IBM

Field Engineering
Theory of Operation
(Manual of Instruction)

2302 Disk Storage, Models 1 and 2

227-5863-3

2302 Disk Storage, Models 1 and 2

IBM® Field Engineering
Theory of Operation
(Manual of Instruction)

Issued to: ______________________

Branch Office: ______________________

Department: ______________________

Address: ______________________

If this manual is misplaced, it should be returned to the above address.

2302 Disk Storage, Models 1 and 2

This manual, Form 227-5863-3, is a merge reprint of the previous edition, Form 227-5863-2, and its supplement, S27-0539. This manual supersedes, but does not make obsolete, Form 227-3863-2 and its supplement, S27-0539.

This manual has been prepared by the IBM Systems Development Division, Product Publications, Dept. 455, Monterey and Cottle Roads, San Jose, Calif. 95114. Address comments concerning the manual to this address. Comments may be written on the comment form at the back of this manual.

CONTENTS

IBM 2302 DISK STORAGE MODEL 1 AND MODEL 2

- 2302 Model 1 has one 25-disk module (designated Module 0).
- 2302 Model 2 has two 25-disk modules (designated Modules 0 and 1).
- Each 25-disk module has 50 recording surfaces.
- Each 25-disk module has two accesses.
- Each access addresses any of the 250 data cylinders and one CE cylinder in its access area.

The IBM 2302 Disk Storage is a high-performance magnetic-disk-storage device of exceptional reliability. Its ease of maintenance and reliability result from the use of solid-state components. The 2302 greatly increases the random-access capabilities of most IBM Data Processing Systems.

The 2302 is available with one or two 25-disk modules. Each module has 50 magnetic recording surfaces. These surfaces store format control, clocking control, and system data.

Each module of disks is serviced by two access mechanisms: one for the inside band of 250 tracks, and one for the outside band of 250 tracks. Each access mechanism is provided with a read/write head for each disk surface used; therefore, only horizontal movement of the heads is required to read any track in the access group. As the disks rotate past the heads, the vertically aligned data tracks form concentric cylinders of data.

Data written by the read/write heads of one access group cannot be read by the read/write heads of the other access group. The clock head is stationary, but all other read/write heads are moved in unison by an electro-hydraulic device to any of the 250 cylinder locations of the access group. The heads are held close to the disk by a mechanical linkage and are supported by an air cushion. Any of the data in a cylinder is available without access motion.

CYLINDER CONCEPT

- Each module has 500 cylinders of data.

Since the heads and disk tracks are mechanically aligned one above the other, the vertical alignment can be thought of as a cylinder of tracks (Figure 1-1). With 500 tracks per disk surface, the module is considered to be 500 cylinders of 50 tracks each. A track is therefore defined as a certain portion of the cylinder lying on each surface.

ADDRESSING

- Record addresses are stored with the record.
- 10,000 addressable data tracks are available per access group.
- 20,000 addressable data tracks are available per module.
- 40,000 addressable data tracks are available per file frame.

A record in the IBM 2302 Disk Storage can be identified and located by its specific record address. This record address is stored as the initial bit configuration of any record.

Since there are 250 concentric cylinders in each access group with 40 data tracks per cylinder, there are 10,000 tracks per access group.

The format data on the 2302 disk is flexible and allows records of different lengths to be stored. The function of the format track is to control the length and number of records of all the tracks in any cylinder; this function is similar to that of a program card on an IBM 24 Card Punch. There are 250 format tracks per access group, one for each cylinder in the access group.

DISK STORAGE CONTROL

- 7631 controls up to five 1301s or 2302s.

Data passing to and from the 2302 is controlled by the IBM 7631 File Control unit in the main Data Processing System. These units control, audit, and synchronize up to five 1301s or 2302s in any combination.

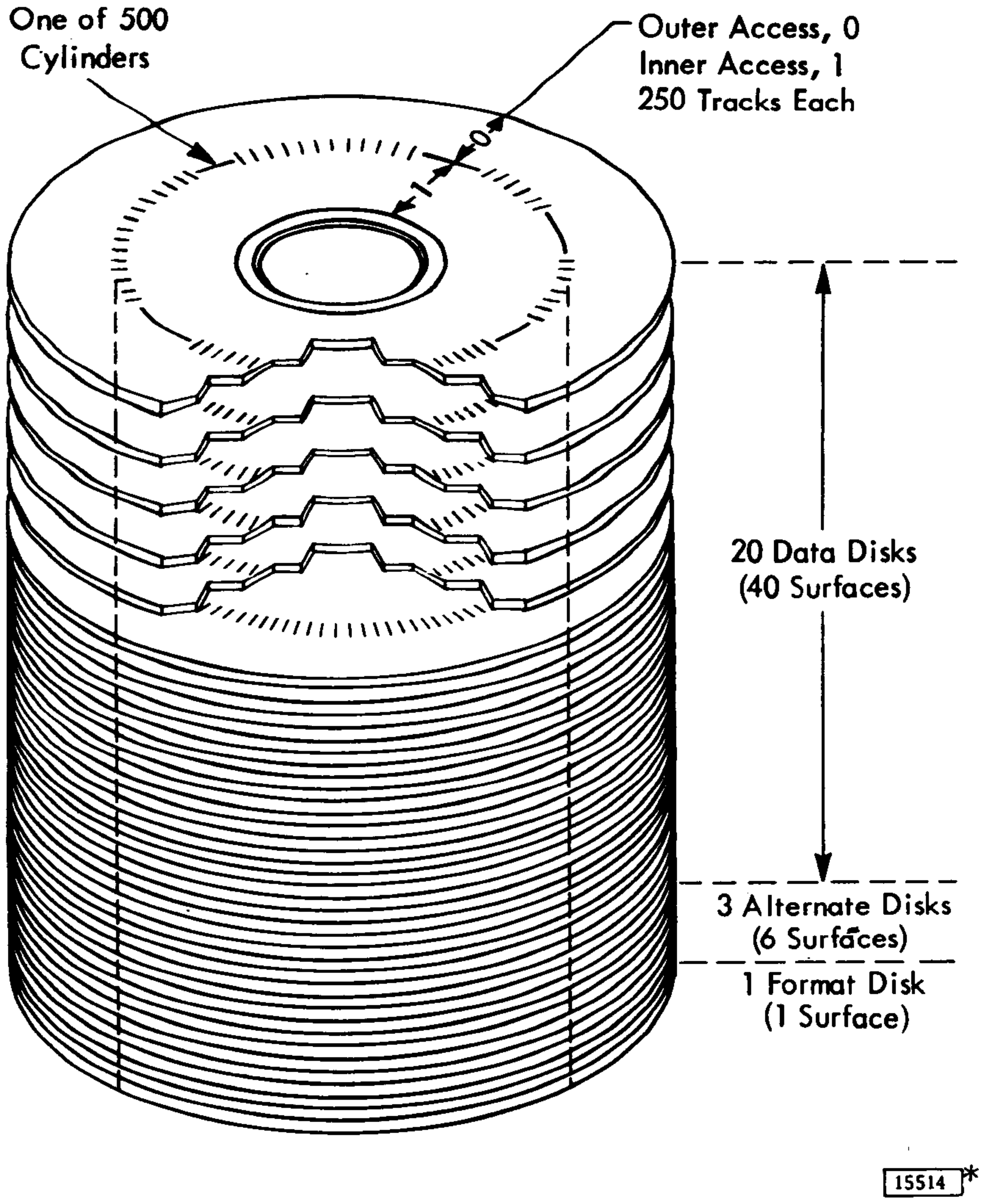


Figure 1-1. Cylinder Concept

SERVICE AIDS

The IBM 2302 contains the following service aids:

- SMS-type plug-in printed circuit cards and gates.
- Standard NOR logic circuits with S-level signals.
- Standard NAND logic circuits with Y-level signals.
- Automatic and manual power-sequence controls.
- Self-checking circuits within the power-sequence unit.
- Two special cylinders for Field Engineering use on each access group (inner for data checking; outer for mechanical adjustment).
- Six identical prewritten clock tracks on the clock disk.
- Alternate data surfaces to replace impaired surfaces.
- Access units that swing out for servicing.
- Electronic gates that swing out to allow accessibility to all cards and wiring.
- A Field Engineering test panel with lights that indicate status and location of the access mechanism.
- Remote CE Box with Seek Repeat feature and CE-Write ability on track 250.

Through the use of these service aids, the IBM Customer Engineer can:

- Manually operate the access mechanism and head selection circuitry.
- Vary power supply voltages to check logic circuitry under marginal conditions.
- Read and write on the special CE tracks to check circuitry.
- Adjust to any one of the six prewritten clock tracks.
- Check hydraulic pressure at various points of the hydraulic system.

CAPACITIES

- Maximum IBM 2302 storage capacity is 117,000,000 alphameric characters with one module, 234,000,000 characters with two modules.
- Each of the 10,000 track locations can store up to 4,533 7-bit characters or 5,850 6-bit characters.
- The 2302 Disk Storage increases the random access disk storage capacities of Data Processing Systems by 45,330,000 7-bit characters or 58,500,000 6-bit characters.

FLEXIBILITY

- Variable length records on the track can be read and written under format control.
- The track format can be altered by the programmer.

NOTE: The illustrations in this manual have a code number in the lower corner. This is a publishing control number and is unrelated to the subject matter.

- Record addresses can be sequential or non-sequential.

- Record addresses can be altered by the programmer.

- Written data can be checked by "reading back."

SPEED

- Access motion time is 50 milliseconds (ms) minimum, 180 milliseconds maximum.

- Rotation time is approximately 34 ms.

- Data transfer of a complete track can be performed in one disk revolution.

- The 2302 consists of two basic systems:
  1. A magnetic system for reading and/or writing of data.
  2. A positioning system for locating the read/write heads at a specified location within the storage area.

- The magnetic system is composed of:
  1. The magnetic disk -- the magnetic medium for the storage of data.
  2. The magnetic read/write heads -- the element that reads or writes data onto or from the magnetic disk.
  3. The read/write amplifiers -- the circuits necessary to control the signals to and from the magnetic heads.

- The positioning system is composed of:
  1. The hydraulic actuator -- the access mechanism that moves the R/W heads to various locations on the magnetic disk surface.
  2. The hydraulic power supply -- the oil pump that supplies the oil pressure to move the actuators.
  3. The solenoid drivers -- the circuitry needed to control the hydraulic actuator.

These systems are packaged in two frames, one mechanical and one electrical (Figure 2-1).

The principal components packaged in the mechanical frame are:

1. The shaft motor that drives and supports the magnetic disks.
2. The power contactor assemblies that distribute all input power within the file.
3. The cradle assembly that supports the shaft motor.
4. A pressurizer that consists of an impeller and filter which supplies filtered air to the disk array.
5. An air compressor that operates the head loading mechanism.
6. The magnetic disk array.
7. Receiver assembly that mounts the read/write heads.
8. The hydraulic actuator.
9. The hydraulic power supply.
10. Power-input cord filter.
11. The clock-head assembly; mounted stationary and adjusted to one of six prerecorded tracks.

The principal components packaged in the electronic frame are:

1. The electrical power supplies that provide power to the electronic and power sequencing circuits.
2. The servicing aids that provide the Customer Engineer with the facilities to manipulate the various file components and to diagnose difficulties.
3. The power sequence circuits that time all power sequencing.
4. The I/O connections.
5. Read/write electronics.
6. Actuator control electronics.

FUNCTIONAL CHARACTERISTICS

The Magnetic System

- Each of the two modules has 25 disks.
- 40 magnetic surfaces are addressed by the access register.
- Each of the 40 data surfaces has 500 concentric tracks.
- Data is written in binary-coded-decimal form.
- Each module has a format surface which has 500 concentric tracks.
- Bit configuration on the format disk can be changed by the programmer.
- Six alternate (flag) surfaces are provided to replace impaired surfaces.
- Data format, and alternate surface read/write heads are moved in unison by the access mechanism.
- Clock head is fixed to the machine frame.
- Read/write electronics are composed of the read amplifier, write drivers, and head switching matrix.

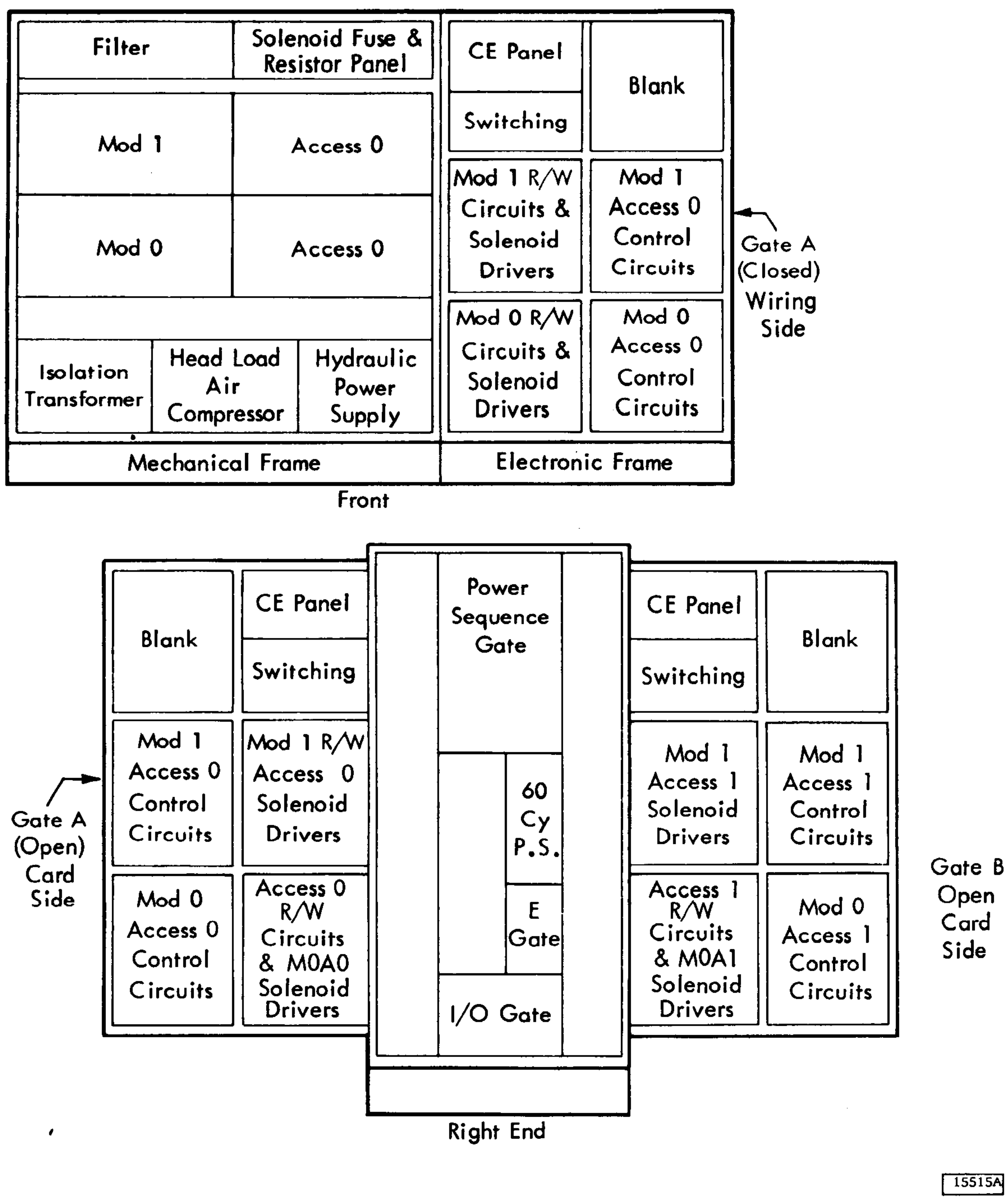


Figure 2-1. Component Orientation

The magnetic disks are arranged in two logical arrays of 25 disks each. Each group of 25 disks is called a module. Each side of the disk is coated and can be magnetized into bit patterns.

Within a module, 40 of the 50 magnetic surfaces can be addressed through the access register in the magnetic system electronics. These 40 magnetic surfaces are called data surfaces. Data is recorded on these disk surfaces in 500 concentric tracks.

Figure 2-2 is an illustration of a data disk with its tracks, addresses, records, and gaps. All data -- alphameric and special characters -- in the 2302 is written in binary coded decimal (BCD). One of the 50 surfaces is addressable by a format line and is referred to as the format surface. The format surface for each access mechanism contains 250 concentric tracks, one for each cylinder. Each format track contains a bit configuration that controls the number of characters in each record and the record address of its respective cylinder.

The system programmer can change the format disk configuration.

Since the record and its address are stored together on the data disk, the more addresses stored, the less room there is for data.

The surface opposite the format is a spare surface and is not addressable.

Six of the 50 magnetic surfaces are alternate surfaces, these alternate surfaces are addressed by a set of three flag lines. They are not addressed through the normal address lines and registers. These extra surfaces have been provided to ensure that each data bit is stored in a magnetically perfect media.

Whenever a physical disk defect is encountered, the entire track is disabled and an alternate surface is specified. This alternate surface is given the disabled track's address.

A complete disk revolution requires a maximum of 34.5 milliseconds (ms) and a minimum of 33.3 ms.

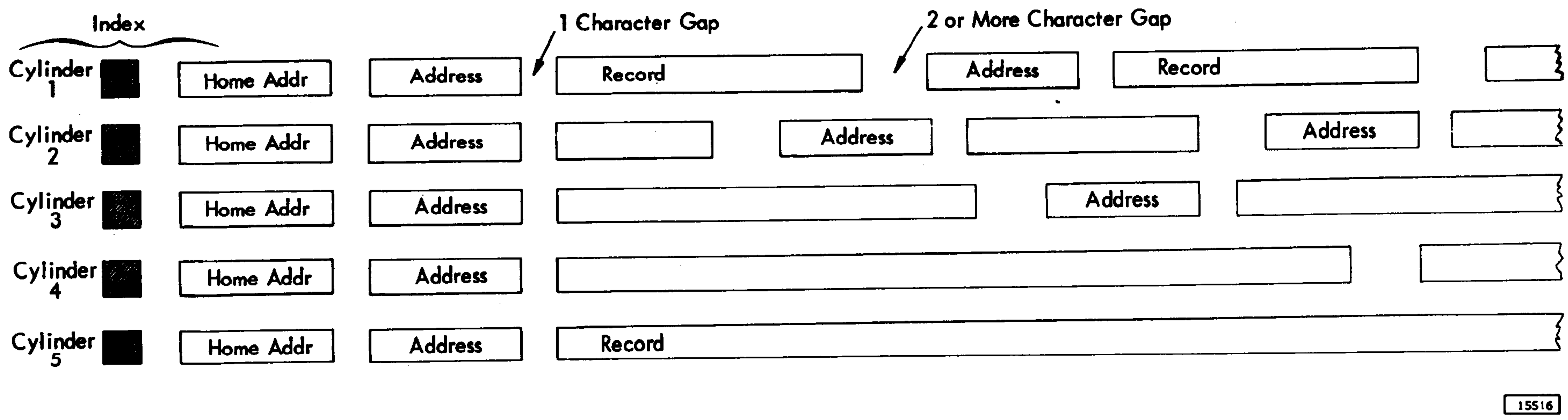


Figure 2-2. Data Disk

The use of 49 surfaces (40 data, 6 alternate, 1 format, 1 spare, and 1 unused) is identical in each of the two modules. The remaining surface is used differently in each of the two modules. In the upper module, the lowermost surface is unused. In the lower module, the lowermost surface is the clock surface. This surface is not addressable.

Read/Write Heads

The access mechanism has 40 data R/W heads, one format head, and from two to six alternate surface heads. The heads are part of a drawer-receiver assembly which is positioned by a hydraulic actuator.

The clock head is not moved by the positioning system. It is mounted on the frame and positioned manually on one of the six clock tracks.

Read/Write Electronics

The read/write (R/W) electronics are composed of the read amplifier, the write driver, and the head switching matrix. The read amplifier and the write driver, under control of the file control unit (FCU) and in conjunction with the selection of a magnetic head, cause the specified head to read data from the disk or cause data to be written on the disk. The R/W heads are capable of operating at a frequency of 2.5 million clock and data bits-per-second (400 nanoseconds per bit).

An SLT (Solid Logic Technology) pre-amplifier is attached on the receiver so that it is near the R/W heads thereby eliminating undesirable line interference.

The write drivers are installed in gates C and D which are physically located between the vertical struts that mount the actuators. The location of these gates is necessary to eliminate undesirable line interference.

Portions of the read/write electronics are shared by all four accesses, therefore, only one access can read or write at a time.

The Positioning System

- R/W heads are all mounted to the receivers.
- Receiver is moved by the hydraulic actuator to any of 250 data cylinders or two CE cylinders.
- Access time is 50 milliseconds (ms) to 180 milliseconds.
- Hydraulic power supply has capacity for 20 accesses per second.

The magnetic R/W heads are mounted on a common receiver block and form a "comb-type" access mechanism.

Each access mechanism is hydraulically driven to simultaneously move all heads horizontally to any one of the 250 data cylinders, or to the service cylinder in its access group.

The two service cylinders (CE cylinders) are the innermost track (250) positions, beyond the data tracks. After the movement is complete, one of the head elements can be selected to read or write.

The time required for adjacent track movements is 50 ms to a maximum of 180 ms. The maximum access time from one track location to any other track location is 180 ms.

The hydraulic power supply, which provides the pressure to move the access, has the capacity to provide oil for a maximum of 20 access motions per second.

POSITIONING CONTROL

- Separate R/W and access controls for each access.
- One access can seek while another reads or writes.

Each access mechanism has its own read/write and access controls so that one access may be in motion while the other is reading or writing. Accesses may move simultaneously, but cannot read and write simultaneously because all four accesses share some common read/write circuitry. The access electronics control the access positioning, select the proper head, maintain the assignment of each individual access mechanism, provide rezero control, and afford manual access control for Customer Engineering aids.

LOGIC FLOW

- Eleven lines run directly between the FCU and each 1302.
- Data and control signals to and from the file pass through a terminator and switching panel (A1 or B1).
- Panels A4, A6, B4, and B6 contain the access control for their respective access.
- Panels A3, A5, B3, and B5 contain the read/write circuits for their respective access.
- Panels C2, C3, D2 and D3 contain the write drivers for their respective access.
- Read amplifiers are available for data, format, and clock signals.

Logic flow is illustrated on System Diagrams Page 01.00.01.0. The logic functions are grouped into blocks and are referenced to logic sections and SMS panel locations.

Lines entering and leaving the 2302 interface are located in the left vertical section of the diagram. Eleven lines run directly between the FCU and each 2302. These are file read data (1), write data (1), format read data (1), clock A and B (2), attention status (4), module zero select (1), and module one select (1). All other lines to the 2302 are connected in parallel with other 2302s, 1301s, or similar devices. All lines and their functions are described under CONTROL LINES.

Data and control signals to and from the file pass through a terminator and switching panel (A1 or B1). The address gates are the only input lines that are not selected by module and access. They are terminated in this panel and go on to the access control unit (ACU) panel. The clock read amplifier is also in this panel. The clock head signal is amplified, selected by module, and driven to the system.

There is an ACU panel (A4, A6, B4, or B6) for each access. This panel accepts the address from the system, signals the actuator to move, and checks the motion time. It also selects the required head indicated by the address.

The read/write panel (A3, A5, B3, or B5) contains the read/write circuits for the data and format surfaces, solenoid driver cards, and motion monitoring circuits under control of the ACU panel. There is a read/write panel for each access.

The write driver panel (C2, C3, D2, or D3) contains 4 write drivers, one for each zone of heads.

The accesses (M0A0 and M1A0) on the front of the 2302 share a common data amplifier, a common format amplifier, and a common format write driver. The accesses (M0A1 and M1A1) on the rear of the 2302 also share a common data amplifier, a common format amplifier, and a common format write driver.

Each module has a read amplifier for the format. A simpler amplifier is used in the clock circuit to supply a clock signal for both modules.

2302 timing pulses originate at the clock, and at the two sets of index heads. The amplified clock lines are sent to the FCU. All file data timing is done in the FCU. The index heads indicate the beginning and end of the tracks.

