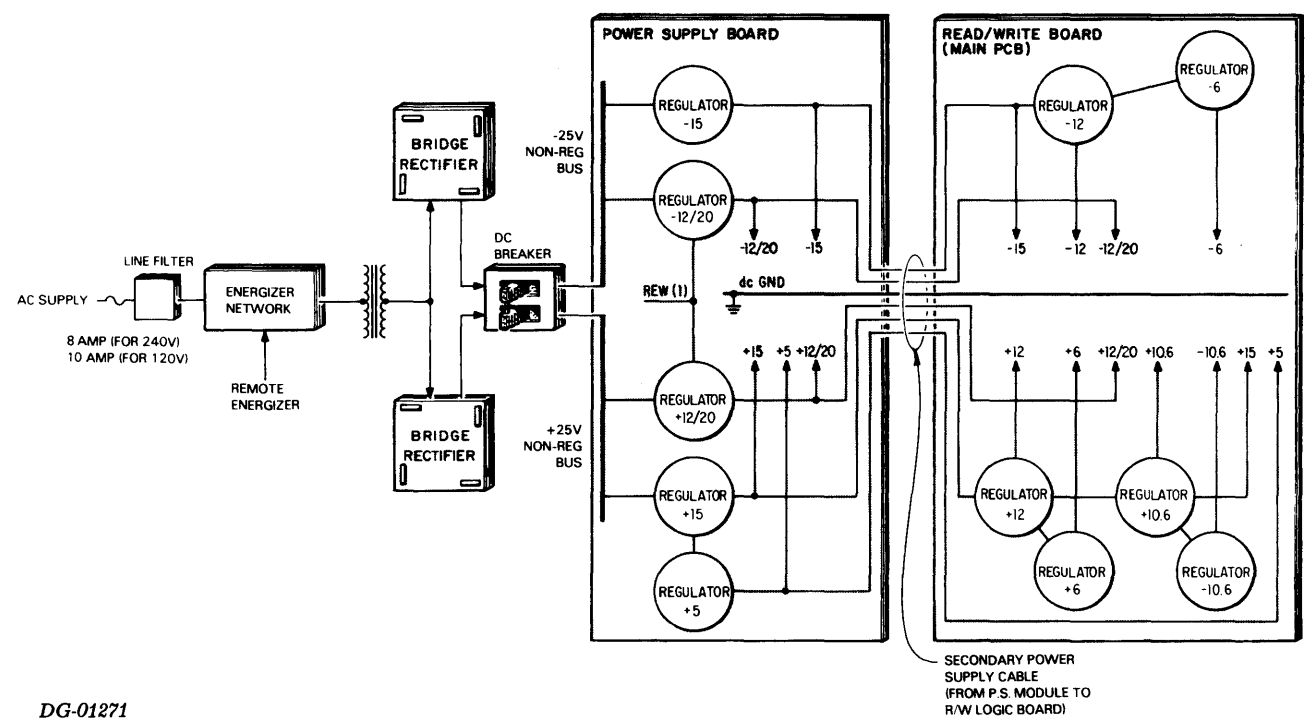
AC power is applied to the split winding primary of the voltage step-down transformer. When 120 volt (nominal) ac power is supplied, the two windings are connected in parallel. For 220 volt ac supply (nominal) the split windings are connected in series. The ventilation fans and the vacuum blower motor operate at 120 volts (nom) regardless of the supply voltage, and are connected across one of the transformer's primary windings.

The ground conductor in the ac power cord is connected directly to the transport case. The metallic enclosure and the transport casting are at ac ground. The low voltage (dc) ground is tied to the ac ground within the power supply.

Fuses

The single line fuse is mounted inside the transport on the top of the power supply module. A ten amp fuse is used for 110 volt operation; an 8 amp fuse, for 220 volt operation.