The valves of the hydraulic actuator are activated by solenoids which are driven by lines from the access register. The other hydraulic inputs consist of the hydraulic detent and rezero controls.

CONTROL LINES

- The control lines consist of coaxial or twisted pair cables which link the 2302 to the FCU.

<u>2302 Control Lines From FCU</u>

<u>Module and Access Select</u> (01.01.01.1 and 01.11.01.1). These four lines select the specific access that is to be used.

<u>Access Register Head Address Set</u> (01.01.01.1 and 01.11.01.1). This line provides a set pulse to set the access register gated data into the head portion of the access register or the flag latches.

Access Register Cylinder Address Set (01.01.01.1 and 01.11.01.1). This line provides a set pulse to set the access register gated data into the cylinder portion of the access register.

Set Access Inop (01.01.01.1 and 01.11.01.1). This line allows an access to be set Inop from the system.

Head Select (01.01.01.1 and 01.11.01.1). This line allows the head portion of the access register to select a head.

Write Gate (01.01.04.1 and 01.11.04.1). This line specifies that a write operation is being performed.

Erase Gate (01.01.04.1 and 01.11.04.1). This line specifies that an erase operation is being performed and will always follow the write gate. Lack of an erase gate signal on this line puts the 2302 into read status.

Store Format (01.01.04.1 and 01.11.04.1). This line allows format data to be stored on the format disk. However, the format key lock-switch must be turned to Write position of the selected module before this line can function properly. If Store Format is not selected, Format Read is operative.

Access Register Gates (01.01.03.1 and 01.11.03.1). These sixteen lines gate the input to the access register latches. A track or head register set then turns all gated latches on, all others off.

Flag Condition 1, 2, 3 (01.01.05.1 and 01.11.05.1). These three lines select an alternate surface head. These lines are not binary coded but are additive (i.e., flag condition 3 selects alternate surface 3, flag conditions 2 and 3 select alternate surface 5, etc.). (Flag 3 is selected by F3 not F1 and F2.).

CE Sync from System (01.01.05.1 and 01.11.05.1). This is a CE unidirectional convenience line from the system to the CE test panel in the 2302.

Write Data (01.01.02.1). This line carries the actual data pulses used to record data or format on the 2302 disks.

Start Stop Sequence (01.50.13.0). This line picks the remote stop relay to begin the start sequence operation. Dropping this line starts the stop sequence. This line is not shown on 01.00.01.0.

Emergency Off (01.50.14.0). This line is activated to pick the Emergency Off contactor. Opening this line at any point will immediately disconnect all ac and dc power. This line is not shown on 01.00.01.0.

Dc Remote Control (01.50.13.1). This line is activated to pick the dc remote relay allowing electronic dc power to be applied to the 2302. Opening this line at any point while the heads are loaded will immediately disconnect electronic dc power. This line is not shown on 01.00.01.0.

Power On (01.50.13.0). This line picks the mainline power contactor of the first 2302 and automatically activates the power-on sequence to all other "on-line" files.

Power On Sequence ac Common (01.50.14.0). This line is the common return between the system and the 2302's for the power-on and emergency-off 24 vac signals.

Machine Reset (01.01.01.1 and 01.11.01.1). This line resets the Attention Status latches in the 2302.

Process Time (01.01.08.1). This line indicates that the file is "being used" by the system and is used to drive the 2302 process-time meter.

2302 Control Lines to FCU

Clock A and B (01.01.01.1). These two lines drive the amplified clock signal to the system.

Mod 0 Acc 0, Mod 0 Acc 1, Mod 1 Acc 0, and Mod 1 Acc 1 Attention Status (01.01.05.1). These four lines indicate that the specific module and access selected have completed a seek that was initiated by a cylinder set from the FCU.

File Read Data (01.01.02.1). This line carries amplified Read data pulses.

File Format Read Data (01.01.06.1). This line carries amplified Format Read data pulses.

Access Ready (01.01.06.1 and 01.11.06.1). This line indicates that the selected access is ready for use.

Early Index (01.01.06.1). This line carries the amplified signal from the Early Index transducer.

Late Index (01.01.06.1). This line carries the amplified signal from the Late Index transducer.

Read Safety (01.01.04.1 and 01.11.04.1). This line indicates that all conditions for safe selection and reading are being met.

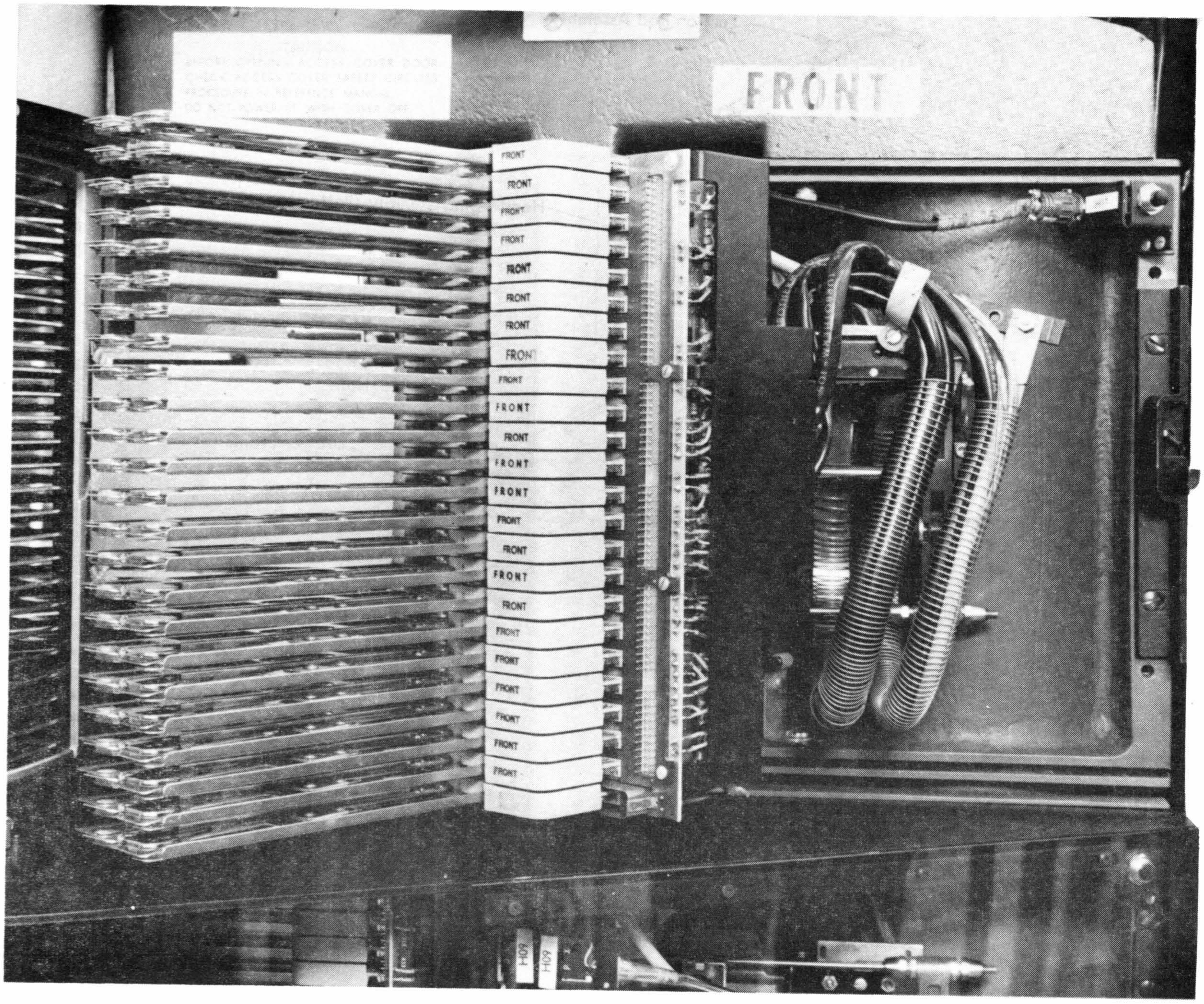
Write Gate Safety (01.01.04.1 and 01.11.04.1). This line indicates that all conditions for safe writing are being met.

CE Sync to System (01.01.05.1 and 01.11.05.1). This is a CE convenience line from the 2302 CE test panel to FCU.

CE Cylinder Located (01.01.07.1 and 01.11.07.1). This line indicates that either of the CE cylinders has been located.

Access Inop Indication (01.01.01.1 and 01.11.01.1). This line indicates that the selected access is Inop, the file is not ready, or no access is selected.

Power On to Next File (01.50.13.0). This line starts the next file start sequence at the time dc supply control is turned on in the originating 2302. This line is not shown on 01.00.01.0.



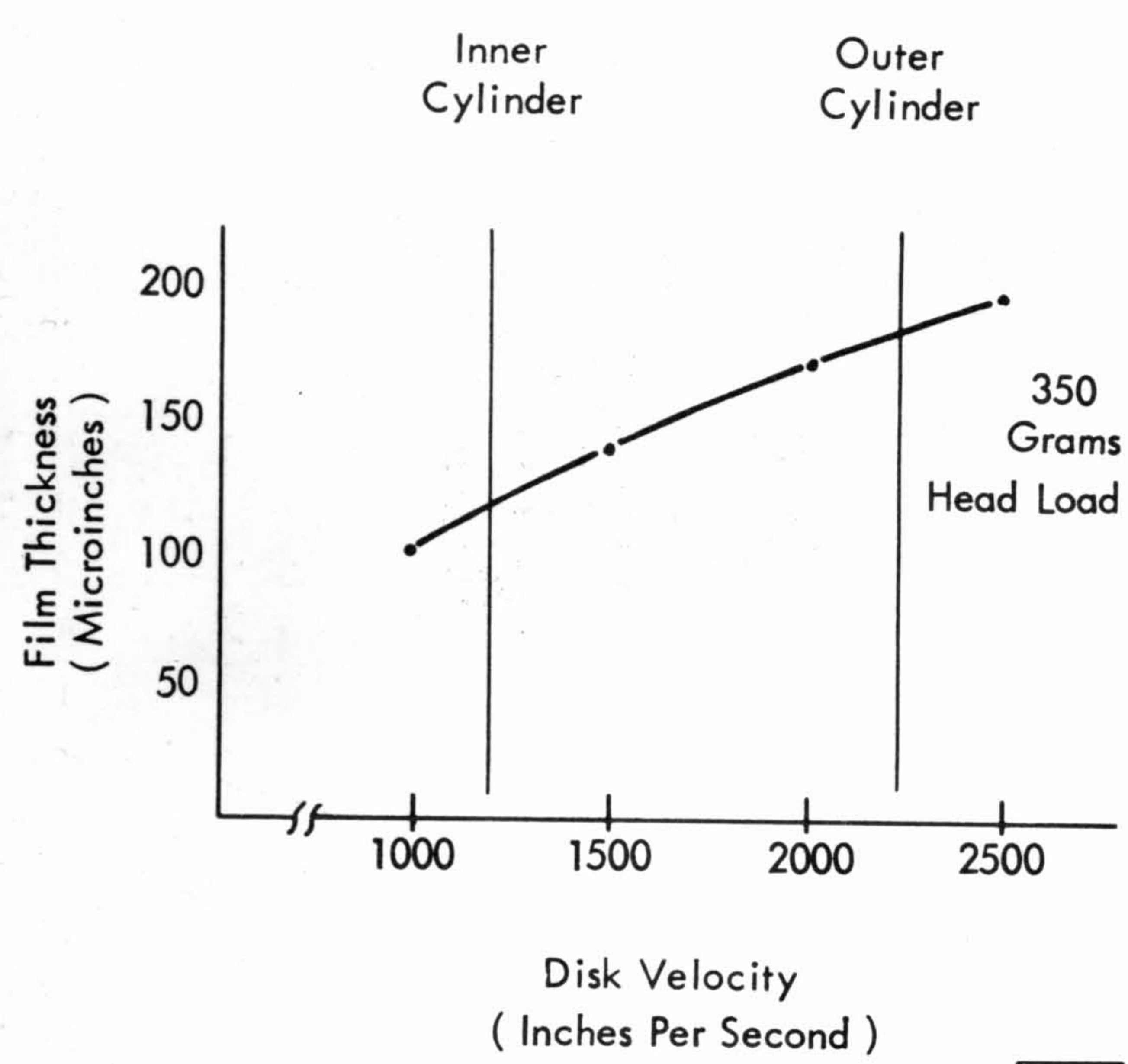
15519

Figure 3-4. Receiver Assembly

The receiver is hinged to the carriage to enable the receiver to swing out for easy inspection and servicing. Two wedge-shaped pins lock the receiver during normal operation. The retaining pin cannot close the interlock switch unless the receiver is locked to the carriage in the normal operating position.

The carriage assembly is positioned by the actuator slave piston rod. The rod is connected to a yoke which in turn is connected by tie-rod to the carriage. In this manner the motion of the actuator is delivered to the carriage assembly.

Carriage motion is guided by ways on the actuator housing. An accurate vertical surface is machined on the carriage to seat the receiver assembly in relation to the disks. The arm stiffeners position the arms in relation to the gaps between the disks, and maintain the relationship of the arms to the machined surface of the drawer assembly.



15521

Figure 3-5. Head Flying Characteristics

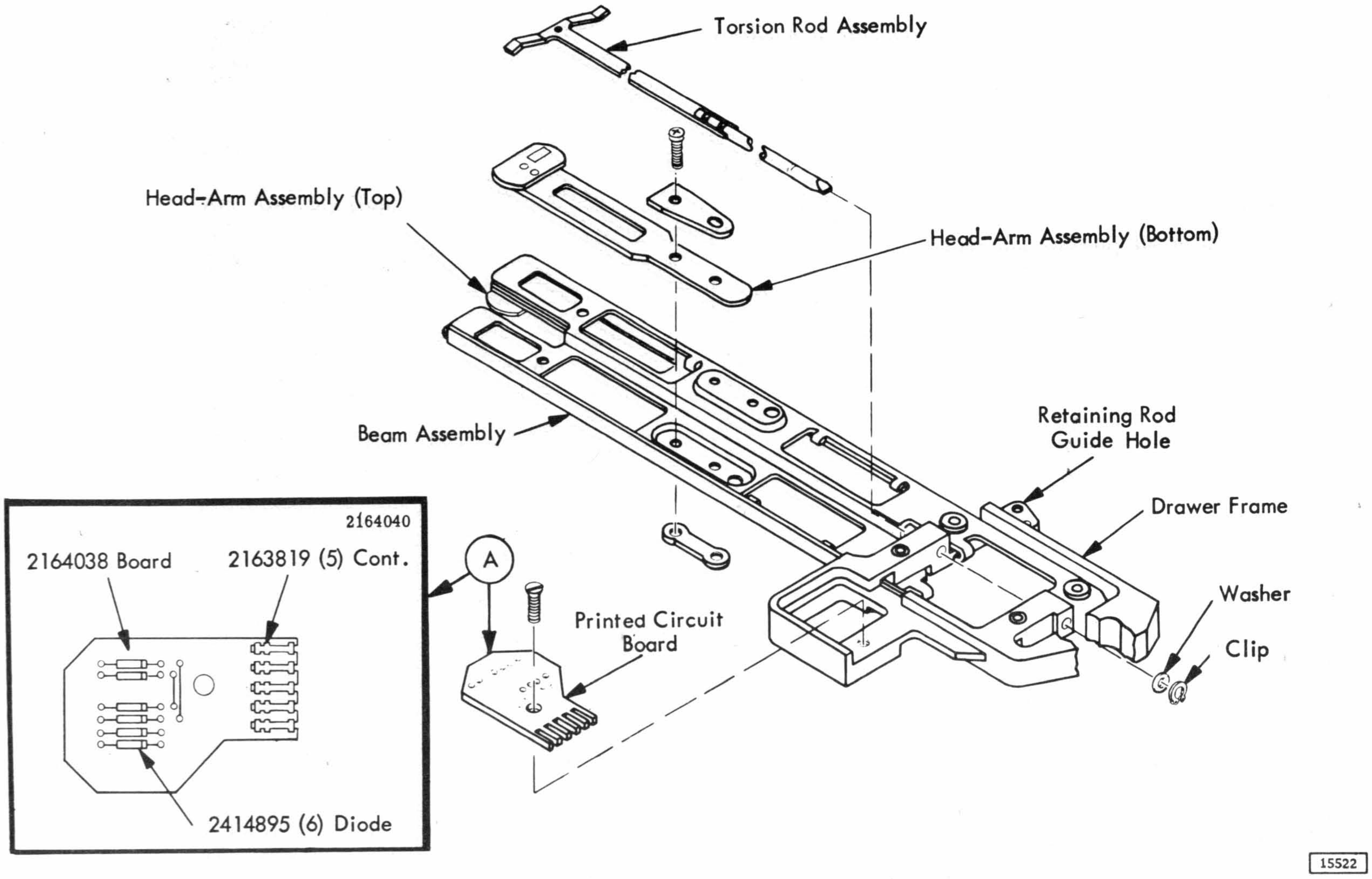


Figure 3-6. Drawer Assembly - Exploded

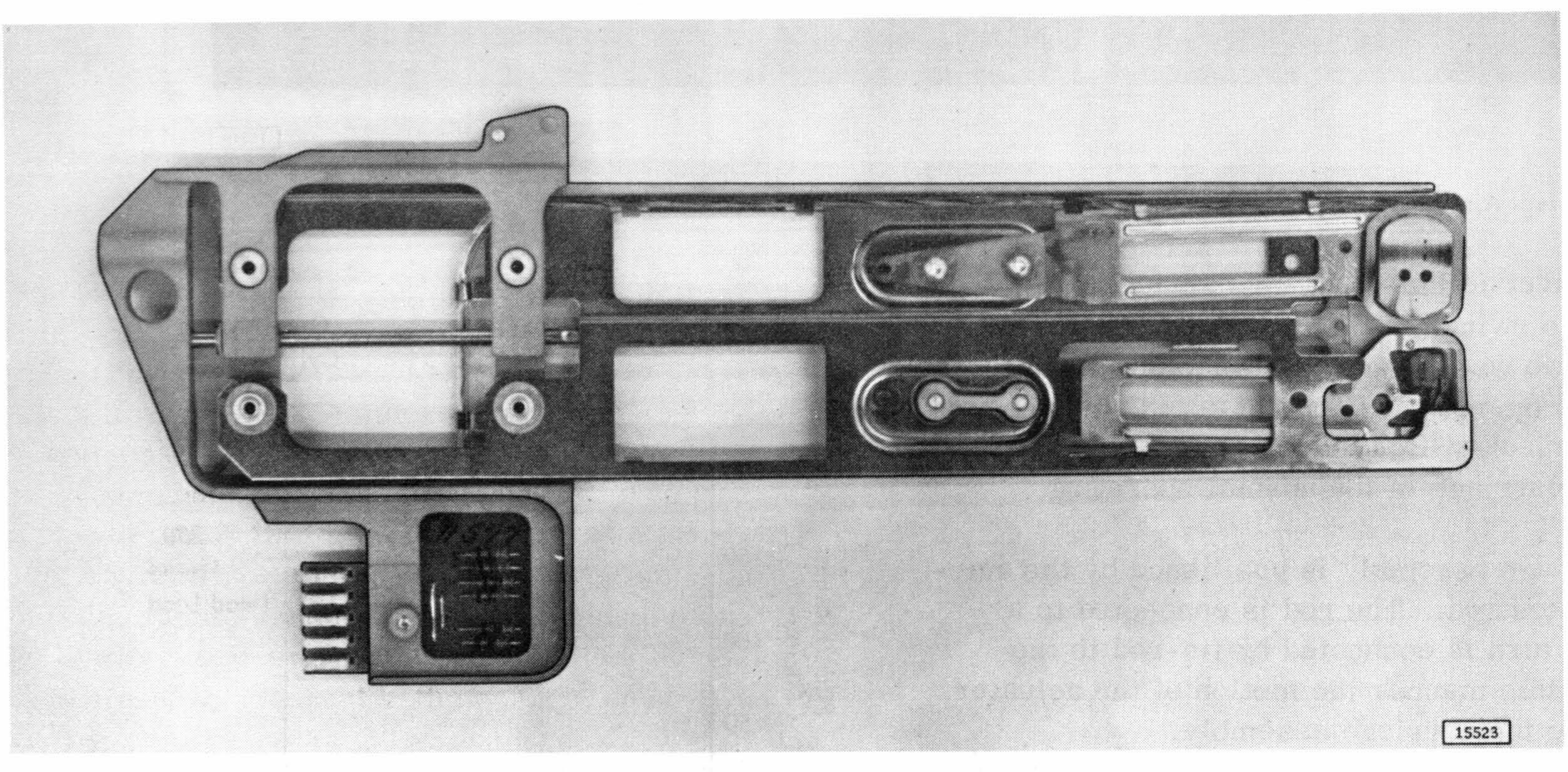


Figure 3-7. Drawer Assembly

Pairs of heads in the drawer are loaded by twisting a torsion bar. The 24 beryllium copper torsion rods in one receiver are actuated by a single stroke of a linkage in the head load mechanism (Figure 3-8). This stroke is delivered to the linkage by an air actuator operated by a small air compressor (Figure 3-9). Loss of the air supply collapses the actuator and unloads the heads.

The torsion rods are twisted by a nominal load of 350 grams. This nominal load achieves the nominal head-to-disk spacing.

Circuits in the 2302 prevent the heads from being loaded while the actuator is in motion.

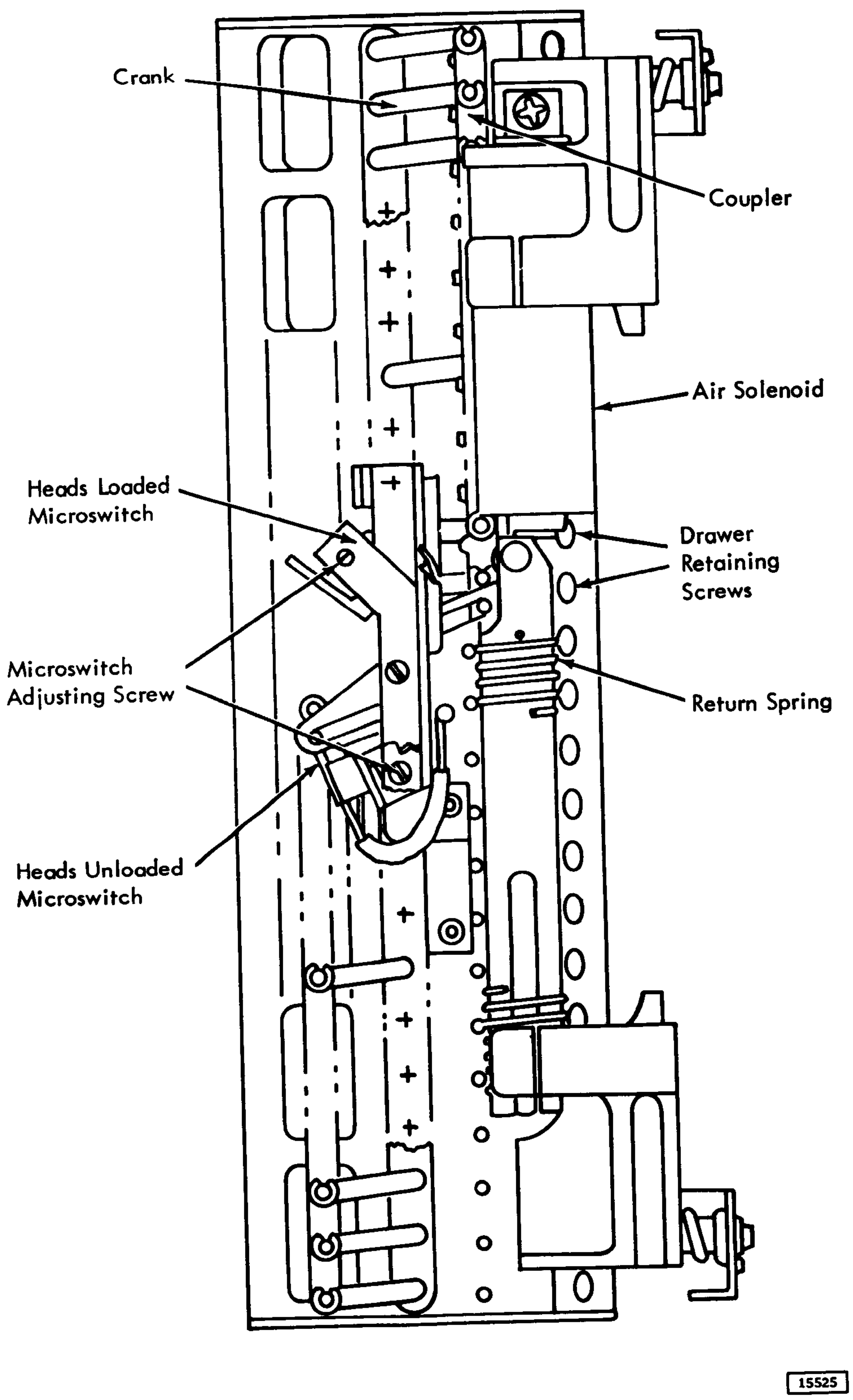


Figure 3-8. Head Load Mechanism

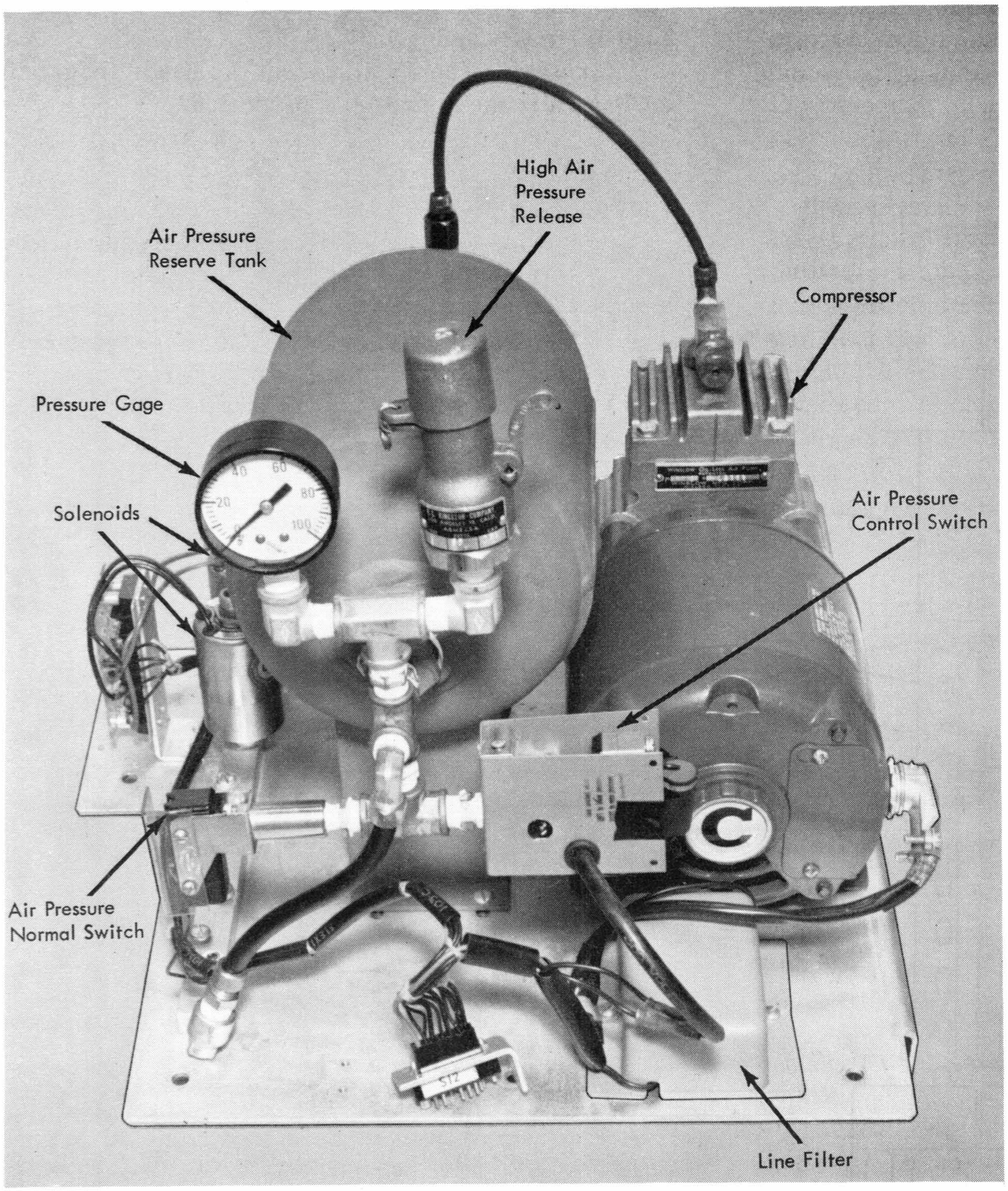


Figure 3-9. Compressed Air Supply

HYDRAULIC POWER SUPPLY

- The hydraulic power supply furnishes the constant oil pressure required for operation of the actuators.
- The hydraulic power supply has the capacity to provide oil for a maximum of 20 random movements-per-second of the four hydraulic actuators.

Description

Each access mechanism is hydraulically actuated and moves the receiver assembly and all heads horizontally to any of the 250 cylinder positions in the access group. After movement has been completed, the head elements of the module are normally activated by electronic switching.

The components of the hydraulic power supply (Figure 4-1) are indicated in the following list:

1. Three horsepower, three phase, 208 v to 240 v, 60 cps induction motor.
2. Tandem oil pump supplying approximately two and four gallon per minute (gpm) deliveries from its primary and secondary section.
3. Accumulator (located at the hose submanifold).
4. Manifold.
5. Sump.
6. Oil filters.
7. Drip tray.
8. System pressure regulator.
9. Low pressure regulator.
10. Float switch.
11. Over temperature switch.
12. Temperature controls.
13. Sump oil lever indicator.
14. System pressure gage and manual shutoff valve.
15. Cooling system gage.
16. Oil cooler.

The hydraulic power supply is located at the bottom of the mechanical frame directly below the vertical strut that mounts the actuator (Figure 4-2).

The following hydraulic and electrical connections to the hydraulic power supply are required:

1. A 550 psi output port and a sump return line in a common disconnect.
2. Bleeder lines, one from each actuator.
3. An electrical cable.

Operation

- Hydraulic power supply is turned on during power-on sequence.
- Two pumps on a common shaft are used.
- Correct oil temperature is maintained by an oil cooler and thermal valve.
- System pressure is controlled by an adjustable relief valve.

Figure 4-3 illustrates the major power supply components and functions. The actuator assembly is shown enclosed in broken lines.

The motor is switched on during auto-start sequence shortly after the disk array reaches operating speed, and remains running during normal operation.

The motor is switched off manually during auto-stop sequence, or is turned off automatically if the oil temperature exceeds 130° F or if the oil level drops below the required limit. There is also an overload switch in the motor circuit which turns off the supply.

The motor armature and the two and four gpm pumps are on a common shaft. The oil inputs to both pumps come through a common strainer from the sump. The pump outputs flow through the separate check valves to the oil filter and actuator. The oil filter output branches to the actuator and high pressure relief valve. The branch line from the four-gpm pump connects to the warm up and transfer valve.

The oil cooler thermal valve is operated by a thermal element. The valve normally channels the four gpm output through the oil cooler. If the oil temperature drops below 123° F., the thermal element closes the thermal valve which forces the oil through the low pressure relief valve to sump. As the oil heats up, the thermal valve opens and the cooler again functions. Oil is cooled by circulation through a radiator in an air stream supplied by the hydraulic power supply motor and fan.

There are three oil filters in the system:

1. A 40-micron sump strainer filter.
2. A two-micron system paper filter.
3. A system combination paper and steel filter.

The adjustable system pressure relief valve provides a high pressure relief to sump.

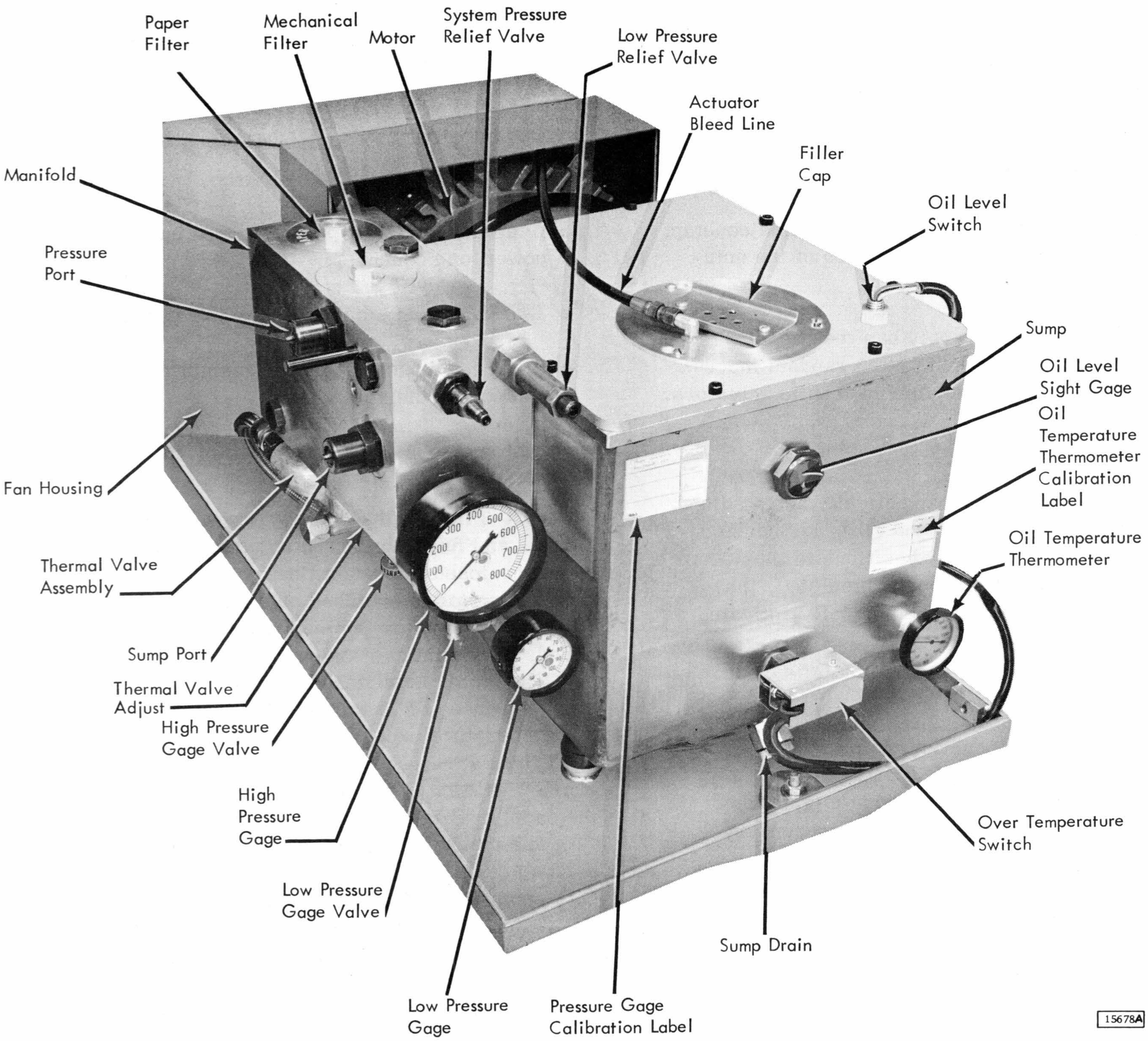


Figure 4-1. Hydraulic Power Supply

The float switch closes at proper oil level turning on an indicator on the CE panel.

The manifold supplies the necessary communication ducts between external ports and internal components. It serves as a mount for the serviceable and adjustable components of the system.

The sump is open to atmospheric pressure and acts as the reservoir for system oil.

The sump pressure regulator check valve is not adjustable and is located in the common sump return line at the sub-manifold. It maintains the sump line pressure at approximately 5 psi to prevent oil draining from the actuator.

The manual valve is closed to check system pressures. The manual valve should be opened during operation to reduce gage wear and to provide a bleed orifice to drop accumulator pressure when the hydraulic power supply is turned off.

HYDRAULIC POSITIONING SYSTEM

- The hydraulic positioning system consists of the glob adder and piston adder systems enclosed in the actuator assembly housing.

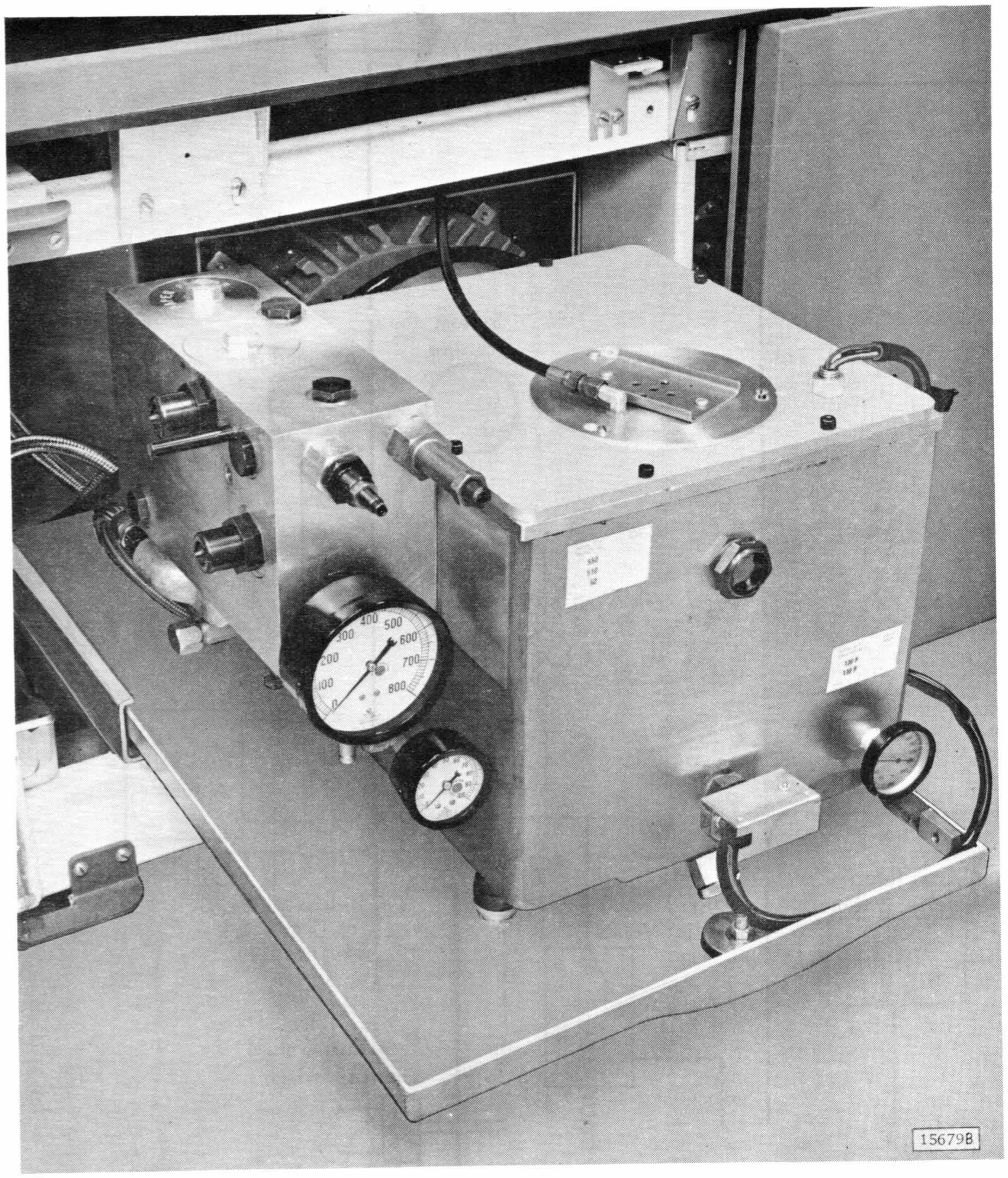


Figure 4-2. Hydraulic Power Supply in Servicing Position

- The function of the adders is to move the actuator shaft to one of 250 tracks.

- Piston and glob adders are controlled by electrically operated valves.

Description

There are two actuators for each of the two modules. The actuator rod moves the receiver assembly on the carriage ways. Retraction of the actuator shaft drives the heads toward the center of the disk array.

The piston adders supply the 1, 2, 4, 4', and 10 increments, and the glob adders supply the 20, 40, 40', 40", and 100 increments.

Special combinations of piston adders and glob adders are used to develop the remainder of the increments (Figure 4-4).

The hydraulic valves are controlled by solenoids picked by solenoid driver circuits. Hydraulic balance is obtained by using a single pressure differential force on opposite ends of the pistons. The glob adder moves the actuator shaft within its cylinder to any combination of physical track positions, 20, 40, 100, and 200. The actuator shaft can be detented at 20 track increments. The piston adder moves the entire actuator shaft and cylinder with its detent to all track positions between the glob adder positions. The piston adder requires no detent because it is a positive locating device.

Actuator

- The actuator is a self-contained device for accurately and consistently positioning the heads on a desired track.

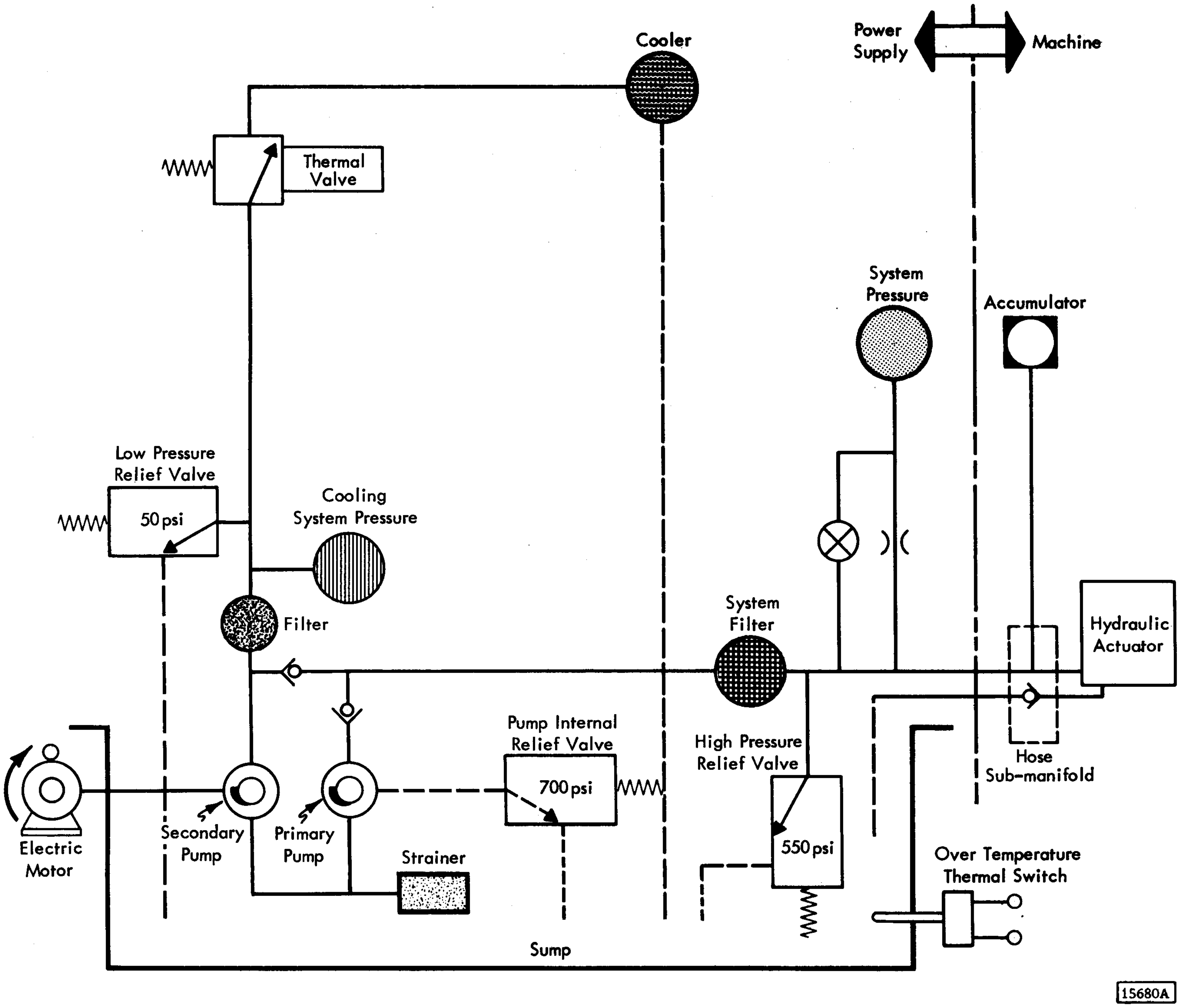


Figure 4-3. Hydraulic Power Supply - Functional Diagram

- Three hydraulic connections from the actuator to the hydraulic power supply are required: system pressure (550 psi), sump return (5 psi), and an air bleed line.

- 30 access control electrical connections are required by the actuator.

The actuator consists of a hollow casting containing a set of five glob adder cylinders and five pistons with matching control valves, a set of five piston adder assemblies with matching control valves, a shuttle valve, a detent with its operating piston and control valve, a slave cylinder and piston (actuator shaft), a pressure regulating valve, and a detent detector. Each glob cylinder has a return bypass check valve on each end.

Three connections from the actuator to the hydraulic power supply are required: 550 psi, sump (5 psi), and an air bleed line.

There are 30 access control electrical connections (Figure 4-5), 5 pair for the piston adder solenoids, 5 pair for the glob adder solenoids, 1 pair for the detent solenoid, 1 pair for the rezero solenoid, and 3 pair for the detent detector (three coils).