CONFIGURATION DIAGRAM

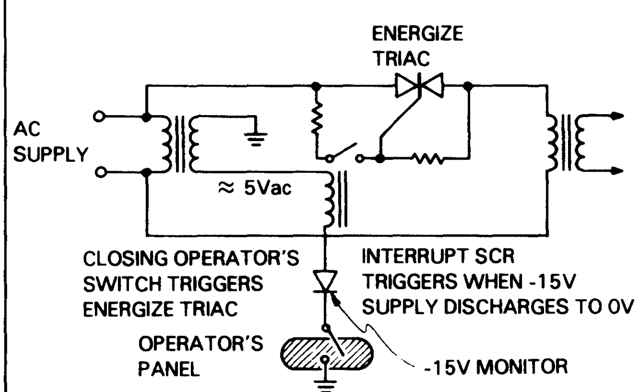


Remote Energizer

In the interests of operator convenience and safety, the ac circuits are energized from the operators panel through a low voltage (5 volts) energizing circuit. The energizer is shown below. A low voltage transformer is always connected across the ac supply lines (they are live whenever the transport is plugged into its supply). One leg of that transformer is connected to dc ground and the other leg passes through the energizing relay to the power ON switch at the operators panel. When this switch closes, the relay closes, triggering the triac and applying power to the main transformer.

The remote energizing circuit also includes an interrupt SCR to protect the transport servos in the event of a momentary power failure in the ac supply. In such a case, power to the transport restores only after the -15 volt supply bus has completely discharged. This is because the plus and minus busses have different loads and discharge at different rates (the -15 bus discharges more slowly). Were power restored immediately, the servo amplifiers could become momentarily unbalanced and any tape held in the vacuum columns could be ruined. It normally takes about 8 seconds for the supplies to completely discharge and for the transport power to restore.

ENERGIZER CIRCUIT



DG-02761

DC Grounds Isolation

Certain major branches of the dc grounding circuits are kept strictly isolated save the one location where they are brought together. The write current return (WRITE GND), the capstan motor return (CAPSTAN GND), and the reel motor return are isolated from all other dc ground which is distributed and common throughout the transport. This eliminates the possibility of ground-loop and common mode errors that could effect particularly the write circuits if strict isolation was not maintained.

RECTIFIERS, DC BREAKER AND NON-REGULATED BUSSES

All dc power is distributed from two bridge rectifiers through the dc circuit breaker and the non-regulated busses.

There are two bridge rectifier modules, each connected across one of the secondary windings of the main power transformer. The bridge circuits are tied together to form a common, dc, ground with positive and negative legs connected through a circuit breaker to the non-regulated dc busses. The busses operate nominally at positive and negative 25 volts. (The full wave output of the bridges is considerably smoothed by the large capacitor banks connected to the non-regulated busses.)

The dc circuit breaker trips at 25 amps. The breaker is located inside the transport enclosure, at the top of the power supply module.

REGULATORS

There are four kinds of regulators used in the power network. One kind of regulator is the switching regulator which uses an LC circuit for temporarily storing energy; and the others are variations of the linear, series-connected, current regulator.

The table below describes each low voltage supply by naming its source, the type of regulator employed, the output voltage, ac ripple, and current specifications, as well as its location in the transport.

OUTPUT VOLTAGE	SOURCE VOLTAGE	SPECIFIED TOLERANCE AND CURRENT	REGULATOR TYPE	WHERE	COMMENTS
+12/20Vdc	$+25V_{nr}$	±10%-17.0Adc Max. 0.75V P-P, ripple	Linear Series	PSM**	IC regulated; silicon power transistors
+15Vdc	$+25V_{nr}$	±10%-1.0Adc Max. 0.5V P-P, ripple	Switching	PSM**	IC regulated; silicon power transistors
+5Vdc	$+25V_{nr}$	±5%-2.0Adc Max. 0.2V P-P, ripple	Linear Series	PSM**	IC regulated; silicon power transistors
-12/20Vdc	$-25V_{nr}$	±10%-17.0Adc Max. 0.75V P-P, ripple	Switching	PSM**	IC regulated; silicon power transistors
-15Vdc	$-25V_{nr}$	±10%-1.0Adc Max. 0.5V P-P, ripple	Linear Series	PSM**	IC regulated silicon power transistors
-12Vdc	$-15V_{reg}$	±5%-350mAdc Max. 150mV P-P, ripple	Linear Series	R/W PCB*	Zener regulated; silicon power transistors
+12Vdc	$+15V_{reg}$	±5%-350mAdc Max. 150mV P-P, ripple	Linear Series	R/W PCB*	Zener regulated; silicon power transistors
-6Vdc	$-12V_{reg}$	±5%-150mAdc Max. 30mV P-P, ripple	Linear Series	R/W PCB*	Zener regulated; silicon power transistors
+6Vdc	$+12V_{reg}$	±5%-150mAdc Max. 30mV P-P, ripple	Linear Series	R/W PCB*	Zener regulated; silicon power transistors
$+V_{ref}$	$+15V_{reg}$	±5%	Linear Series	R/W PCB*	Direct IC output
$-V_{ref}$	$-15V_{reg}$	±2.5%	Precision, unity inverter	R/W PCB*	Direct output of op ampl