The actuator is mounted on a vertical strut alongside the disk array. The inside face of the housing is bolted against the strut. The 550 psi line and the sump (5 psi) line enter the back of the actuator through a hole in the strut. The air bleed line is connected

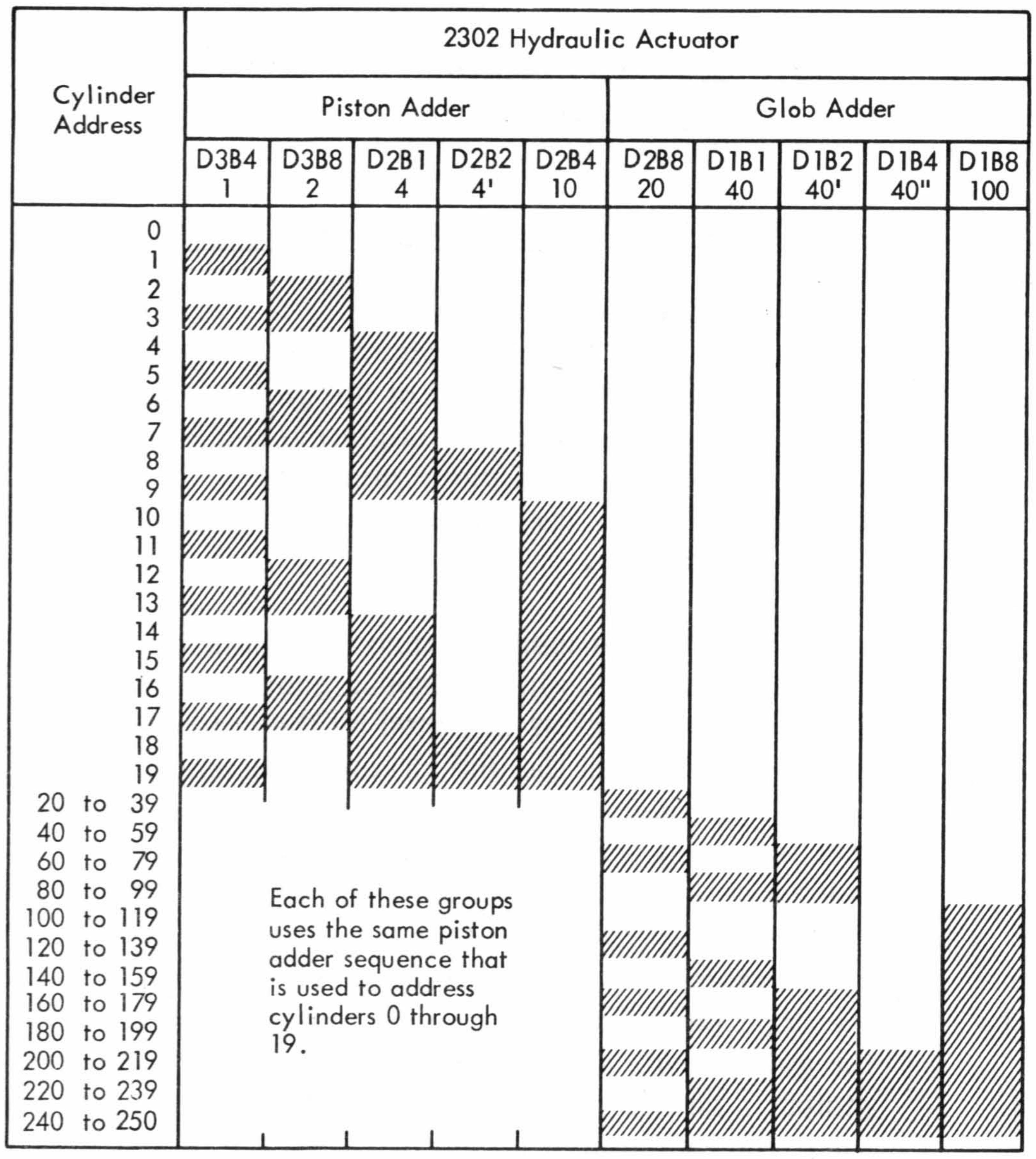


Figure 4-4. Hydraulic Adder Decode Chart

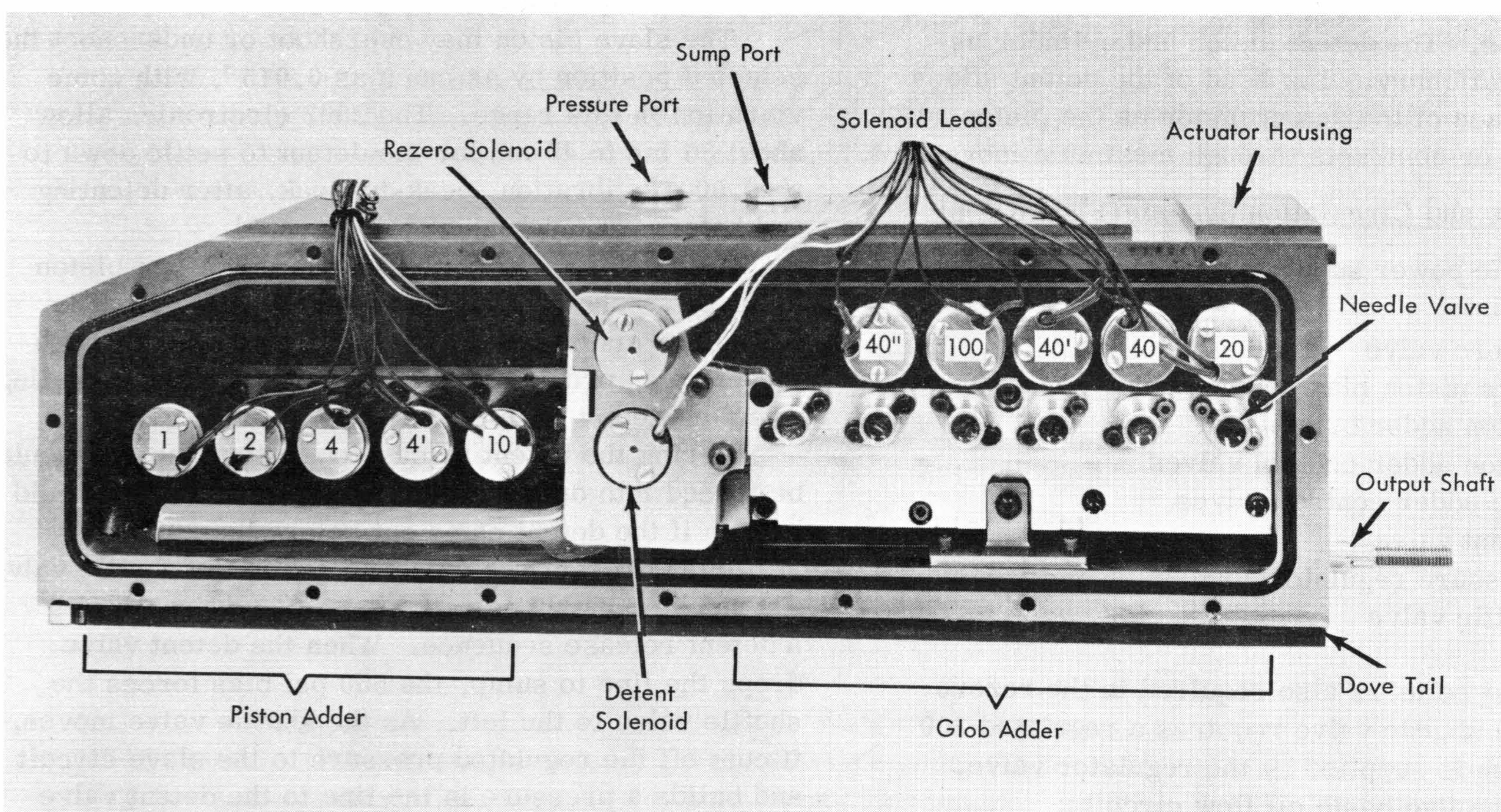


Figure 4-5. Hydraulic Actuator Solenoids

15751

to the top lid. The outer face is machined flat with a V groove along the top and bottom edges to support a sliding carriage. This groove is called the carriage way. The receiver assembly, including the heads and arms, is mounted on the carriage. The actuator shaft is connected to the carriage with an adjustable yoke and two flexible rods, and is extended and detented in the outermost detent notch when the heads are over the outer cylinder (00).

The actuator shaft is an extension of the slave piston within its slave cylinder. The slave piston moves to the left (viewed from the front of the machine) whenever a glob solenoid is picked, and moves to the right when one is dropped. The distance moved (in increments of 20 tracks) corresponds to the amount of oil added or subtracted to or from the slave circuit by the glob adders. When glob movement is complete, the detent piston engages the detent in one of the 13 circumferential grooves on the slave piston.

The entire slave cylinder and detent assembly is moved to the right or left in its floating sleeves by the piston adders. Piston and glob adder motion may be simultaneous. Piston adder motion is opposed by a bias piston with a system pressure of 550 psi. System pressure also biases the slave piston shaft.

The area of the piston adder bias piston is one-half the pressurized area of the piston adders and the pressurized area of the shaft end of the slave piston is one-half that of the head end. These area differences give the force differences necessary for effective bias. The detent piston and cylinder assembly is stationary. The head of the detent slides across the face of the detent piston as the piston adder expands or contracts through maximum movement.

Oil Pressure and Circulation System (Figure 4-6)

The hydraulic power supply maintains 550 psi to the following points:

1. Rezero valve
2. Slave piston bias
3. Piston adder bias piston
4. Piston adder control valves
5. Glob adder control valves
6. Detent valve
7. Pressure regulator
8. Shuttle valve

A 350 psi relief is also required in the rezero circuit. The shuttle valve requires a regulated 300 psi bias which is supplied by the regulator valve.

There are five basic oil flow circuits:

1. Detent control
2. Regulator
3. Glob adder control
4. Actuator rezero
5. Piston adder control

Detent and Regulator (Figures 4-6 and 4-7)

The detent has two functions:

1. To lock the slave piston and cylinder together at the end of the glob stroke, and to correct for slight overshoot or undershoot of the piston rod.
2. To allow recalibration of oil in the slave cylinder.

The detent is inserted through a hole in the slave cylinder. Its movement is controlled by the detent piston which is actuated by the detent control valve. As long as the detent valve solenoid is picked, 550 psi is connected to the detent piston and the detent is seated. Figure 4-6 shows the detent in a released position. It can be seen that the 550 psi is blocked in the valve and that the detent cylinder is open to the sump. System pressure is allowed past the right end of the slave piston, through grooves in the guide head, and into the detent sleeve. The slave piston is sealed on the left end. This pressure drives the detent and detent piston out when the detent cylinder is connected to the sump. The difference in cross sectional area between the detent and the detent piston allows this bias to be overcome when the piston is at system pressure.

The slave piston may overshoot or undershoot the selected position by as much as 0.015", with some vibration in this range. The 2302 electronics allow about 36 ms to 45 ms for the detent to settle down to a ±0.0001" vibration, peak-to-peak, after detenting and before a ready signal is generated.

A detent detector is located in the detent piston cylinder as shown in Figure 4-6. A brass shaft in the hollow piston has an iron tip that moves through three coils, providing magnetic coupling and signaling when the detent is in or out.

During the detent release operation, no oil should be forced into or out of the slave circuit. This could happen if the detent came out before the 300 psi regulated pressure is disconnected in the shuttle valve. Therefore the shuttle valve must move first during a detent release sequence. When the detent valve drops the line to sump, the 550 psi bias forces the shuttle valve to the left. As the shuttle valve moves, it cuts off the regulated pressure to the slave circuit and builds a pressure in the line to the detent valve and piston. This pressure is sufficient to delay the detent release until the shuttle valve has completed

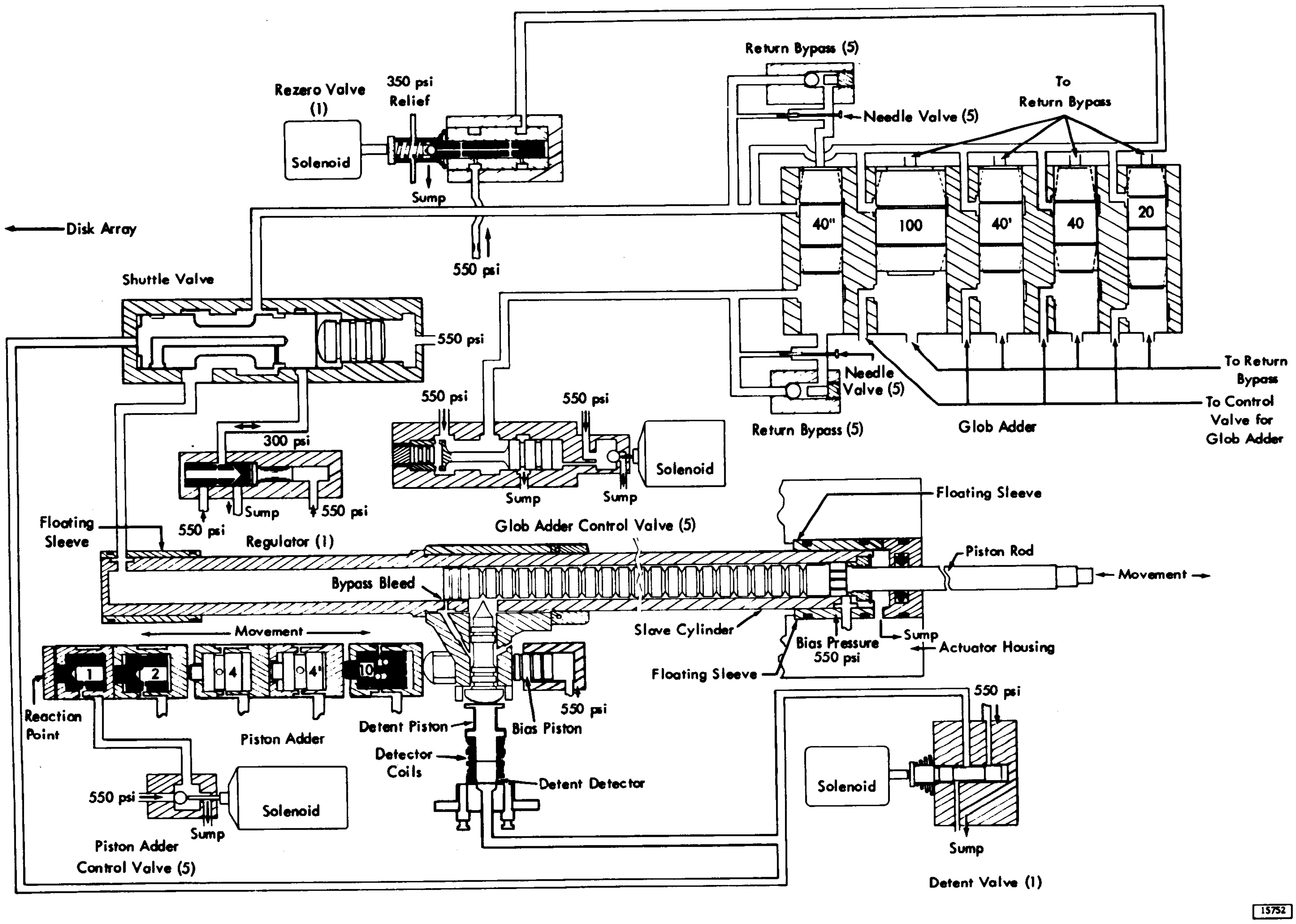


Figure 4-6. Hydraulic Positioning System

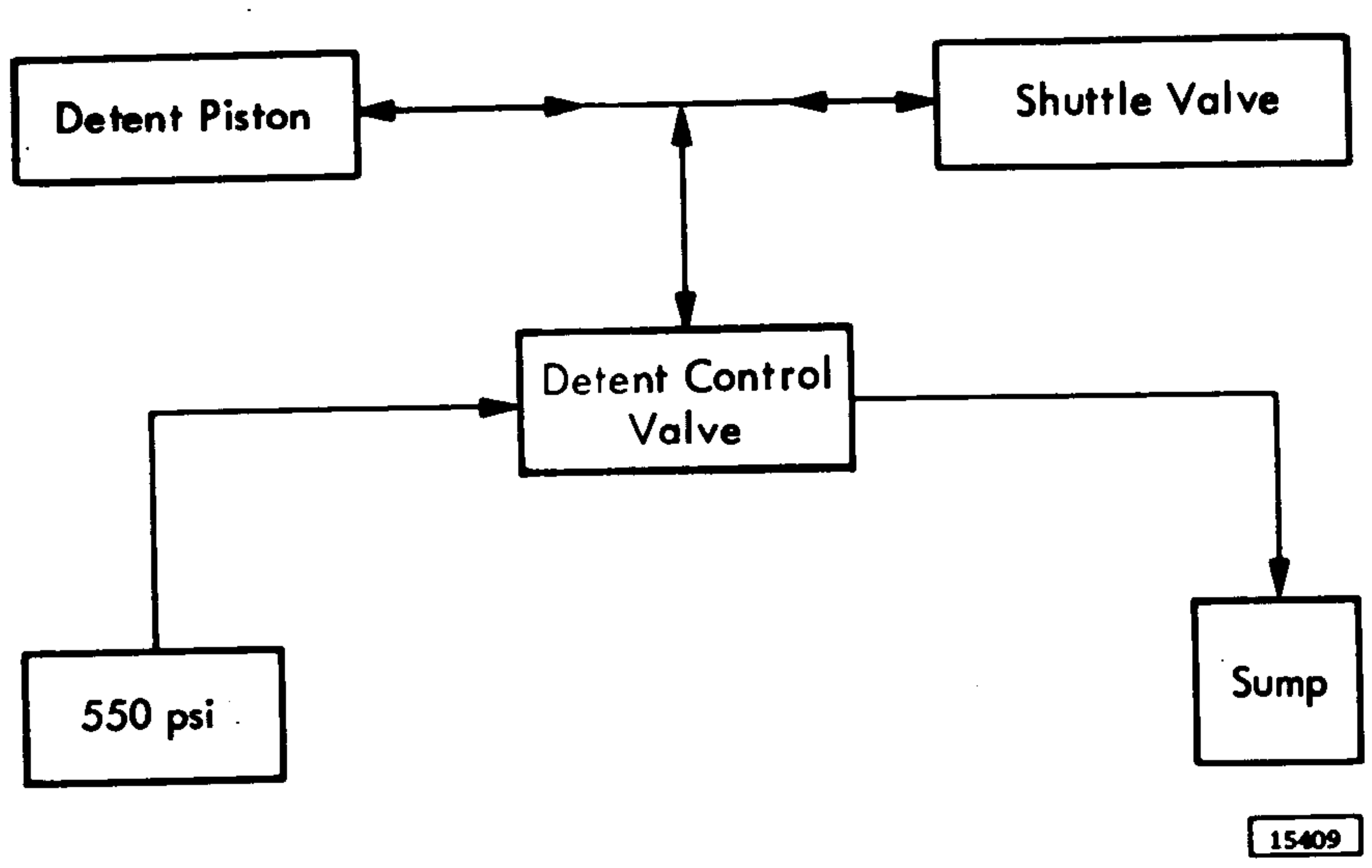


Figure 4-7. Detent Control

its stroke to the left and completely cut off the 300 psi to the slave circuit. Ideally, the shuttle starts its motion before the detent begins to move, thus allowing enough time for the operation. Another function of the shuttle valve is to supply oil to recalibrate the slave circuit after detenting has been accomplished. When the detent is driven in under pressure, the shuttle valve is pushed to the right and cuts off the glob adders and connects the regulated 300 psi to the slave cylinder.

The regulator valve (Figure 4-8) has two functions:

1. To supply a source of oil to recalibrate the slave cylinder after "detent in" in the event of minor leakage in the actuator.
2. To balance the forces on the slave piston when detenting.

The difference in area between the two ends of the pistons was calculated to give the 300 psi output. In the position shown in Figure 4-6, the output is balanced against the right-hand input. If the output pressure drops, the piston moves to the left and opens another 550 psi input. If the output increases, the piston moves to the right and drains some oil to the sump until the pressure decreases to 300 psi then the sump is cut off. The piston is continually oscillating to maintain this 300 psi.

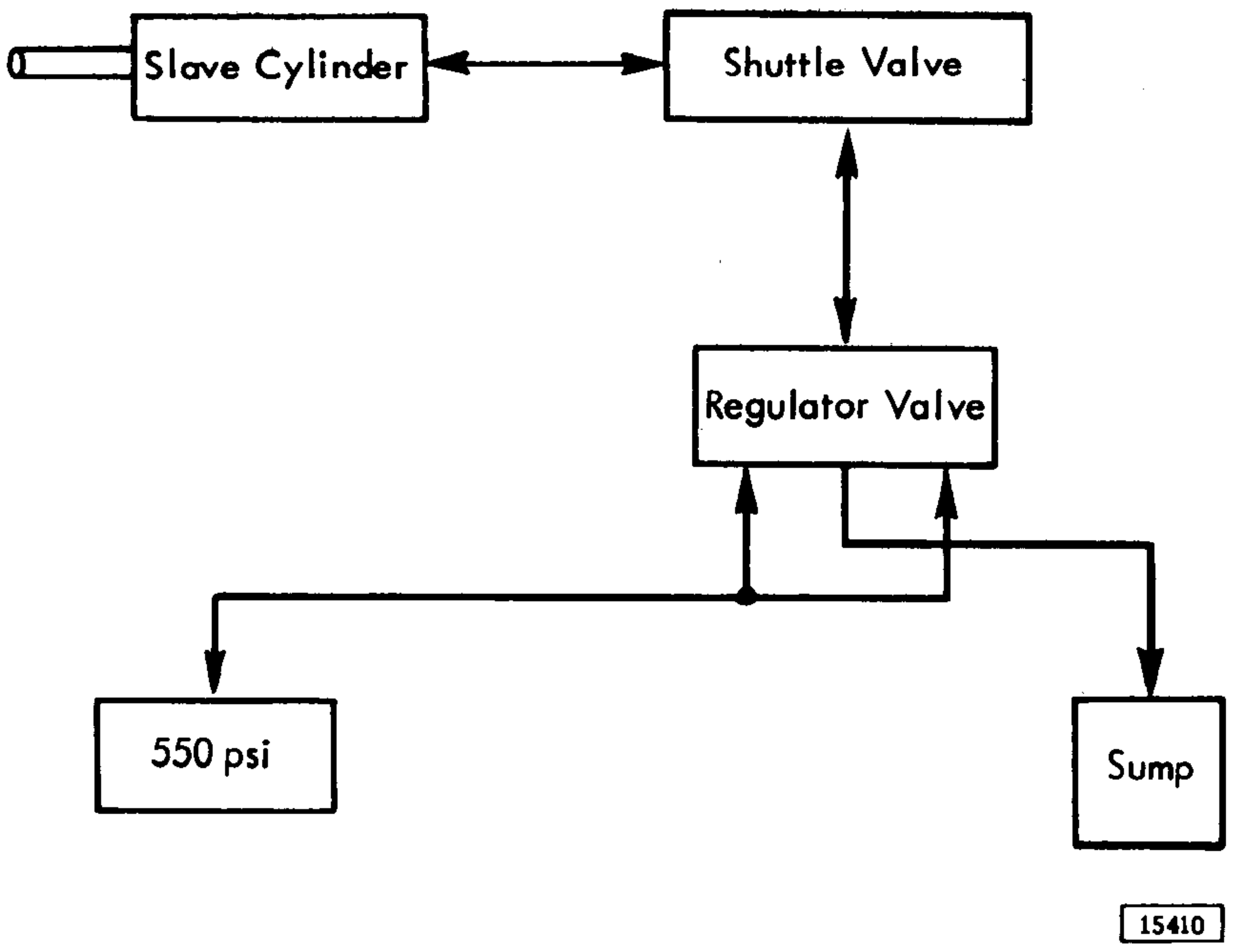


Figure 4-8. Regulator Valve

The detenting sequence can be summarized as follows (Figure 4-6):

1. The detent solenoid is picked, closing the sump port and applying 550 psi to the detent piston and shuttle valve.
2. The detent piston force overcomes the detent bias, seats the detent while the shuttle valve moves to the right, disconnects the glob adder line and connects the regulated 300 psi to the slave cylinder.
3. The oil in the slave cylinder is recalibrated through the shuttle valve. (This is necessary to compensate for any leakage in the actuator).
4. The detent detector signals detent in.

The detent release sequence is as follows:

1. The detent solenoid is dropped.
2. The spring returns the valve, cutting off 550 psi and opening the detent and shuttle valves to the sump.
3. The shuttle valve, biased by 550 psi, begins its stroke to the left, disconnects the 300 psi from the slave cylinder, and connects the glob adder line.
4. Detent bias pressure drives the detent out.
5. Detent detector indicates detent out.

Glob Adder Functions (Figures 4-6 and 4-9)

The five glob adder cylinders are shown in the "pressure to cylinder" condition with 550 psi connected to the bottom of the cylinder by the glob adder control valves. The shaft is fully extended within the slave cylinder. The control solenoids are all dropped. When one is picked, 550 psi is cut off and that glob cylinder is switched to sump. After the detent release sequence, bias pressure on the slave piston moves it to the left, moving oil in the slave circuit through the shuttle valve, through the upper return bypass, and into the cylinder, forcing the piston down. The lower bypass return check valve closes and oil leaves via the plant-adjusted needle valve. The needle valve and tapered slots cause the required damping at the end of the stroke. Similar damping action occurs when the cylinder is switched to pressure and the piston moves upward. When a control solenoid has been energized and is then dropped, the sump is cut off and 550 psi is switched in. After detent is released, the 550 psi at the glob cylinder forces the piston up, moving oil out of the cylinder, through the shuttle valve and overcomes bias pressure on the slave piston and moves it to the right.

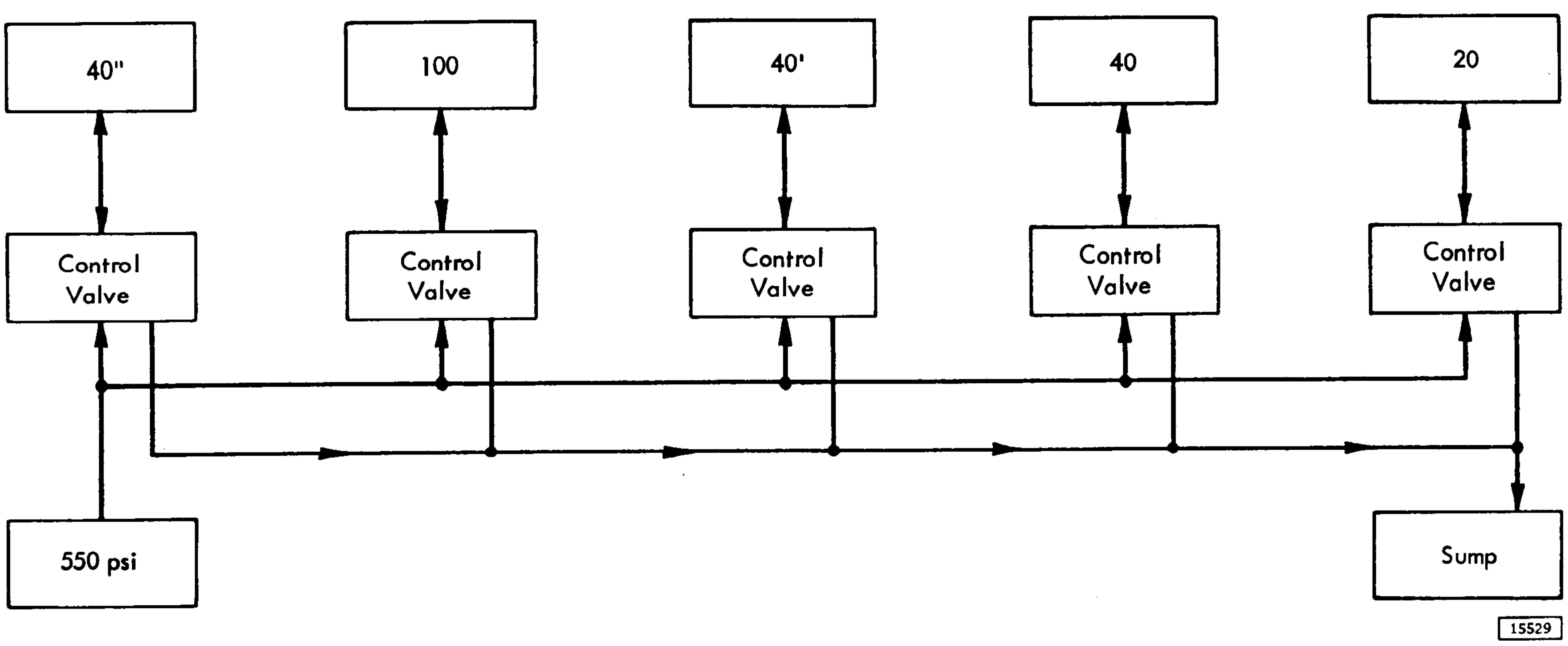


Figure 4-9. Glob Adder Control

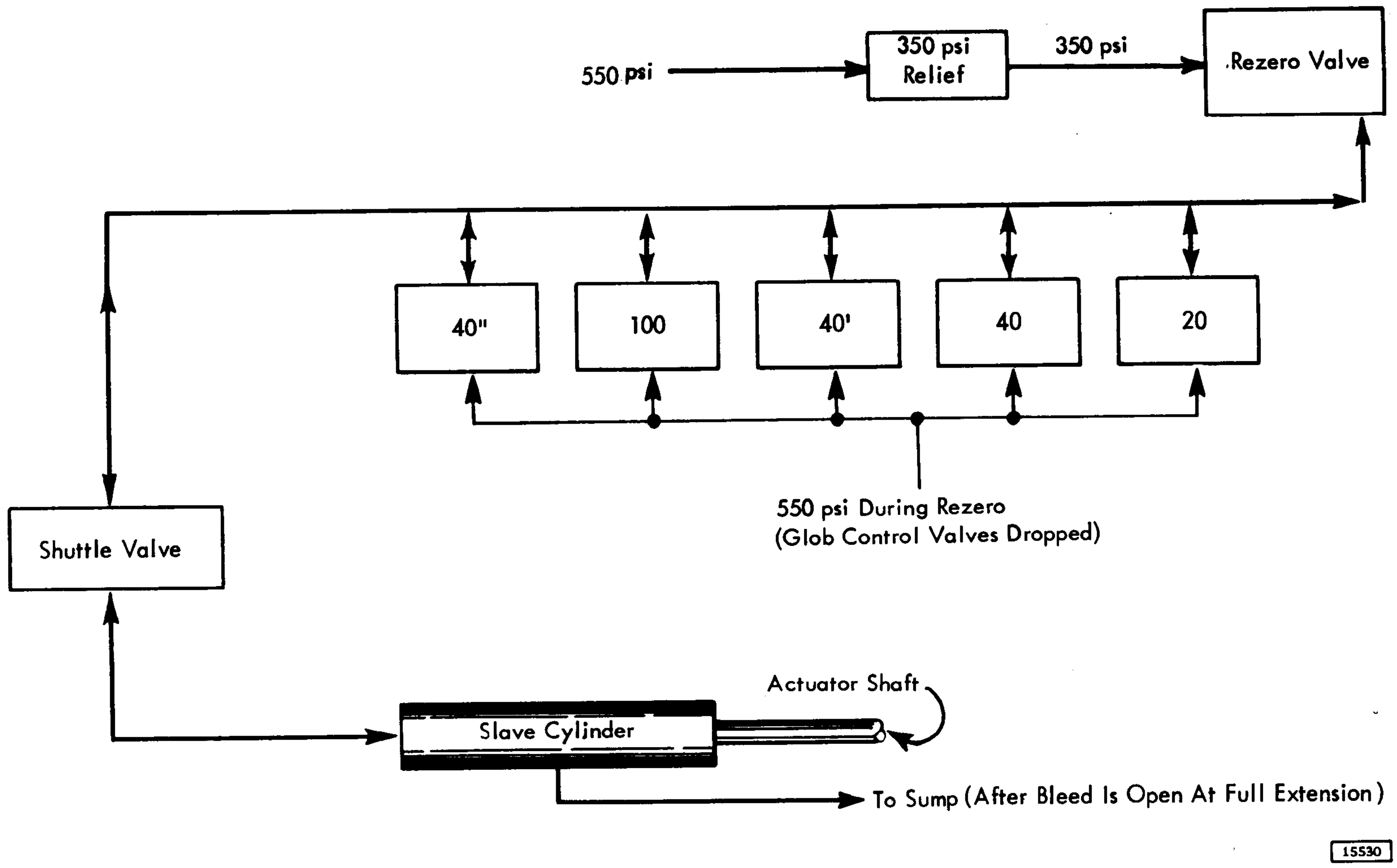


Figure 4-10. Actuator Rezero

The valves of the glob cylinders are in a relationship of 20, 40, 40', 100, and 40" from right to left. The numbers correspond to the number of tracks that will be passed by the heads when the corresponding glob solenoid is picked. The 20, 40', 40" and 100 are picked together to give 200.

There are five glob adder control valves that are hydraulically biased, and solenoid controlled. In a dropped condition, 550 psi is connected to the glob cylinders and the sump is blocked; the reverse is true in a picked condition. The solenoid action is assisted by hydraulic pressure.

Rezero (Figures 4-6 and 4-10)

If a small amount of air accumulates in the slave circuit, or if the glob adder gets out of step with the slave piston, the problem is corrected by the rezero circuit. Rezero occurs automatically during a power sequence ON. Rezero also occurs any time the inner CE cylinder switch condition does not agree with the access register or when an invalid address is recognized or when the access fails to "arrive" at a specified cylinder within the allotted time. Rezero causes the oil to circulate through the slave circuit thereby removing air bubbles and recalibrating the quantity of oil in the slave cylinder.

When rezero is initiated, all glob solenoids are dropped and the rezero solenoid is picked. The detent is held until the globs drop, then the detent is released. The rezero valve connects 350 psi to the slave circuit. The pressure exerted is enough to slightly overcome the slave piston bias, causing it to drift at a controlled rate to a 0.030" over-travel position to the right for A0, or left for A1 (outer CE cylinder). At this point, a system pressure bypass bleed port is opened to the slave circuit. This port can be seen to the left of the detent in Figure 4-6. This port allows the fluid to pass through the detent cylinder and out to sump return. Normal service is restored by detenting. The detent forces the actuator to the left, closing the bleeder port. The rezero solenoid then drops and the valve is spring returned, closing all ports.

Piston Adder Function (Figure 4-6 and 4-11)

The five piston adders are physically placed end to end in the same cylinder. They normally function together to provide actuator positions of 19-track increments or less. The piston assemblies are coded as 1, 2, 4, 4', and 10. To move from one track position to an adjoining track position requires a movement of 0.010", the maximum piston adder extension required, therefore, is 0.190". Piston adder movements of up to 9 tracks (not involving the ten piston) can be accomplished within 50 ms. A 550-psi pressure is supplied to the interior of the piston

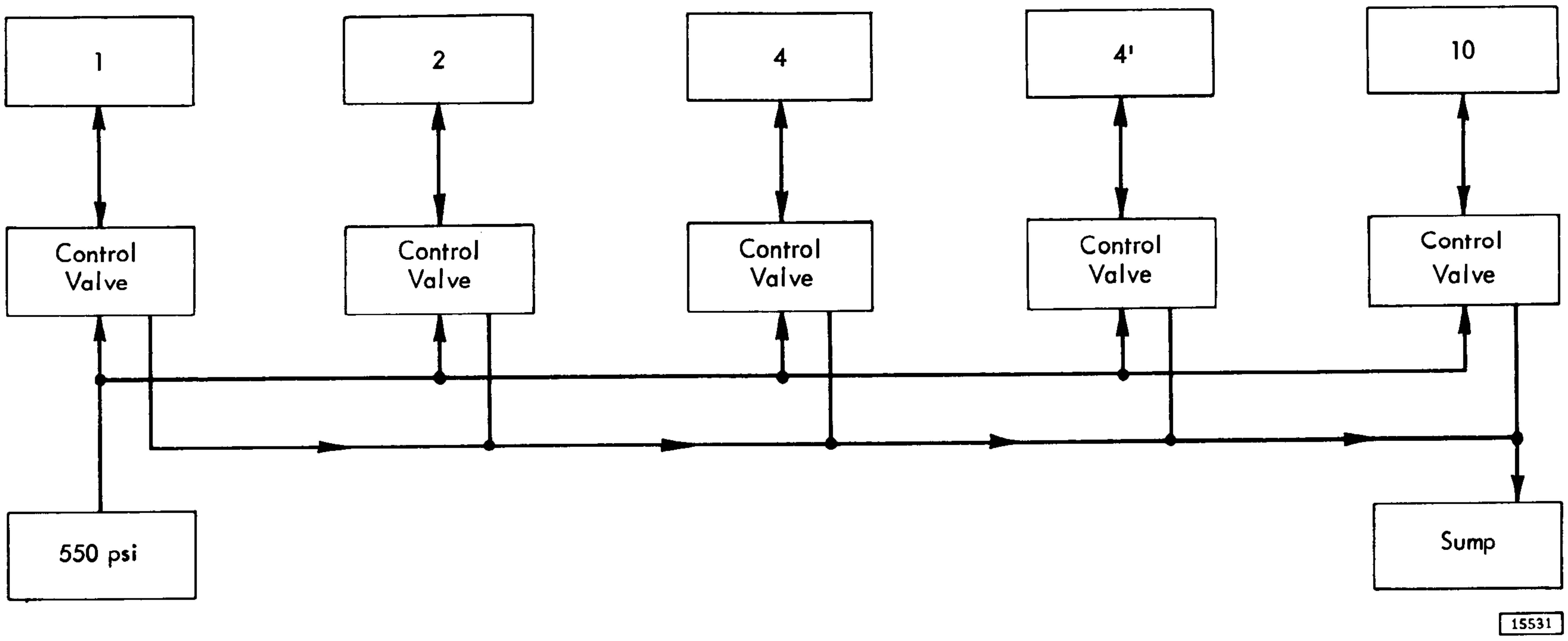


Figure 4-11. Piston Adder Control

capsule assemblies by a set of five piston adder control valves that are solenoid operated.

Assemblies 1, 2, and 10 are identical in structure. The 4 and 4' assemblies are identical and each contains internal ball check valves. The 4 capsule is cutaway in Figure 4-6 to show detail. Oil flows into these pistons through the bottom port and out the top. Structural details of the ports, that are not shown in the illustration, restrict the flow of oil as the internal member approaches either maximum position, thereby causing damping. This damping is not adjustable. Each capsule assembly is a piston within a sliding cylinder. When pressure is applied to the core, the piston (inner member) protrudes beyond the cylinder (outer member) pushing the cylinder and all other assemblies on its right to the right. This motion is transmitted to the slave cylinder assembly and the actuator shaft by the detent assembly.

When a control valve solenoid is picked, the 550 psi to the expanded piston is cut off and the sump path is opened. The piston adder bias piston pressure then collapses the selected piston, and the actuator shaft moves to the left. In the dropped condition, as shown in Figure 4-6 for piston one, 550 psi is applied and the piston overcomes the bias and expands one track position.

- Standard SMS NOR and NAND logic is used.

- Systems diagrams are divided into sections by panel designation.

Functional descriptions of the SMS cards used in the 2302 are included in the components circuits section of the system diagrams. Additional information concerning electronic, diode, and transistor theory can be found in the following IBM Field Engineering Manuals of Instruction: Transistor Component Circuits (Form 223-6889), Transistor Theory Application (Form 223-6783), Transistor Theory Illustrated (Form 223-6794).

The 2302 logic circuitry is standard SMS NOR logic using S-level (0 v high -12 v low) signals and NAND logic using Y-levels (0 v high, 6 v low) signals. Various other logic blocks and levels are used for read/write, line drivers, and other special operations.

The terms "trigger" and "latch" are generally used synonymously in this manual and throughout IBM. These terms are not normally intended to designate the actual type of component used.

The systems diagrams are divided into sections by panel designation (Figure 5-1). For example, panel 1 in gate A is panel A1. The system diagrams for this panel are in section 01.01.XX.X. The system diagrams for panel A5 are in section 01.05.XX.X. The system diagrams for panel B1 are in section 01.11.XX.X., etc.

Most of the descriptions in this manual are written for a single module machine.

Panels A3, and A4 in a dual module machine are the same physically and logically as panels A5 and A6 respectively except in the rare cases that duplicate circuits are not required. Circuits that are not duplicated (e.g., data read amplifier and format read/write circuits) are in panel A5 because A5 is the panel associated with the first module installed. Panels B1, B3, B4, B5, and B6, are "mirror" images of panels A1, A3, A4, A5, and A6, respectively, except in the rare cases that duplicate circuits are not required (Figure 5-2).

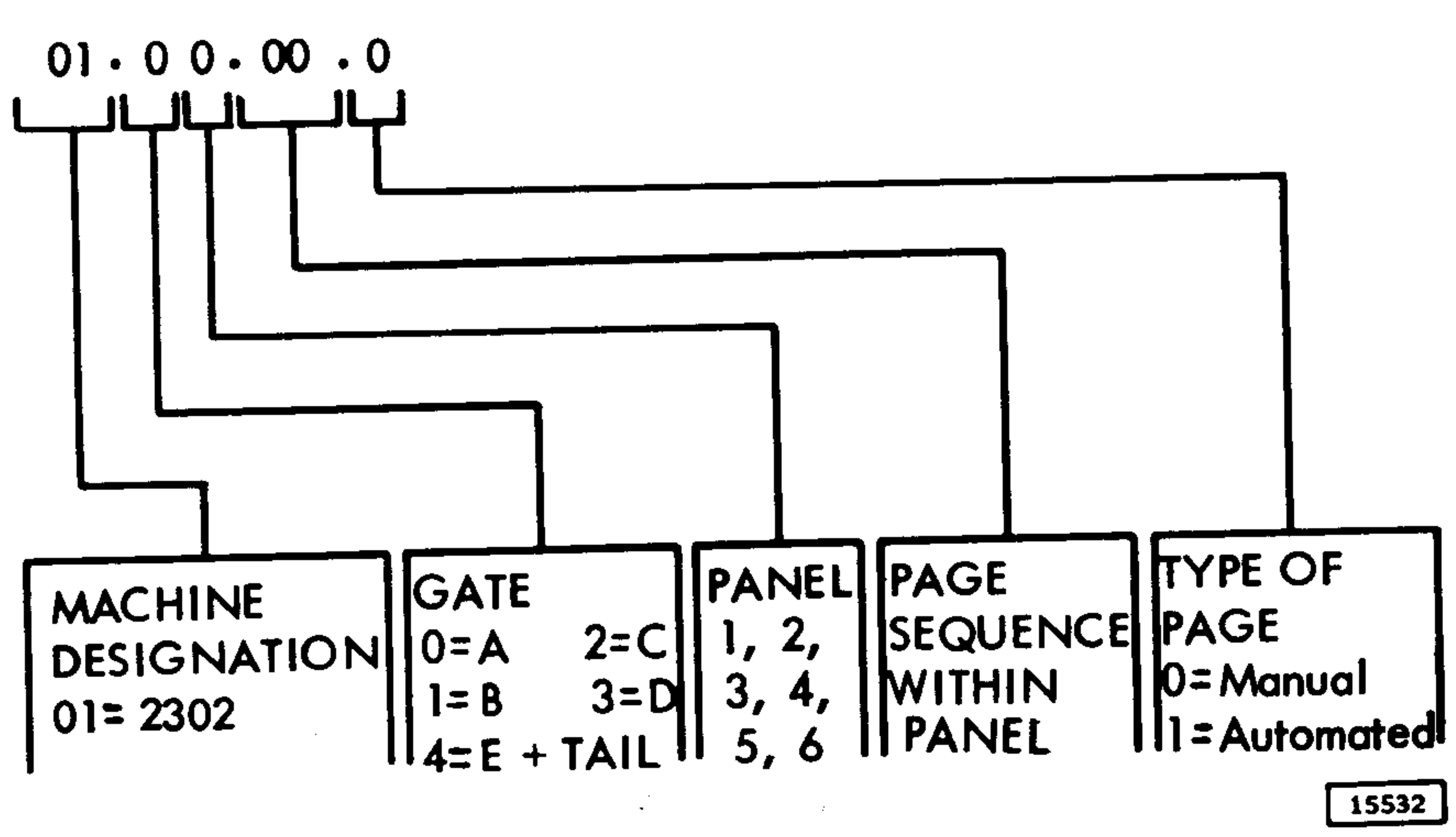


Figure 5-1. System Diagrams Page Numbering

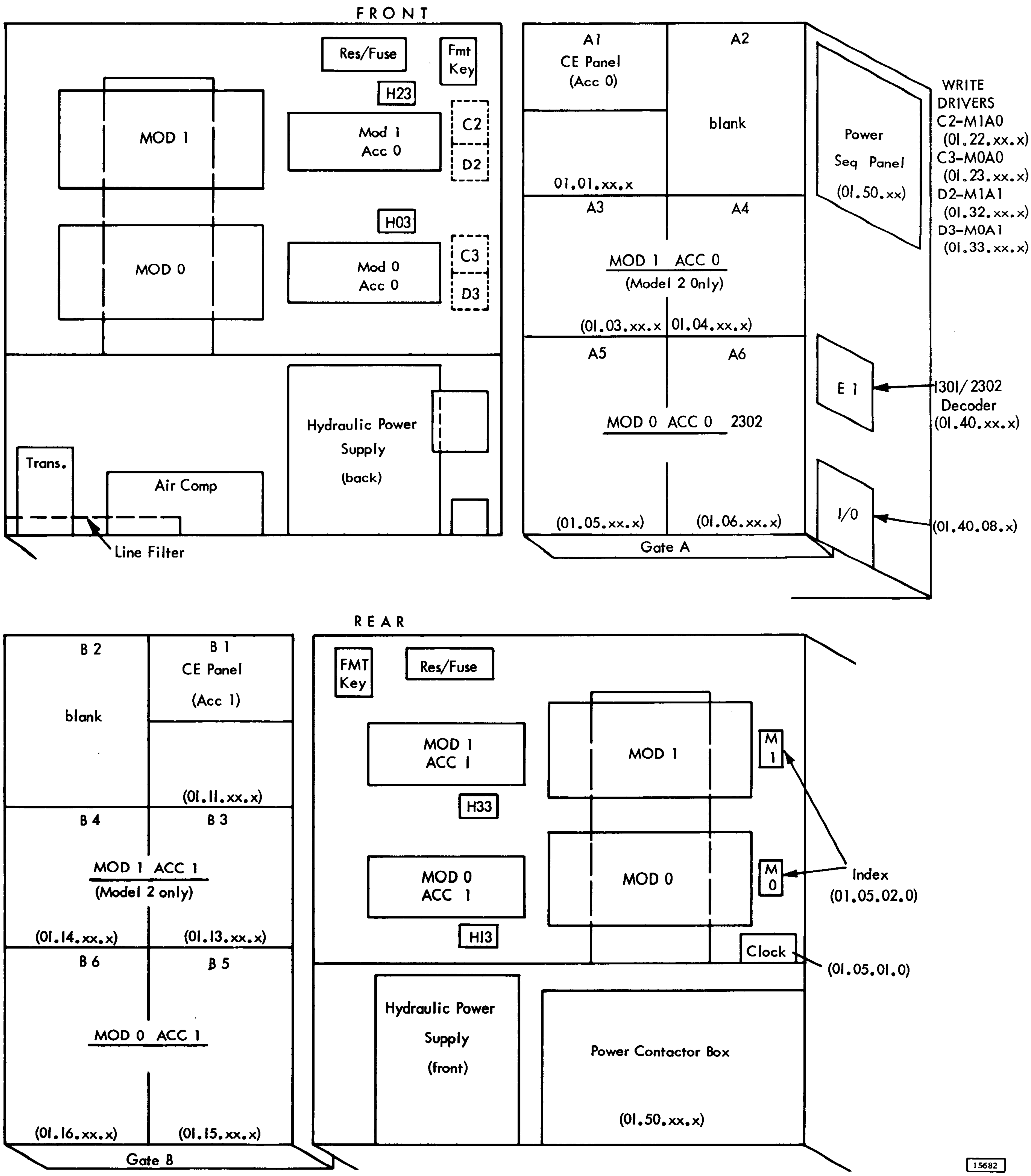


Figure 5-2. Locations

- Basic timing in the 2302 is generated from two sources, a clock track on the clock disk and an index stud on the format disk.

CLOCK

- The clock-track pulses are prewritten at the plant and are controlled during writing by a crystal oscillator and counter. All files have 21510 cycles (or 43,020 clock bits).

- Read and write bit times are synchronized by the File Control Unit and referenced to this prewritten track on the clock disk via the format track.

Because the clock tracks are written on a disk, a variation in disk speed results in a change in clock frequency. This ensures that write data is always "in step" with the clock. Read data is synchronized by a Variable Frequency Oscillator in the control unit.

The clock track is read by a single read head located on the rear of the machine at the bottom of the disk array. This head is manually positioned over the clock track and is not moved by the access mechanism.

Six clock tracks (approximately 640 KC) are written on the clock disk in a span of two inches. The CE can position the clock head over any of these tracks.

The clock head reads the raw clock-track signal into a preamplifier (Figure 6-1). This signal is then amplified through two linear amplifiers. This amplified signal is ANDed with module one select or module zero select and driven to the system. Either module selected causes the clock signal to be driven to the system because there is only one clock for the two modules.

INDEX

- Index indicates the physical beginning of the track.

The format disk in each module has a stud mounted in its periphery. As the disk rotates, the stud passes two sensing heads (transducers) mounted about 1 in. apart in the disk array shield (Figure 6-2). It takes 475 μsec for the stud to pass from one sensing head to the other. Therefore, the late index pulse follows the early index pulse by 475 μsec.

Early and late index pulses are ANDed with module select because each module has its own index. The amplified and selected signal is driven to the FCU.