Ref. 009-000076-00

** PSM = Power Supply Module*

*** R/W PCB = Read/Write Printed Circuit Board*

DG-01312

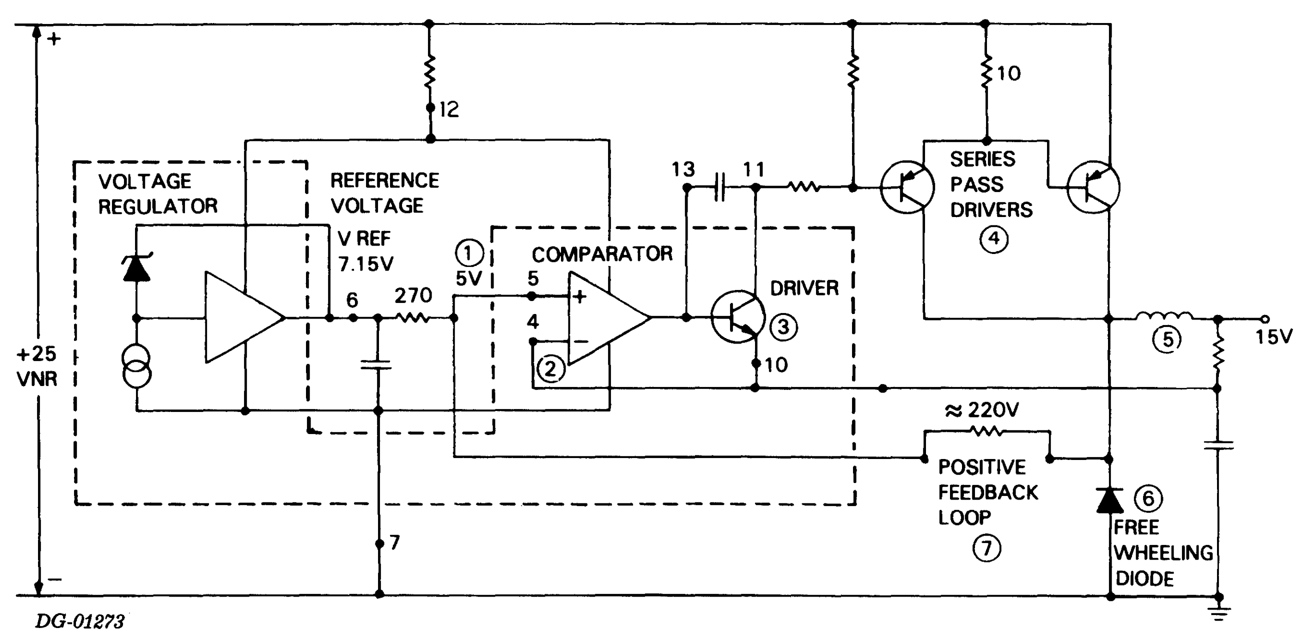
Switching Regulators

The simplified drawing below shows the switching regulator that supplies +15Vdc from the 25V, non-regulated bus. It is typical of series switching regulators.