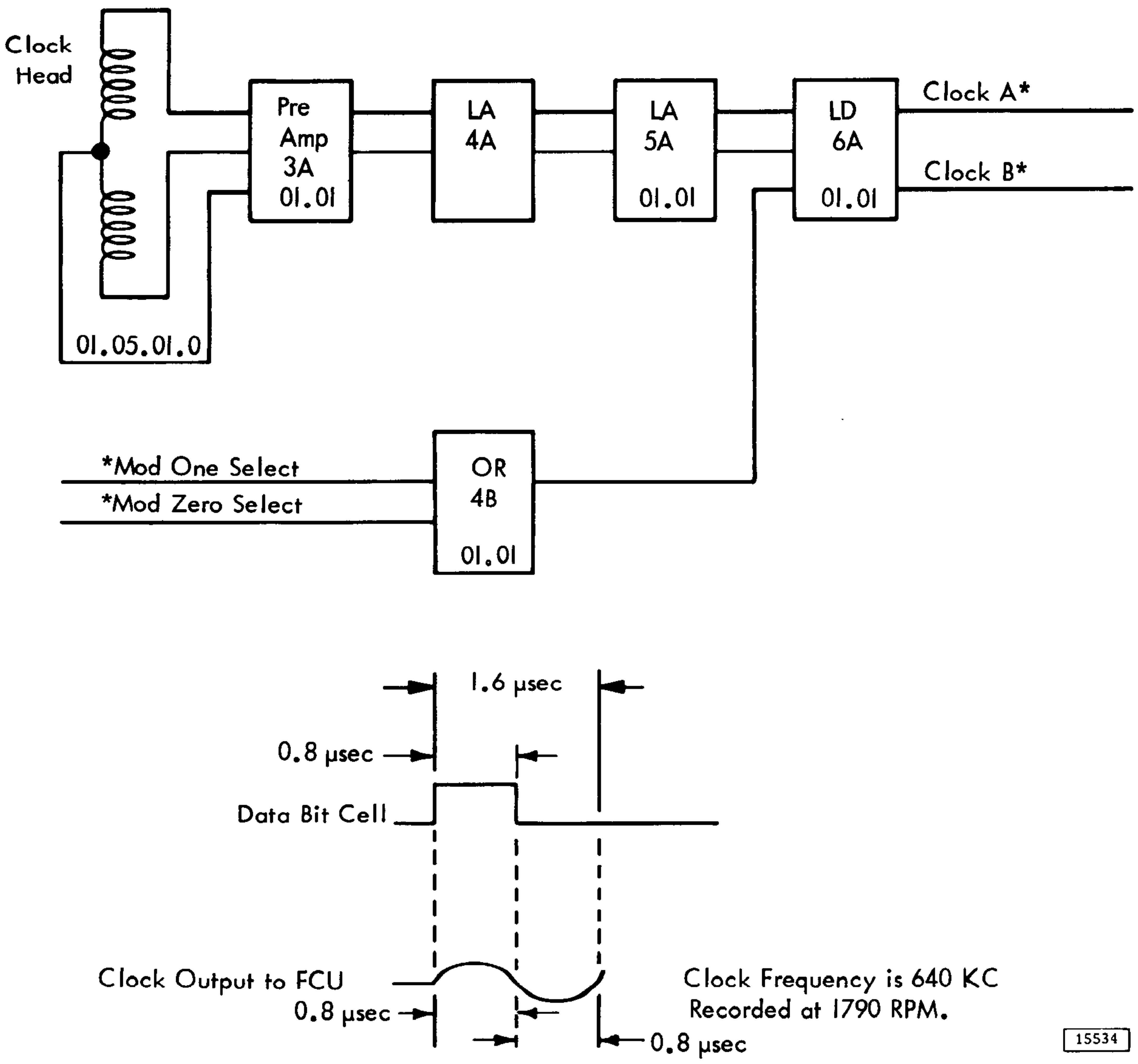


Figure 6-1. Clock Read

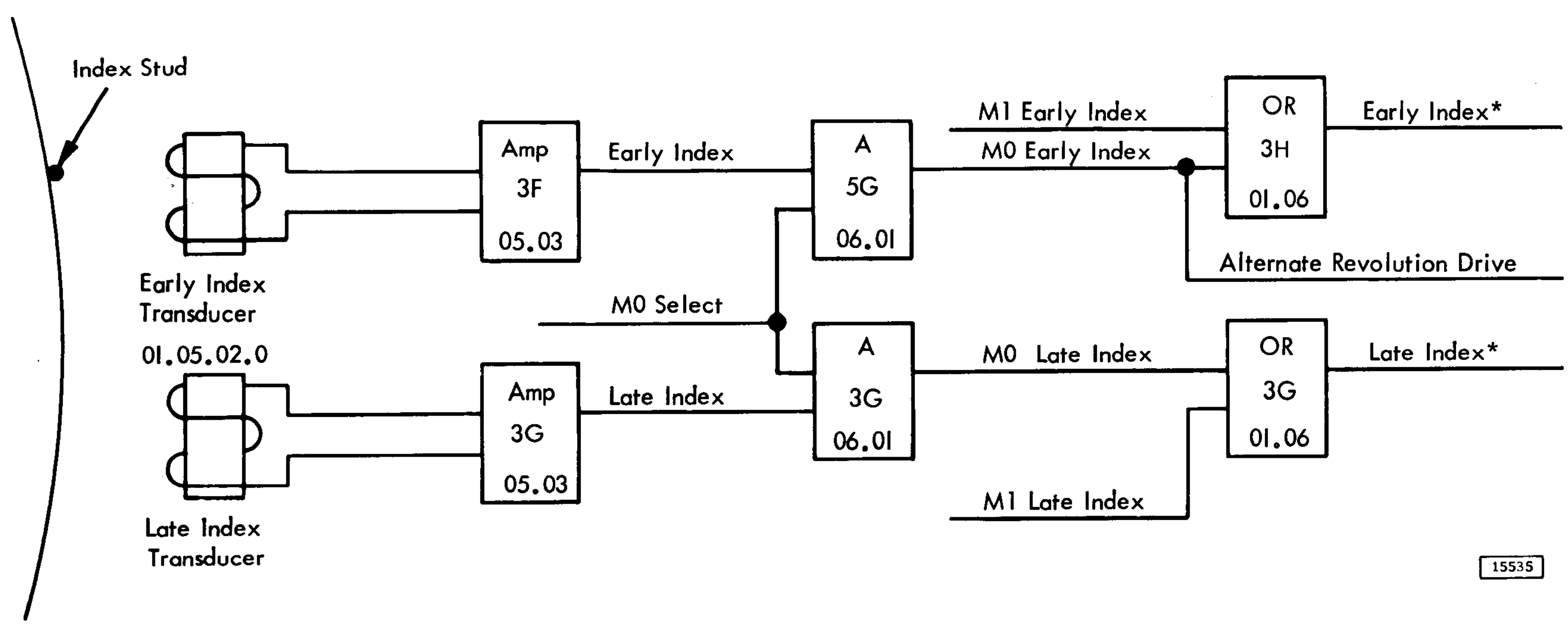


Figure 6-2. Index Generation

- Input power to the 2302 is terminated in the power contactor panel.
- A power sequence panel is provided to integrate control of the power contactors and to maintain reliable operation of the file components.

POWER CONTACTOR BOX (Figure 7-1)

- The 60-cycle power requirements of the 2302 are supplied by a 208 v -230 v, 3-phase, 4-wire system.
- Inrush current during motor starting is 125 amperes for a maximum of 35 seconds.
- Supply circuit must be rated for 60 ampere service (70 ampere circuit breaker).
- Normal running current is less than 30 amperes.
- Input is 7.5 kva giving a 5-kw input wattage at an assumed power factor of 0.65.
- Phase rotation is counterclockwise looking at the receptacle or clockwise looking at the plug.
- The input 60-cycle power line to the 2302 has a 100-ampere, 3-phase line filter, in a series, at the file end.
- Input power control consists of 5 contactors (Figure 7-1).

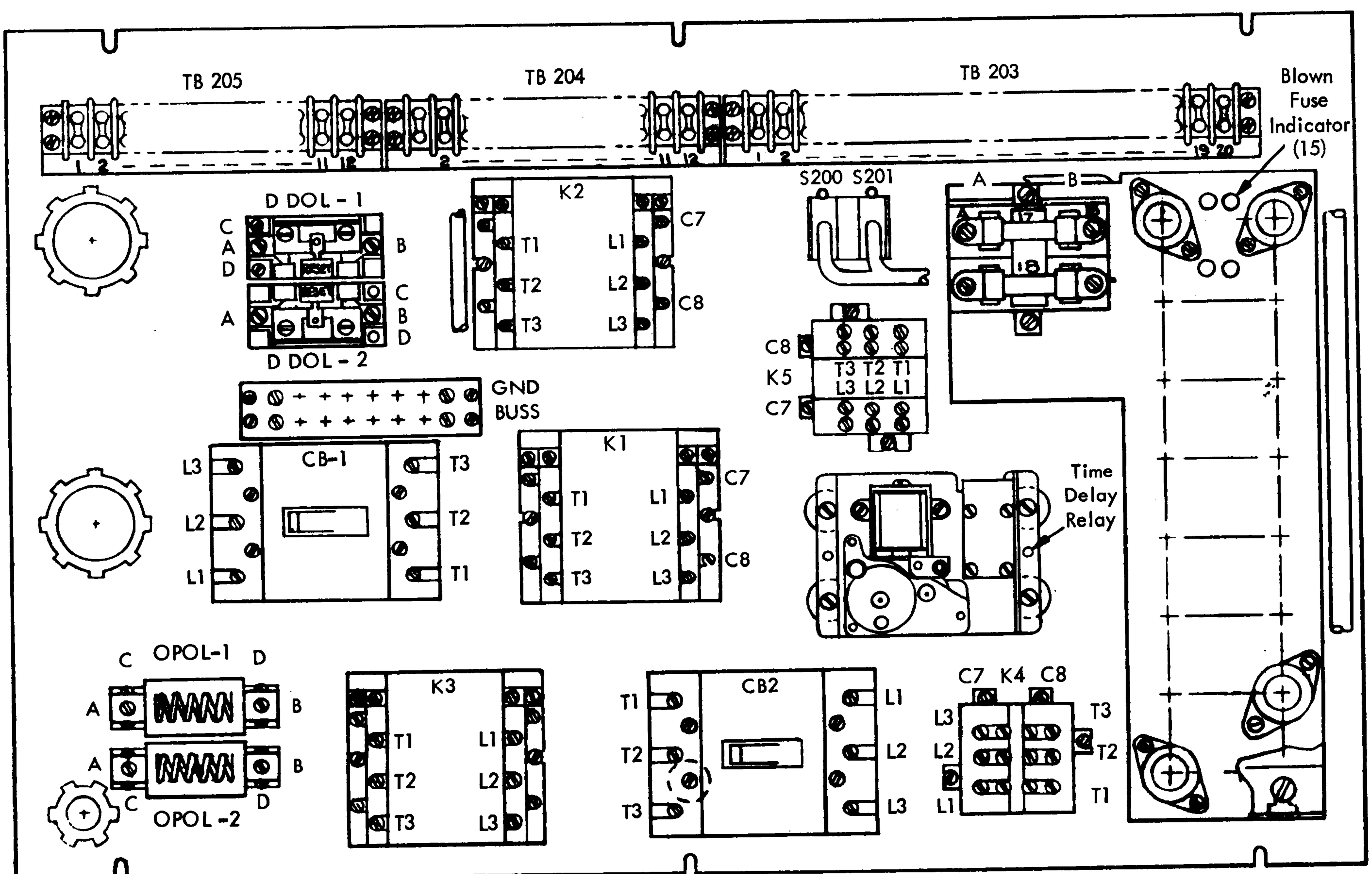


Figure 7-1. Power Contactor Box

Description

The input filter is included to reduce high frequency line noise in the range from 150 kc to 10 mc.

When the main line contactors (K2, K3, and K4) are off, all power is removed, except the power required for the isolation transformer, air compressor, and -48 vdc relay power supply. The power start contactor (K5) removes all remaining power except that to the isolation transformer. The emergency-off contactor (K1) removes all 60-cycle power. All contactor coils operate on 24 vac. The emergency-off contactor (K1) is picked by a 24 v (Emergency Off) line from the system and remains picked during normal operation. Any break in the 24 v line will cause K1 to drop and turn off all file power.

The disk drive motor contactor (K2) controls the shaft motor power. It is picked and dropped by the power sequence controls during normal start and stop procedures. Line overload relays provide locked rotor protection, and two internal thermal overload switches give running protection. Either protective device will shut down the entire file if activated.

The oil pump motor contactor (K3) controls oil pump motor power. It is operated by the power sequence controls during normal start and stop procedures. Protective circuits have been incorporated in the form of line overload switches and a high oil temperature switch. Either condition causes the oil pump to shut down.

The electronic dc contactor (K4) controls the electronic dc.

The power start contactor (K5) is picked by a power on line from the system. K5 controls the air compressor and 48 v relay power supply, the electronic gate blowers, and delivers 24 vac to the power sequence gate for file control.

DC POWER SUPPLIES

- The dc supply control contactor is operated by the power sequence controls during normal start and stop procedures.
- High temperature switches on cards in the gates open at excessive machine temperatures and set a dc fail condition.
- Detection of dc failure opens the dc power contactor (K4).
- Blowers for cooling the gates are turned on by K5.
- The voltages generated in the 2302 dc power supply are +6 v, -6 v, +12 v, -12 v, +30 v, -36 v, and -48 v.
- The +12 vac power supply has marginal checking facilities.

Description

The 2302 power supplies are of the SMS type, therefore, they are not described here in detail. IBM FE Manual of Instruction, 60-Cycle SMS Power Supplies (Form 225-6478-0) contains additional information on this subject.

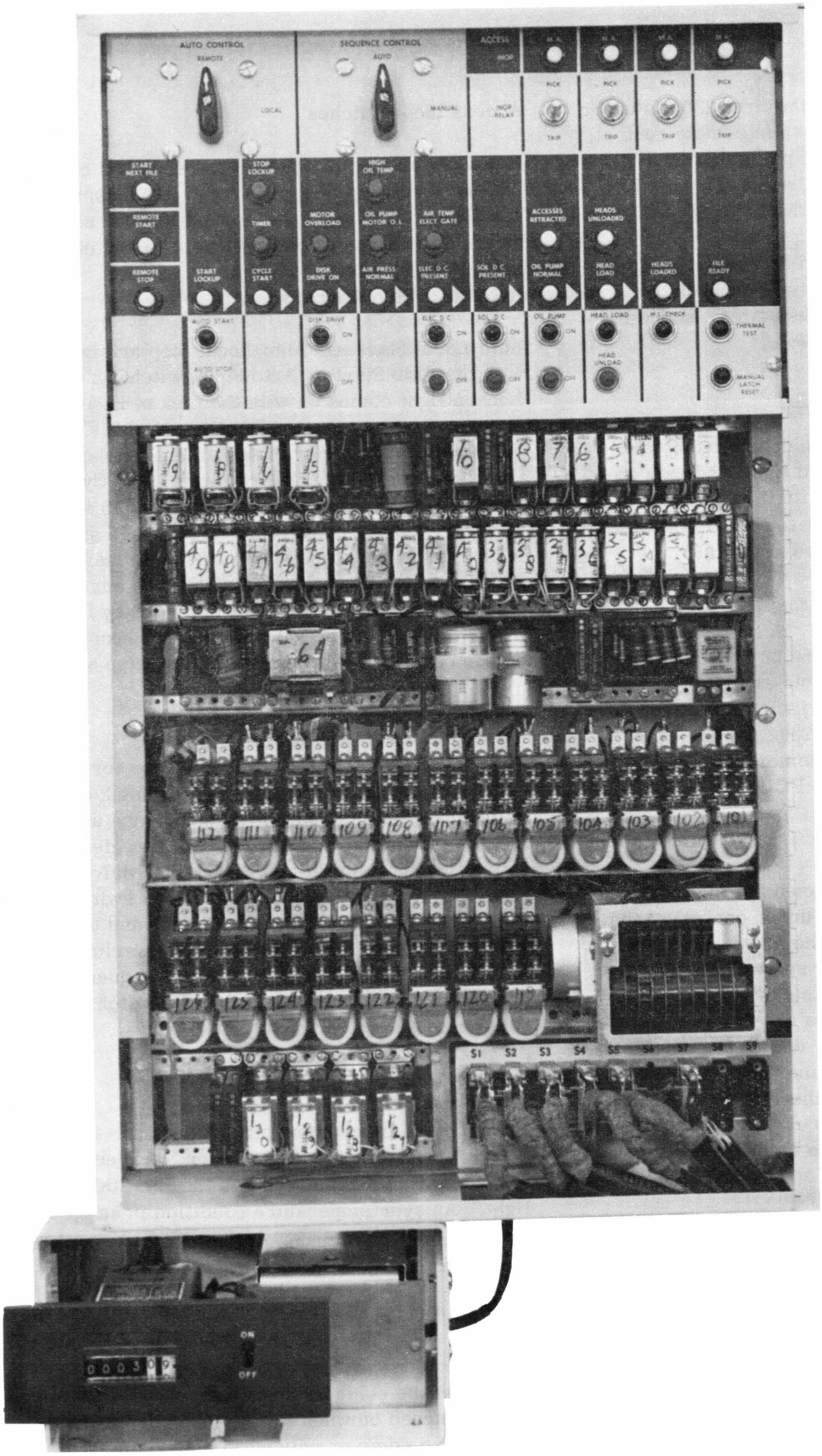
The 48-volt dc power distribution in the 2302 is divided and controlled as if it were two supplies. One for the operation of the actuator solenoid driver circuitry and one for the relay circuitry in the start sequence controls.

The power supplies consist of transformers, diodes and capacitors. The primary voltage is stepped down by transformers, rectified by diodes, and filtered through capacitors. The plug-in SMS card is easily accessible for maintenance. The output impedance of the power supplies is low enough that the output current will not appreciably affect the output voltage. For this reason, regulation is performed on the primary side of the power supply.

All dc power supplies are referenced to the dc common lines; none of the dc power supplies are referenced to each other. Individual circuit breakers are supplied for each output voltage and these are mounted on the power supplies. There are 15 blown-fuse indicators in the 2302, associated with fuses 1 through 15 (Figure 7-1). Fuse Nos. 16, 17, and 18 (spring loaded) are self indicating.

POWER SEQUENCE CONTROLS

- The power sequence control panel (Figure 7-2) provides the facilities for starting and stopping the file during normal operation and ensures proper operation of file components.
- Sequence control may be either automatic or manual.
- Manual control of power sequence has been provided for CE manual start or component check.
- Automatic control of power sequence is under control of a 4-minute timing device.



15753

Figure 7-2. Power Sequence Gate

Normally, initiation of start on the first 2302 is under system control. Subsequent files, in remote control, are started on receipt of a timed pulse during the sequencing of a preceding 2302. If an access in a file is selected before the file is ready, a No Op condition is indicated.

Indicator lights are provided as servicing aids for the Customer Engineer. They indicate both normal and malfunction conditions as long as the line 70-amp breaker is closed.

Power Sequence Panel (Figure 7-2)

All power sequence functions are controlled by and monitored at this panel. The red lights indicate unsatisfactory conditions. The white lights indicate satisfactory conditions. Normal sequence is indicated by the small arrow heads next to the lights.

Auto Control Switch

This switch selects the originating point of the start or stop sequence signal. A remote signal originates at the system. A local signal originates with the Auto Start or Auto Stop switch on the 2302 power sequence panel. This switch must be in Remote position to operate the 2302 on line with the FCU.

Sequence Control Switch

Auto or Manual sequence is selected by this switch. Auto sequence puts all functions under control of the sequence timer. Manual sequence allows the CE to select the time and sequence for most functions.

Damage to the heads or disks can result if the heads are loaded before the disks are at operating speed. To prevent this damage, the head load circuit is always directed through the timer 180-second contact. The disks and the timer, therefore, must run for 180 seconds before the heads can be loaded. In a stop sequence, the heads must be unloaded before the disk array is stopped.

System Function Lights

Remote Start and Remote Stop from the FCU to the 2302, and Start Next File from the 2302 to the next file are indicated by these lights.

Access Inop Lights

If any access is put Inop, manually or automatically, the associated Inop relay picks, turning on the respective Inop light.

Access Inop Switches

Manual operation of any of these switches causes an Inop relay to be picked or tripped. Accesses that have been set Inop by any method can be reset only by tripping the Inop relays with these switches.

Auto Start Stop Controls

Auto Local Start and Auto Local Stop are initiated with the Auto Start or Auto Stop switches. The Start Lockup light comes on with the pick of R10 during an auto start sequence. The timer light is tied in parallel with the timer motor and is on whenever there is power to the timer motor. The Cycle Start light comes on with the pick of R111 at 15 seconds after the start of an auto power sequence start. During a manual sequence start, the cycle start light does not come on unless the disk drive auxiliary (R32) picks and R111 (timer check) is picked by R42 (manual head load delay). The Stop Lockup light comes on when R47 picks during any stop sequence.

Disk Drive

The disk drive On and Off switches are for manual control of the disk drive motor. The disk drive can be manually started only if the heads are unloaded and the timer is at the beginning of a cycle. The Disk Drive light is in parallel with the disk drive contactor (K2). If a disk-drive-motor-overload switch or overtemperature switch opens, R39 picks and turns on the Motor Overload light. A disk drive overload or overtemperature condition causes a stop sequence to occur. In manual mode, the Disk Drive On switch starts the timer motor.

Electronic DC

The electronic dc on and off switches are for manual control of the electronic dc power. If electronic dc is applied,R44 picks to turn on the Elec DC Present light. An overtemperature condition in an electronic gate causes R48 to drop. R48 picks R36 which turns on the Air Temp Elect Gate light.

Solenoid DC

The solenoid dc on and off switches are for manual control of the solenoid dc power. The Sol DC Present light is turned on when R8 is picked by K301. Solenoid dc can come on only when electronic dc is present. Loss of electronic dc results in dropping solenoid dc. This protects the solenoid driver cards from damage caused by having 48 volts without proper biasing voltages.

Oil Pump

The Oil Pump On and Off switches are for manual control of the hydraulic power supply motor. An oil level switch in the hydraulic system picks R7 when the oil pump is turned on through R102. R7 turns on the oil pump light. Opening an overload in the oil pump drops R2 which in turn picks R40 which turns on the Oil Pump Motor O. L. light. When oil temperature exceeds 130°, R49 drops to pick R38 which turns on the High Oil Temp light.

Head Load

The Head Load switch is for manual loading of the heads. The switch is effective only after the timer has run 180 seconds. This time must be allowed to build pressure in the array and remove particles of dirt. The Head Unload switch is for manual unloading of the heads. In any stop sequence, the heads must be unloaded before the disk array can be stopped.

Before the heads can be loaded, at least one access must be retracted and air pressure must be normal (above 30 psi). The Access Retracted light is picked by R4. R4 is picked by all the access retracted switches or Inop relay points in series. The air pressure Normal switch closes to pick R46 which turns on the Press Normal light. The Head Load light is turned on by R125. R125 also picks the clock head solenoid and the head load air solenoid control (K202). The Heads Unloaded light is turned off by the drop of R43. R43 holds only if all the heads, including the clock head, are unloaded. The head load check switch is for manual control of the head check operation. Depression of this switch in manual control will pick the head load check relay (R45). This relay, in series with the head loaded switches on each access and the clock head, will pick R5 if all heads including the clock head are loaded. R5 turns on the Heads Loaded light.

The first depression of the Head Load switch loads module 0 heads. The second depression of the Head Load switch loads module 1 heads. This prevents overloading the air compressor and assures prompt head loading.

Warm Up Timer (30 minutes)

The warm up timer (T-2) is started when K5 (power start contactor) is picked. The timer (at point T2-1) is in series with the strut thermal contact and will make 30 minutes after the timer is started. If operating temperature is attained, and 30 minutes have elapsed, the thermal sense relay (R41) is picked. This relay (R41-3 n/o), is in series with file ready. The Thermal Test push button on the power sequence panel will bypass the warm up timer to establish File Ready condition.

File Ready

The File Ready light is turned on by the file ready relay (R64) if all of the following conditions are present (01.50.09.0).