A series pass switching regulator is essentially a multivibrator that sets when a low voltage is detected at the regulator's output and which resets when a high output voltage is sensed. When the regulator is set, current is gated from the 25V non-regulated supply into an LC circuit. When the regulator is reset, current flow is stopped and the load draws power from the LC circuit until the voltage drops to a level that sets the regulator again. The frequency at which the regulator toggles in this manner varies from 0 to 25kHz, depending on the load.

When the comparator senses a difference between the (divided) reference voltage (1) and the output voltage (2), it switches, turning on the driver transistor (3) and consequently the series pass transistor (4). Current is shunted through the series pass transistors to the coil, output capacitor and the load (5). The output voltage rises, reducing the error voltage to the comparator, which resets, turning off the driver (3) and consequently the series pass transistors. Now the load is supplied from power stored in the LC circuit. The back EMF developed across the coil as a result of this switching is dropped across the free-wheeling diode (6). Note that each time the comparator is forced to switch it is driven into saturation by the positive feedback loop which includes the 220K resistor (7).

SWITCHING REGULATOR CIRCUIT



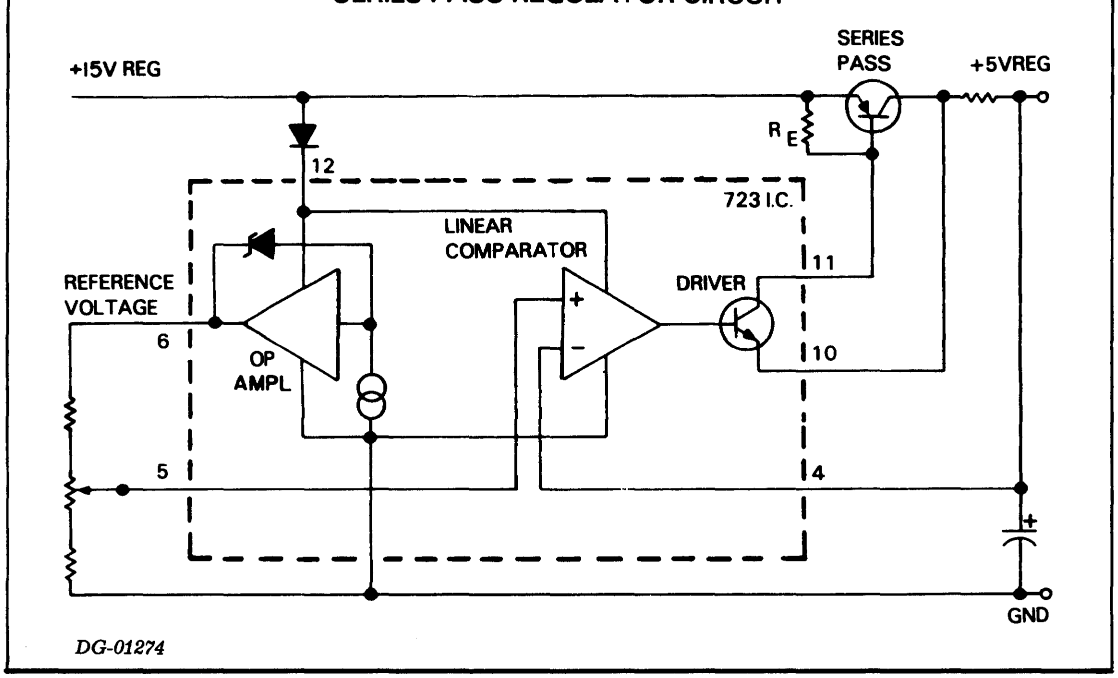
Linear, Series-Connected, Regulators

The illustration below is a simplified drawing of the 5Vdc series pass regulator. It is typical of series, linear regulators.

Although the series-pass regulator serves to monitor and control the output voltage of a power supply, it actually accomplishes this by controlling current flow. The output voltage is monitored and the current flow is adjusted to maintain the desired voltage.

In operation, a 7.15 volt reference is developed by the operational amplifier with its zener diode. This reference voltage is divided and applied to the non-inverting (+) input of a linear comparator. The 5V output of the regulator is applied to the inverting input (-) of the comparator. The output of the comparator, proportional to the difference between the divided reference voltage and the output voltage causes a proportional current in the driver. This develops a voltage drop across Re, which determines the drive on the series pass transistor.