1. Not stop sequence delay (R3-1 n/c).
2. Heads loaded (R5-2 n/o).
3. Thermal sense (R41-3 n/o) (77°F Model 1, 85°F Model 2).
4. Electronic dc present (R44-4 n/o).
5. Head Load Check (R45-4 n/o).
6. Oil pressure normal (R7-2 n/o).
7. Solenoid dc present (R8-1 n/o).
8. Solenoid power supply control (R108-Bu n/o).

Manual Reset

Depression of the manual reset switch is the only way the following conditions can be reset (01.50.17.0):

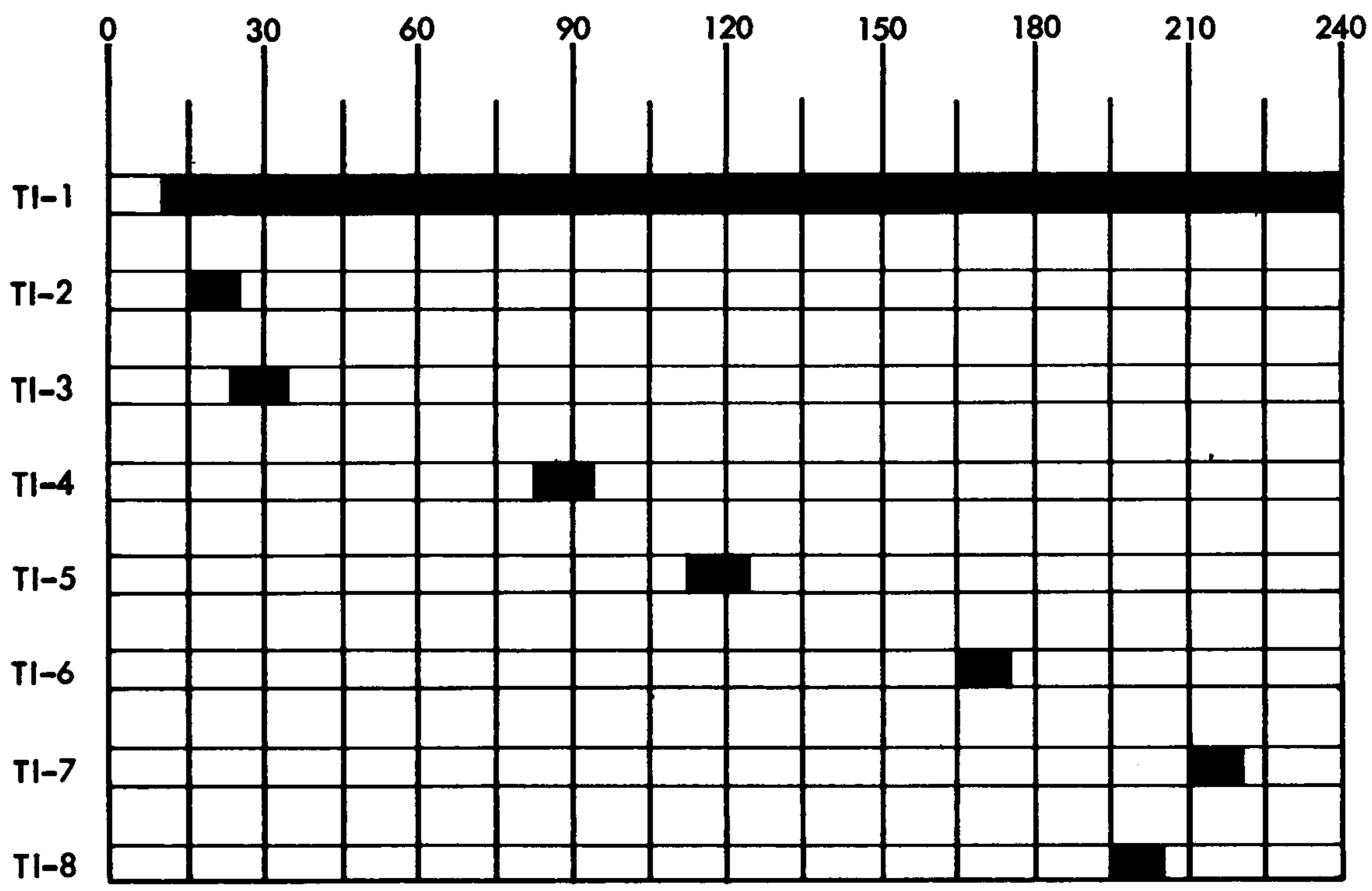
1. Disk drive overload (R-39).
2. Electronic air overtemperature (R-36).
3. Oil overtemperature (R-38).
4. Oil pump overload (R-40).
5. Dc failure indication (R37).
6. Air pressure normal (after disk drive on) (R 46).
7. Service interlock.

Thermal Test

Closing this manual push-button switch will bypass the 30-minute warm-up timer (at point T2-1) and pick thermo sense relay (R41) if the strut temperature is at operating level. This switch permits the CE to establish a File Ready condition prior to the 30-minute warm up period, and permits testing the strut thermal contacts for operating level.

Automatic Power Sequencing

The 2302 power on sequence is an automatic function when the Sequence Control switch is at Auto. The Auto position allows the automatic sequencing to be initiated at the 2302 power sequence panel when the Auto Control switch is on Local or at the system when the switch is on Remote. The emergency contactor (K1) must be picked to allow power sequencing and must remain picked to maintain file power (01.50.14.0). K1 is picked when power is brought up on the using



TIMER CAM FUNCTIONS

TI	LOCATION	MAKE	TOL	BREAK	TOL	FUNCTION
1	01.50.07.0	10	±3	240	±3	Timer Motor Operation
2	01.50.08.0	15	±3	25	±3	Timer Check
3	01.50.08.0	22	±3	32	±3	Disk Drive Control
4	01.50.08.0	82	±3	92	±3	Timer Auxiliary
5	01.50.08.0	112	±3	122	±3	Oil Pump Control
6	01.50.09.0	180	±3	190	±3	Access Retracted and Head Load M0
7	01.50.09.0	210	±3	220	±3	Head Load Check M1
8	01.50.09.0	195	±3	205	±3	Head Load Check M0 Load M1

15760

Figure 7-3. Power Sequence Timing Chart

system or previous file in multiple file system if the emergency off circuit is normal.

Auto Local Start

This operation is accomplished by developing the following basic objectives in sequence (Figures 7-3, 7-4, and 7-5).

1. Energize air compressor motor and gate blowers.
2. Energize timer motor.
3. Energize disk drive motor.
4. Establish electronic dc and solenoid dc.
5. Energize oil pump motor.
6. Start rezero operation.
7. Load heads.
8. Establish "file ready."

Energize Compressor Motor. The auto local start operation is initiated by depressing the start switch (SW 20) to pick K5 (01.50.14.0). K5 then provides a circuit to energize the compressor motor and electronic gate blowers. From this point, the compressor is under control of an internal pressure switch. The compressor runs only enough to maintain system pressure. K5 also allows the -48 v relay supply to be initiated and delivers 24 vac to the power sequence gate.

Energize Timer Motor. The timer motor is started when R10 is picked (01.50.07.0). R10 is picked following the initiation of the -48 v relay supply provided the safety and interlock relays are picked. Contact TI-1 provides a hold to the timer motor for 3 minutes and 50 seconds. TI-2 picks the timer check relay

(R111) 15 seconds after R10 is picked if the heads are unloaded and air pressure is normal. R111 prevents additional timer cycles allowing the timer to stop at zero.

Energize Disk Drive Motor. The disk drive motor is energized through the n/o contacts of K2 (01.50.14.0). K2 is picked by R110 which is picked by TI-3, 22 seconds after the timer motor is started. Sixty seconds are allowed for the disk array to reach operating speed. The auxiliary disk drive relay (R32) is also picked by K2 (01.50.12.0). R32 is used later in the sequencing to signal that disk drive power has been applied.

Establish Electronic DC and Solenoid DC. The electronic dc is turned on when the electronic dc contactor (K4) is picked (01.50.07.0). K4 is picked by R124 which is picked by R107. R107 is picked by TI-5 60 seconds after the disk drive motor is started (01.50.08.0). R107 sends out a "power on to next file" signal (01.50.13.0). K4 also picks the auxiliary electronic dc relay (R33). R33 is used later to signal that electronic dc power has been applied.

Solenoid dc is energized when K301 is picked by the electronic dc present relays (R44 and R108).

Energize Oil Pump Motor. The oil pump motor is energized when K3 is picked (01.50.14.0). K3 is picked by R109 which is picked by TI-4, 112 seconds after the timer motor is started (01.50.08.0). Normally, oil pressure reaches 500 psi in 2 to 3 seconds. When the oil pressure reaches 500 psi, the pressure switch is closed and R7 is picked to indicate normal pressure (01.50.12.0) and to hold R109.

Start Rezero Operation. The presence of electronic dc (-12 v) is used to pick R51. R33 and R51 then pick R44 which picks R108. R108 is used to pick the solenoid dc contactor (K301) which picks R8. R8 causes a power sequence rezero operation (01.50.13.0).

Load Heads. The heads of module 0 are loaded when the M0 A0 and M0 A1 head air solenoids (K202 and K204) and the clock head solenoid are energized (01.50.09.0). These solenoids are energized when R125 is picked. R125 is picked by R4 if disk drive power has been

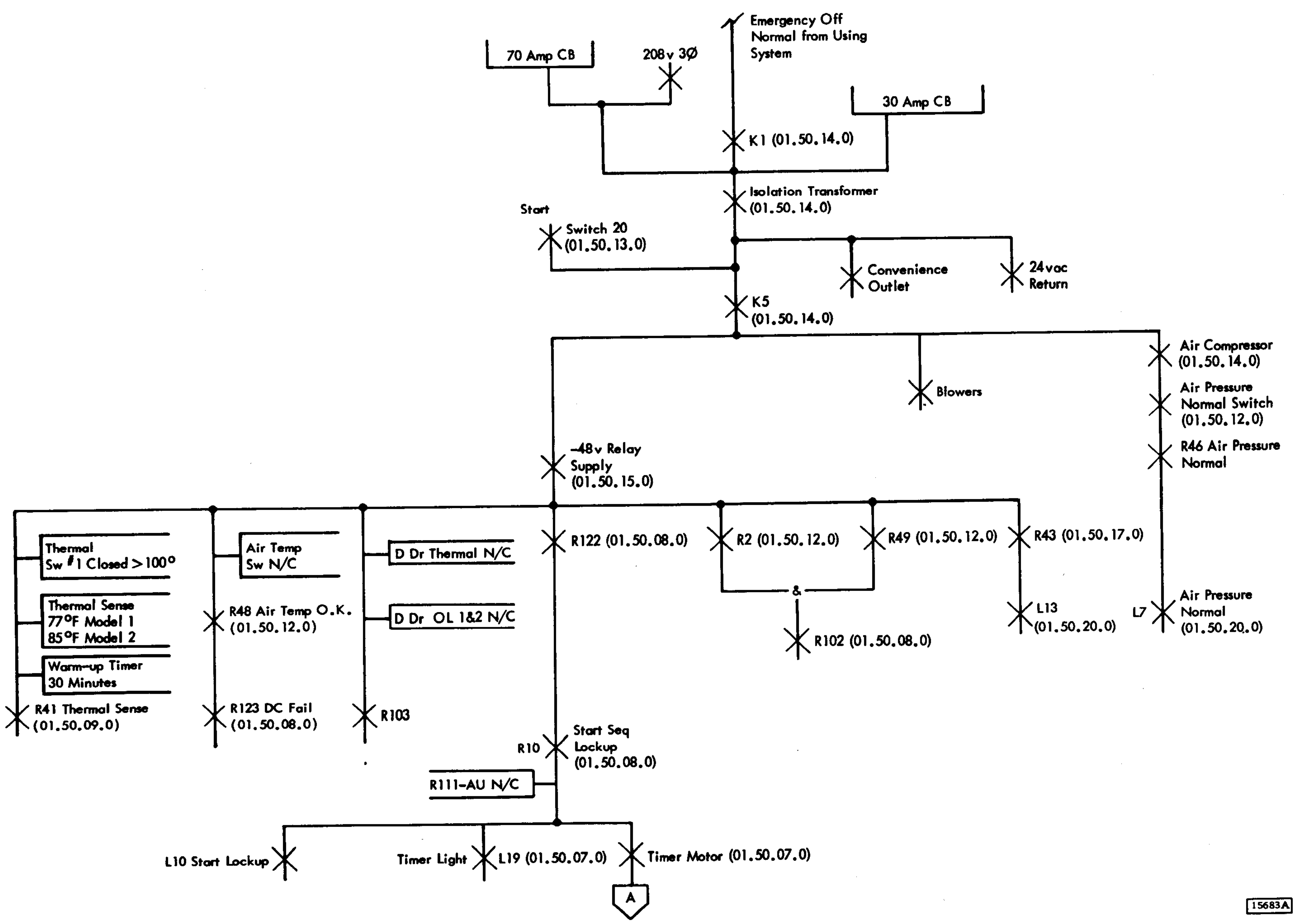


Figure 7-4. Power Sequence Auto-Local-Start (Part 1)

applied (R32) and air pressure is normal (R46). R4 is picked by TI-6, 180 seconds after the timer motor is started, through the access retracted switches in series or through the proper combination of access retracted switches and inop relay points. However, if all accesses are inop, R4 cannot pick because its common side is open (01.50.10.0).

The heads of Module 1 are loaded when the M1A0 and M1A1 head air solenoids (K203 and K205) are energized (01.50.09.0). These solenoids are energized when R126 is picked. R126 is picked by TI-8, 195 seconds after the timer motor is started, through R34. R34 is installed only if the 2302 has both modules. R34 enables the heads of each module to be loaded at different times.

Establish "File Ready." The file ready relay (R64). (01.50.09.0) is picked if the heads are loaded (R5), the thermal sense circuit has not detected an under temperature (77° F Model 1, 85° F Model 2) condition and 30-minute timer (R41) has not timed out, electronic dc is present (R44), heads have been checked for proper loading (R45), oil pressure is normal (R7), solenoid driver voltage is present (R8 and R108), and Local-Remote Switch in Remote position. The last function accomplished in this group is the thermal sense function. This is because the thermal sense circuit normally achieves proper temperature 20 to 90 minutes after power on. The time required is determined by the room temperature and the 30-minute timer.

If head load power has been applied (R125), picks R45 212 seconds after the timer TI-7 is started. If the heads have properly loaded, R45 picks R5. Note, R5 can pick through the proper combination of head loaded switches and access Inop relay points.

Auto Remote Start

To start the normal remote power on sequence of the file, the power on circuit must first be activated from the using system (01.50.13.0). This circuit provides a pick to the power on contactor K5, thus establishing the -48 v relay supply and power to the air compressor.

Any combination of files can be sequenced up or down depending on the auto control switch. If this switch is in Local, all system and other file signals will be sent directly to the next file. If the switch is in Remote, the file will become part of the sequencing operation.

The power on sequence can then be initiated by activating the "start stop sequence" circuit from the using system (01.50.13.0). This circuit provides a pick to the remote stop relay (R35). The start sequence lockup relay (R10) is picked through the n/o points of R35 (01.50.08.0). The power on sequence proceeds from this point as described under Auto Local Start. (See Figure 7-4 and 7-5.)

Auto Local Stop

The first step in all power off sequences serves to rezero all actuators to the Outer Limit switch. The second step must cause the heads to unload. All other functions can then be interrupted simultaneously.

Auto local stop is initiated when SW10 is pressed and the stop sequence lock-up relay (R47) is picked (01.50.08.2). The sequence then proceeds as shown in Figure 7-6.

Auto Remote Stop

Remote stop is initiated when the using system drops the "start stop sequence" line holding R35 (01.50.13.0). When R35 drops, R47 picks (01.50.08.2). The stop sequence then proceeds as shown in Figure 7-6.

Manual Power Sequencing

The manual sequence control is a CE aid. To be effective as such, it is necessary to remove some of the normal safety interlocks while in this mode. Therefore, caution must be used when sequencing the file in manual sequence control. Sufficient time must be allowed between each step to allow the respective components to reach operating level as indicated by the lights on the power sequence panel.

Manual Local Start and Stop

The start sequence is selected by the CE, however the heads cannot be loaded until 180 seconds after the disk array is started. Figures 7-7 and 7-8 illustrate the operating sequences.

The stop sequence is selected by the CE, however the disk drive motor cannot be turned off unless the heads are unloaded first.

SAFETY INTERLOCKS

Protection devices have been incorporated in the 2302 to prevent damage in case of component malfunction.

Oil Pump Protection

The oil pump is protected by two motor overload switches and an oil overtemperature switch. The

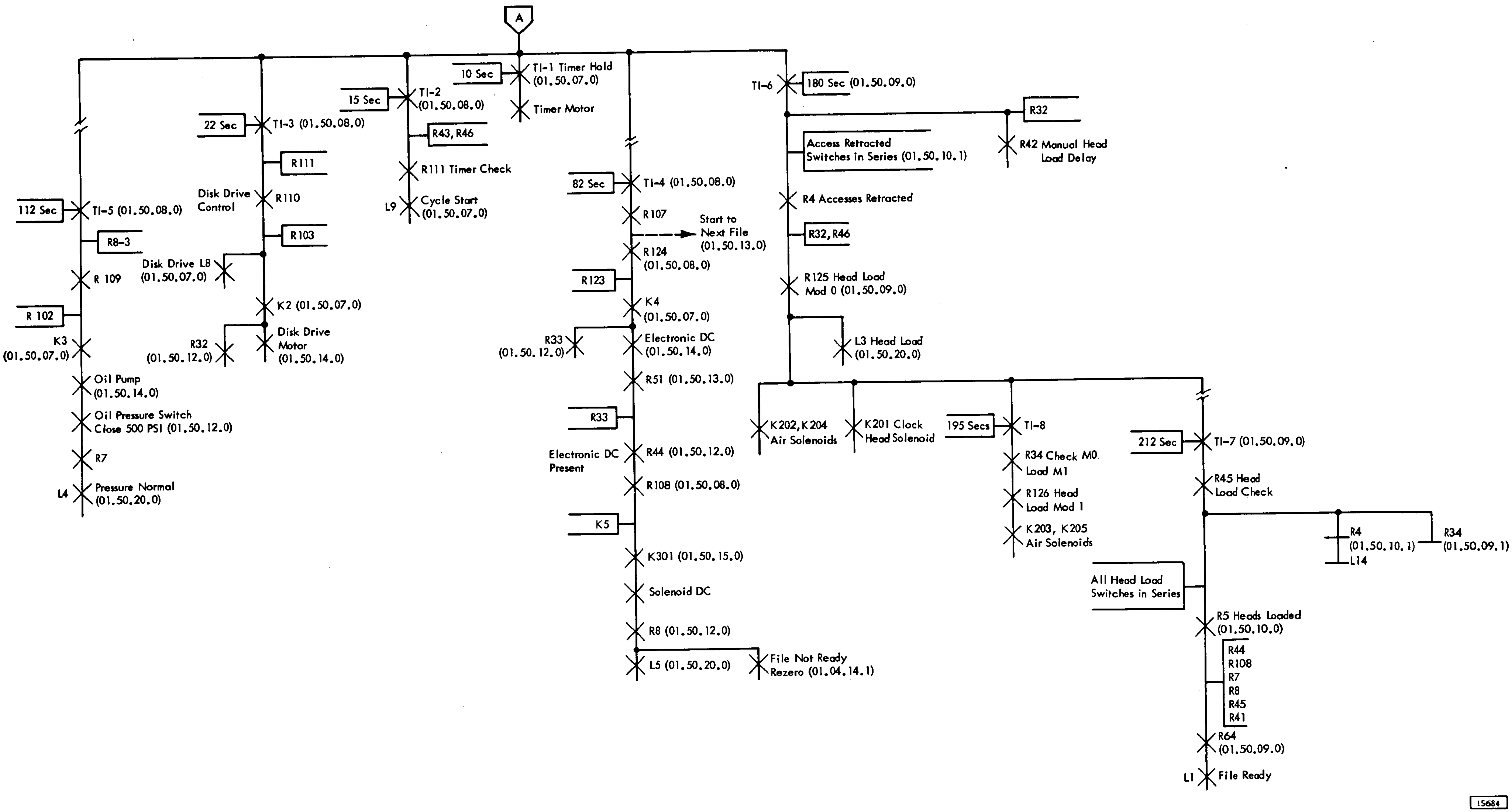


Figure 7-5. Power Sequence Auto-Local-Start (Part 2)