SERIES PASS REGULATOR CIRCUIT



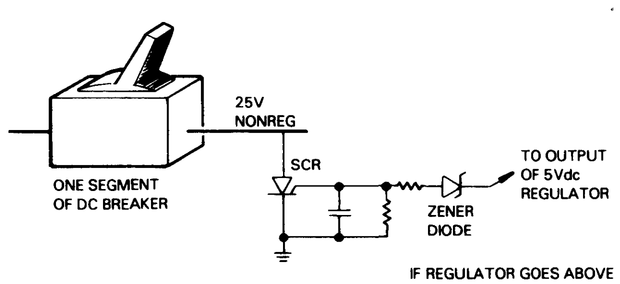
Over Voltage Protection, The Crowbars

The power supply is monitored in three locations for over voltage conditions: at the output of the +15V and +5V regulators, and at the output of the -15V regulator.

If the voltage at any of these locations rises above a safe limit, a crowbar circuit shorts one of the 25V non-regulated busses to ground and trips the dc breaker. (An SCR is used to shunt the +25Vnr bus to ground; a power transistor is used on the -25V bus.)

The monitoring circuit for the +5V regulator and its "fuse popping" circuit is shown below.

CROWBAR CIRCUIT



DG-01275

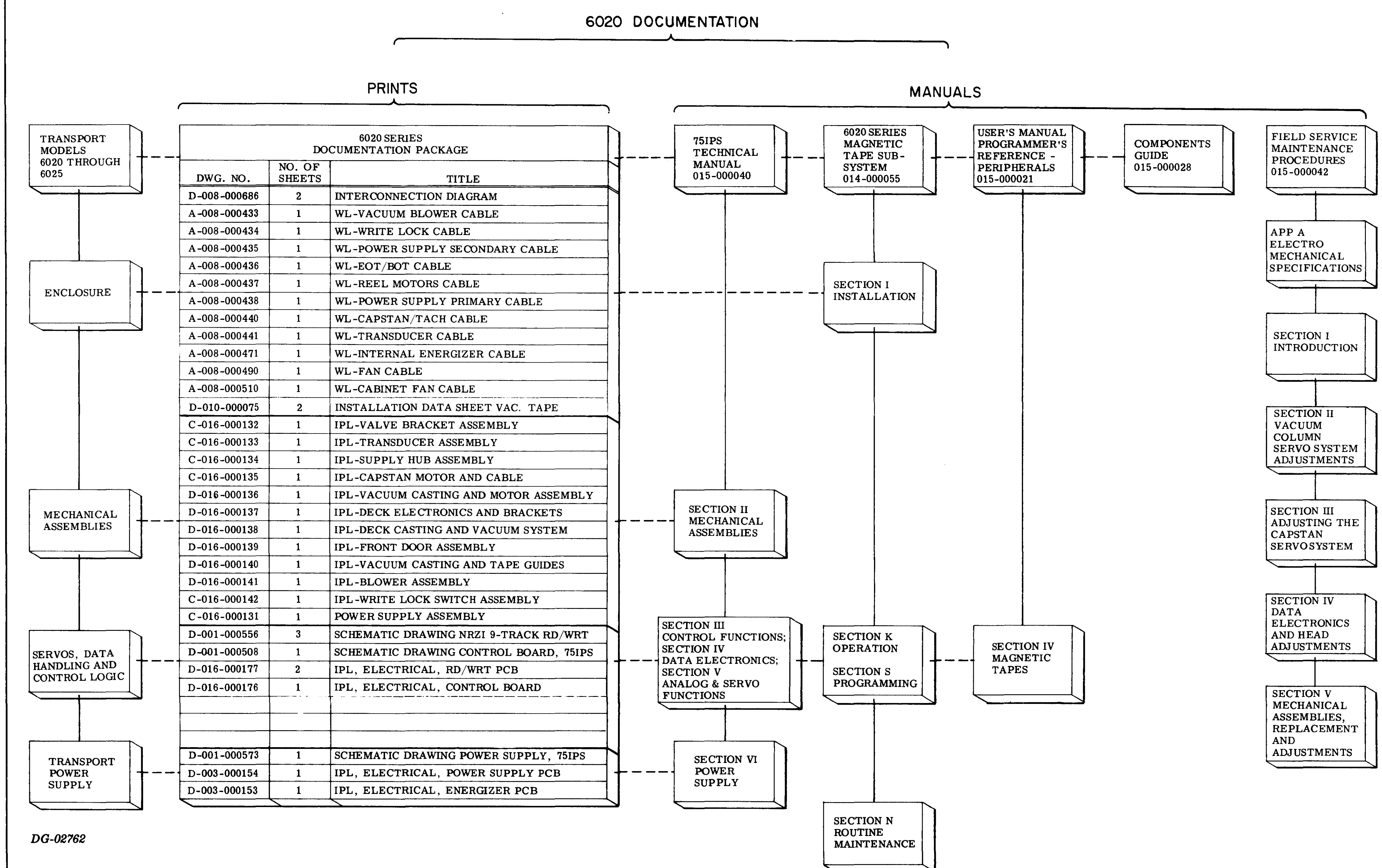
REFERENCES

DGC Print No. 001-000573-10

DOCUMENTATION SUMMARY

Documents that describe the early version are shown on the diagram to the right. Included are the schematic numbers, the illustrated parts lists and the wire lists for the internal cables.

6020 DOCUMENTATION



6020 SERIES DOCUMENTATION PACKAGE

DWG. NO.	NO. OF SHEETS	TITLE
D-008-000686	2	INTERCONNECTION DIAGRAM
A-008-000433	1	WL-VACUUM BLOWER CABLE
A-008-000434	1	WL-WRITE LOCK CABLE
A-008-000435	1	WL-POWER SUPPLY SECONDARY CABLE
A-008-000436	1	WL-EOT/BOT CABLE
A-008-000437	1	WL-REEL MOTORS CABLE
A-008-000438	1	WL-POWER SUPPLY PRIMARY CABLE
A-008-000440	1	WL-CAPSTAN/TACH CABLE
A-008-000441	1	WL-TRANSDUCER CABLE
A-008-000471	1	WL-INTERNAL ENERGIZER CABLE
A-008-000490	1	WL-FAN CABLE
A-008-000510	1	WL-CABINET FAN CABLE
D-010-000075	2	INSTALLATION DATA SHEET VAC. TAPE
C-016-000132	1	IPL-VALVE BRACKET ASSEMBLY
C-016-000133	1	IPL-TRANSDUCER ASSEMBLY
C-016-000134	1	IPL-SUPPLY HUB ASSEMBLY
C-016-000135	1	IPL-CAPSTAN MOTOR AND CABLE
D-016-000136	1	IPL-VACUUM CASTING AND MOTOR ASSEMBLY
D-016-000137	1	IPL-DECK ELECTRONICS AND BRACKETS
D-016-000138	1	IPL-DECK CASTING AND VACUUM SYSTEM
D-016-000139	1	IPL-FRONT DOOR ASSEMBLY
D-016-000140	1	IPL-VACUUM CASTING AND TAPE GUIDES
D-016-000141	1	IPL-BLOWER ASSEMBLY
C-016-000142	1	IPL-WRITE LOCK SWITCH ASSEMBLY
C-016-000131	1	POWER SUPPLY ASSEMBLY
D-001-000556	3	SCHEMATIC DRAWING NRZI 9-TRACK RD/WRT
D-001-000508	1	SCHEMATIC DRAWING CONTROL BOARD, 75IPS
D-016-000177	2	IPL, ELECTRICAL, RD/WRT PCB
D-016-000176	1	IPL, ELECTRICAL, CONTROL BOARD
D-001-000573	1	SCHEMATIC DRAWING POWER SUPPLY, 75IPS
D-003-000154	1	IPL, ELECTRICAL, POWER SUPPLY PCB
D-003-000153	1	IPL, ELECTRICAL, ENERGIZER PCB

DG-02762

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CUT ALONG DOTTED LINE

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- Well written.................YES ( ) NO ( )
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