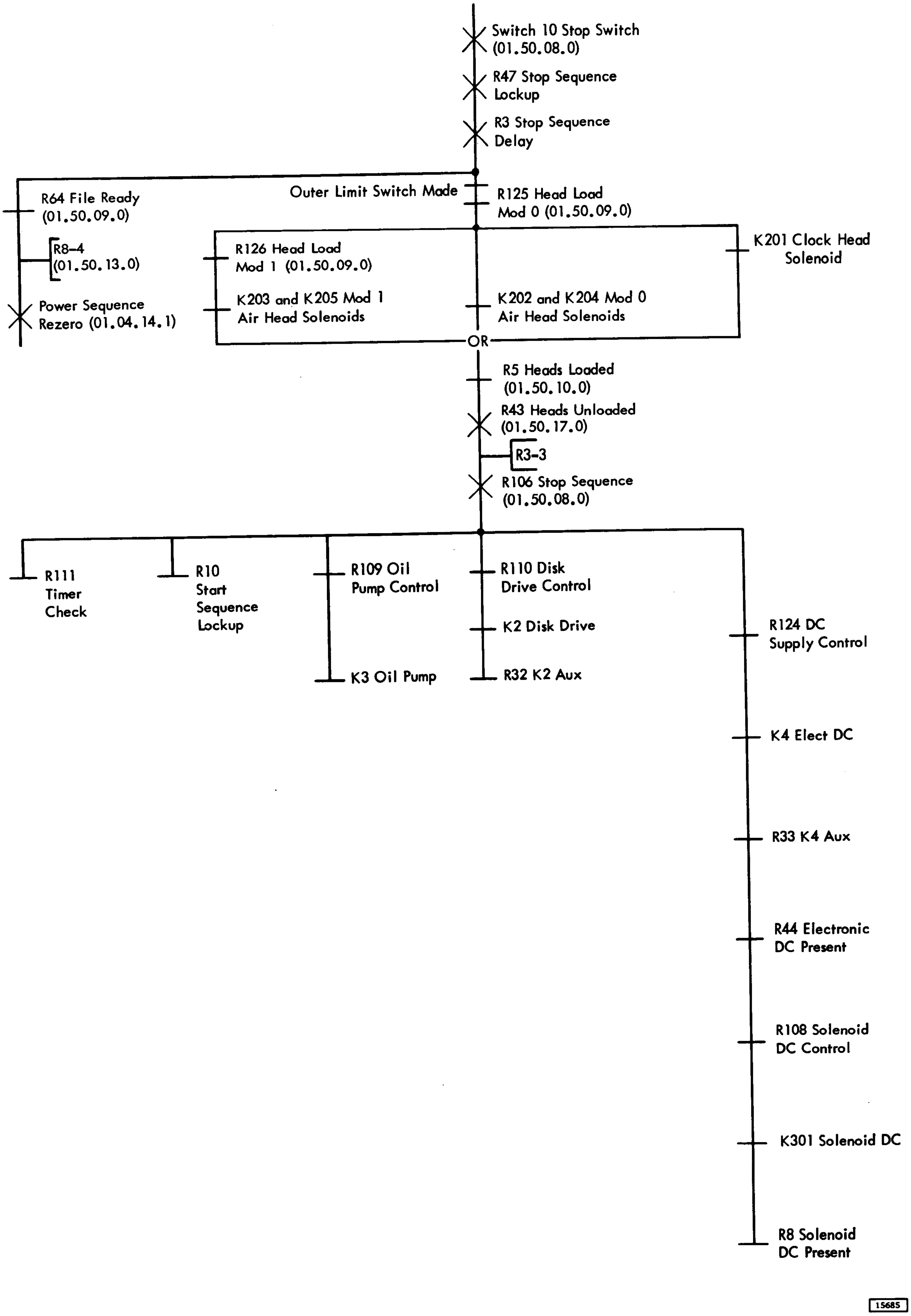


Figure 7-6. Power Sequence Auto-Local Stop

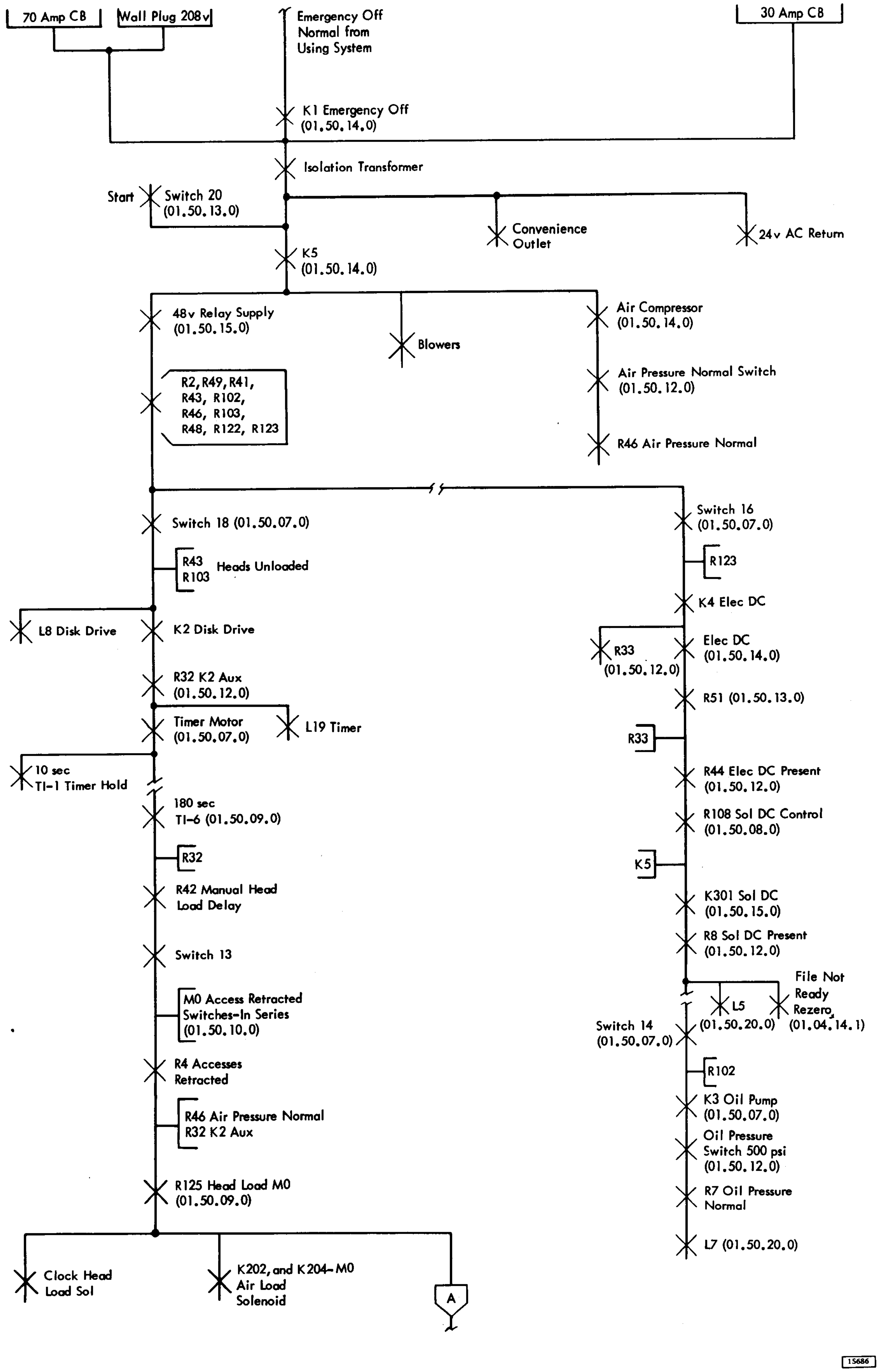


Figure 7-7. Power Sequence Manual-Local-Start (Part 1)

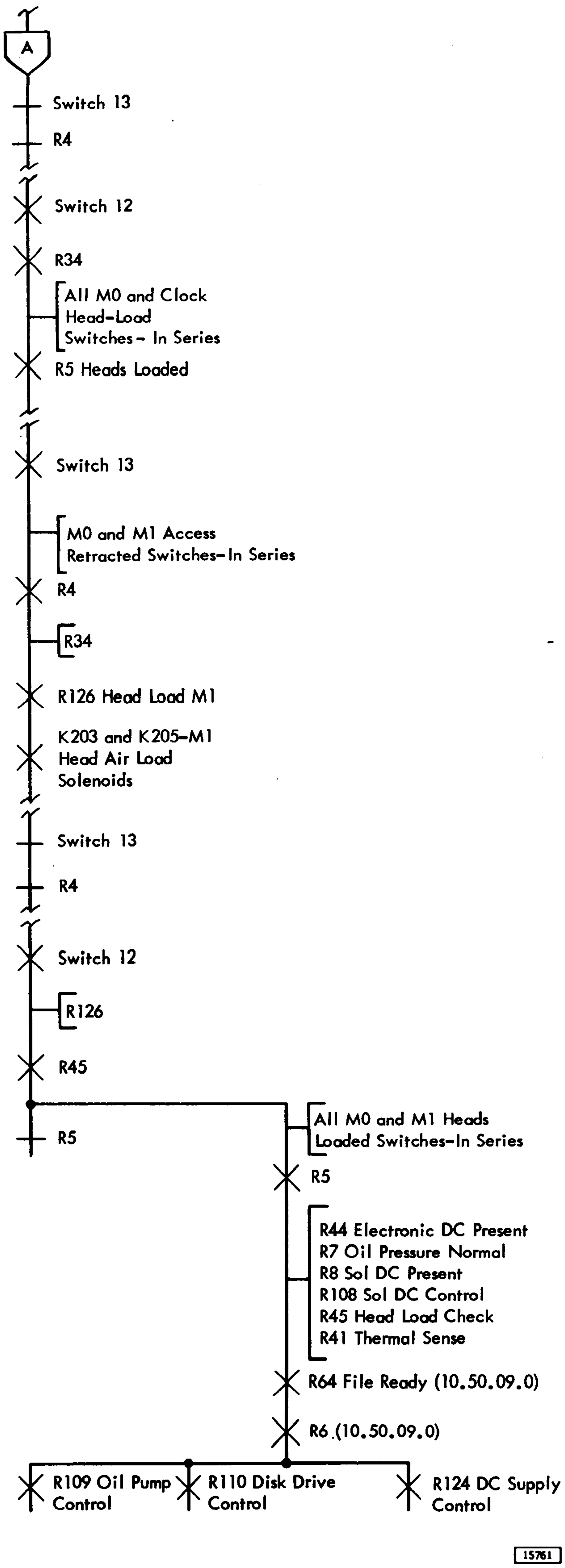


Figure 7-8. Power Sequence Manual-Local-Start (Part 2)

motor overload switches open when an overload condition is sensed (Figure 7-9). The oil overtemperature switch opens if the oil temperature exceeds 130°F. When any of these switches opens, the oil pump contactor drops.

Disk Drive Protection

The disk drive is protected by two motor overload switches and an overtemperature switch. These switches open if an overload or overtemperature condition is sensed (Figure 7-10). When any of these switches opens it causes the disk drive contactor to drop and the entire file to shut down.

NOTE: Two overtemperature switches are installed in the disk drive motor, but only one is connected at a time.

Electronic Gate Overtemperature

An air temperature thermal card is located in the upper part of each electronic gate. If the switch on either of these cards opens, the electronic dc and solenoid dc is dropped (Figure 7-11). The file does not shut down in either mode.

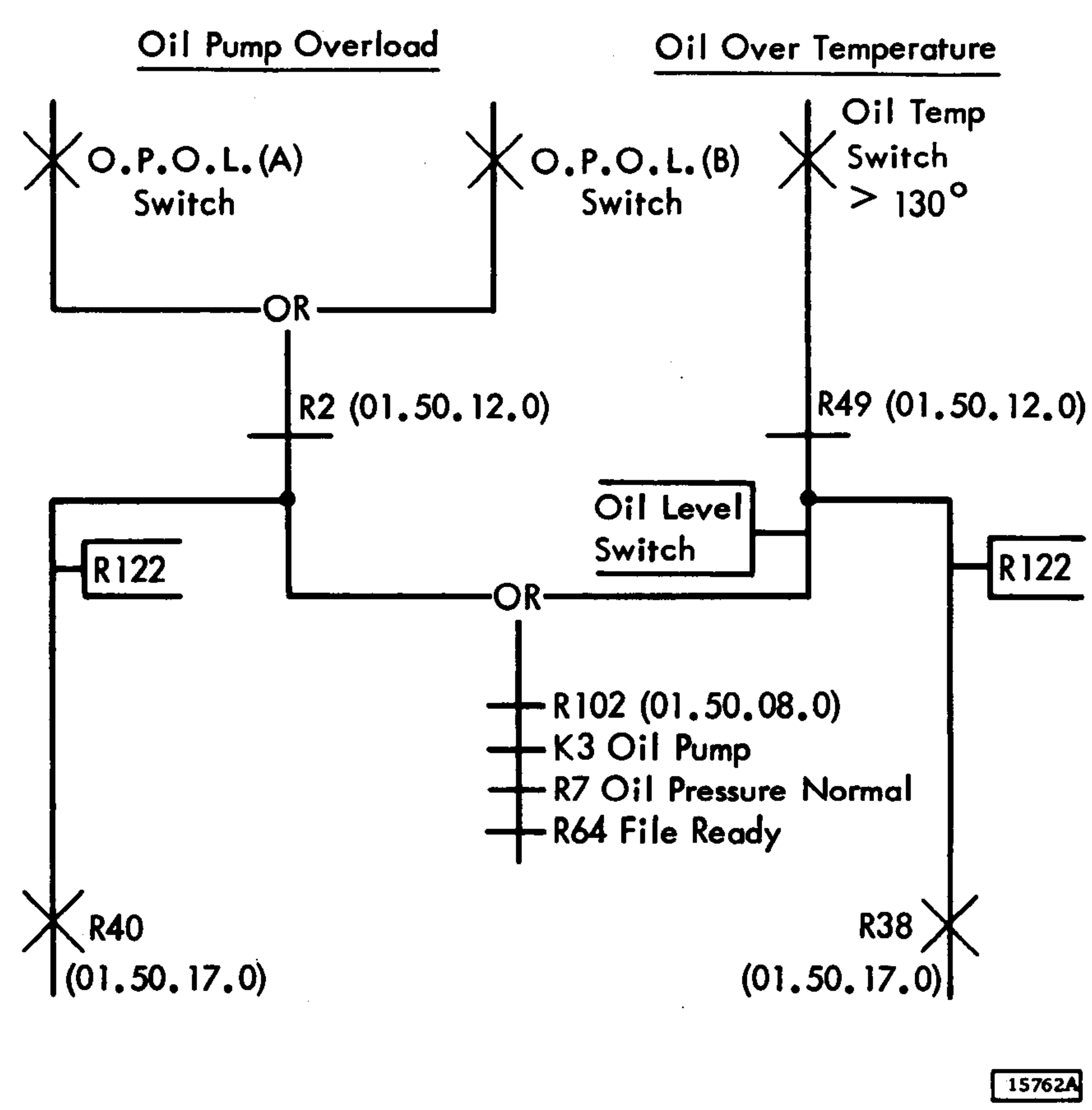


Figure 7-9. Oil Pump Protection

Operating Temperature Thermal Sense

A temperature sensing switch (01. 50. 09. 2) is located between the front and rear vertical struts of the 2302, above the C and D gates. This switch defines the operating temperature requirements of the 2302 (77° F Mod 1, 85° F Mod 2).

The upper 2302 operating temperature limit is controlled by the over temperature switch of the hydraulic power supply which turns off the hydraulic power supply when the oil temperature exceeds 130° F.

Air Pressure Loss

Loss of air pressure opens the air pressure normal switch (Figure 7-12). R46 drops when the air pressure switch opens; the heads unload but the file does not shut down.

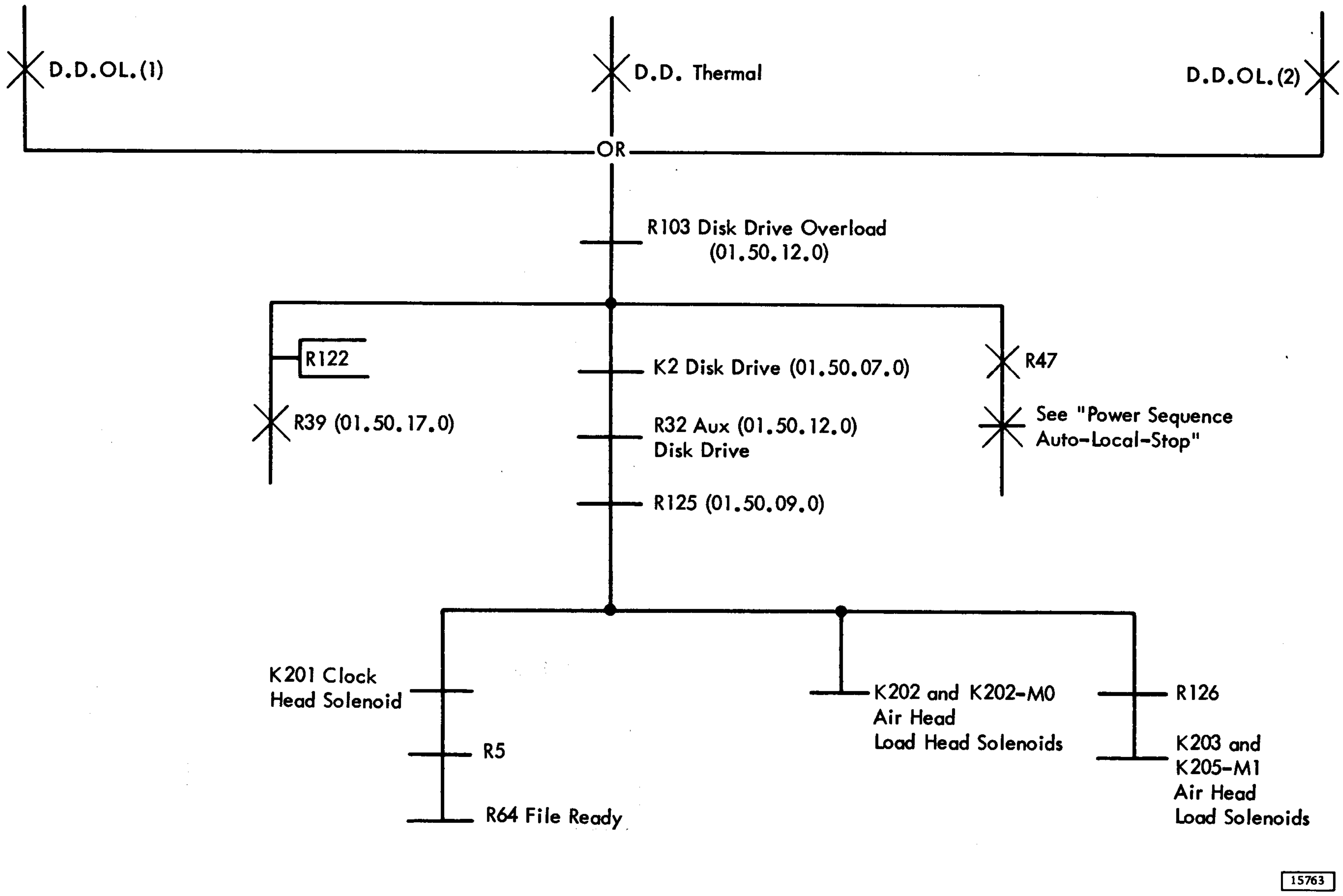


Figure 7-10. Disk Drive Protection

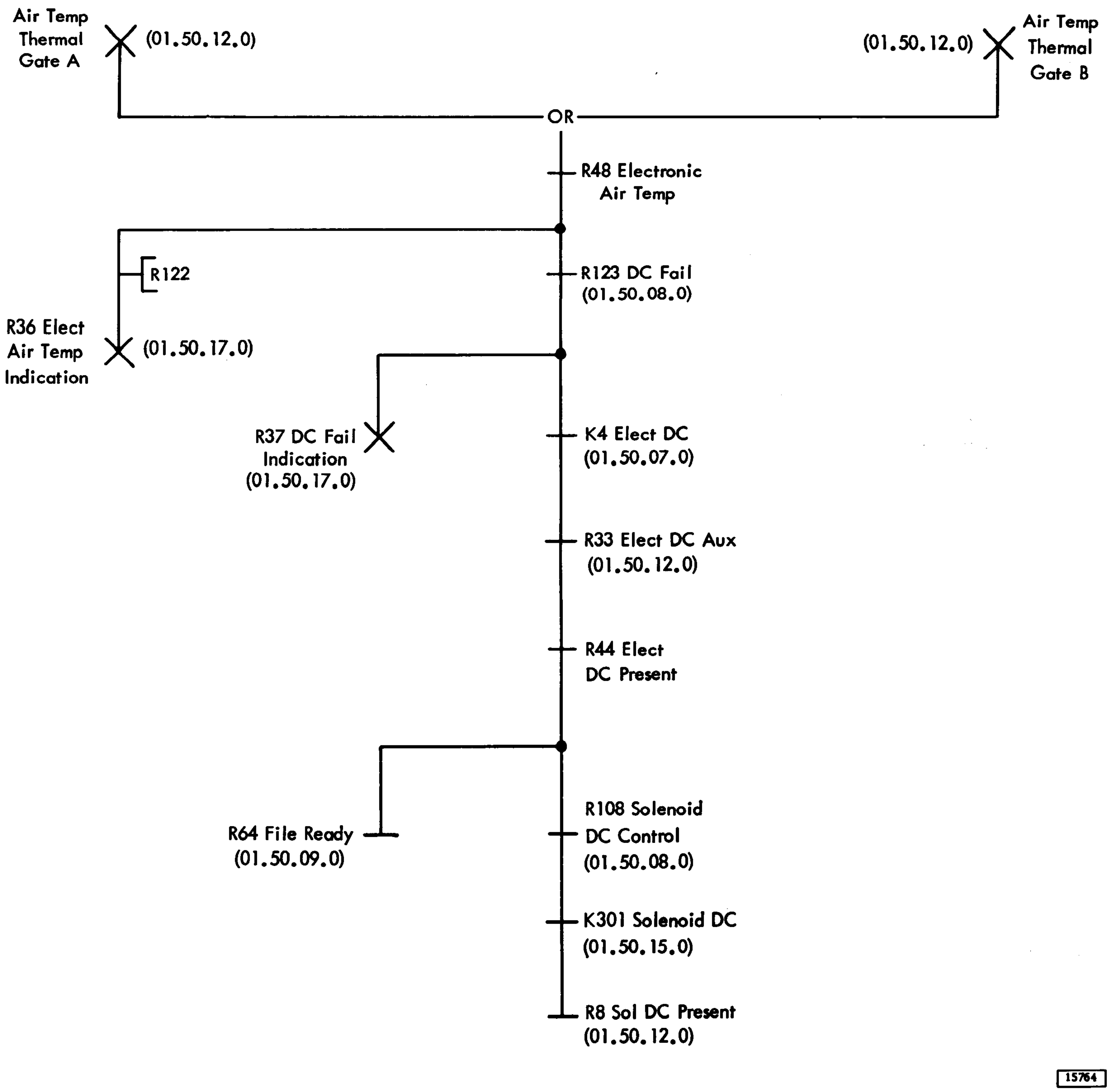


Figure 7-11. Electronic Gate Overtemperature

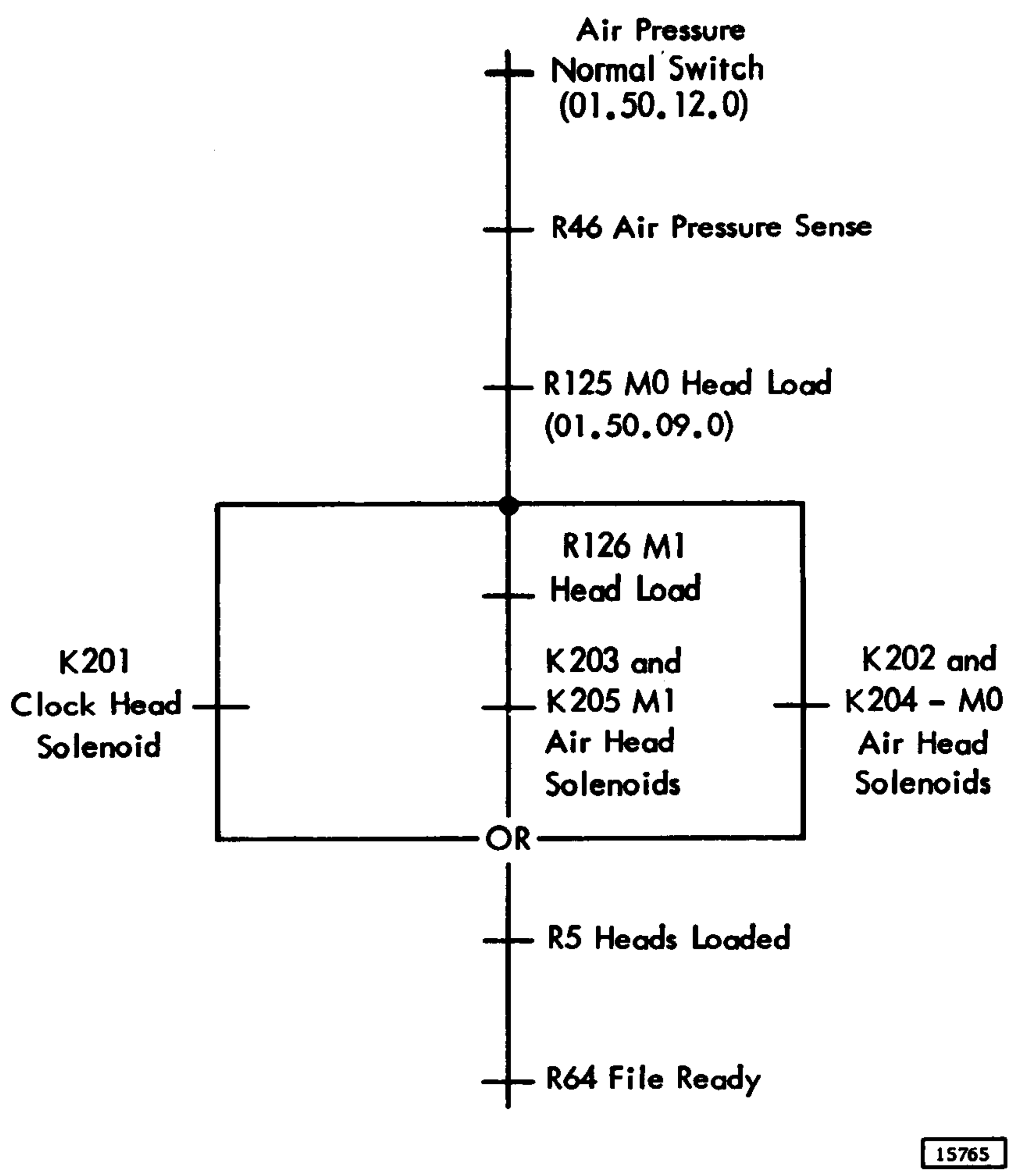


Figure 7-12. Air Pressure Loss

- Many service aids are incorporated into the IBM 2302 Disk Storage.
- These aids allow the CE to observe or duplicate machine functions.

CE TEST PANELS (Figure 8-1)

- The CE test panels are located in panels A1 and B1.
- From these panels, the CE can monitor most file functions.
- The respective access must first be set Inop and the access cover must be on before most of the switches on these panels are effective.

Head Select Switch

This on-off toggle switch turns head select on or off. It is not necessary that the access cover be on to select a head.

Cylinder Select Lights

Ten cylinder select lights indicate the contents of the access register, and are driven by the outputs of the access register. Above each light is the binary and cylinder equivalent number represented by the light.

Head Select Lights

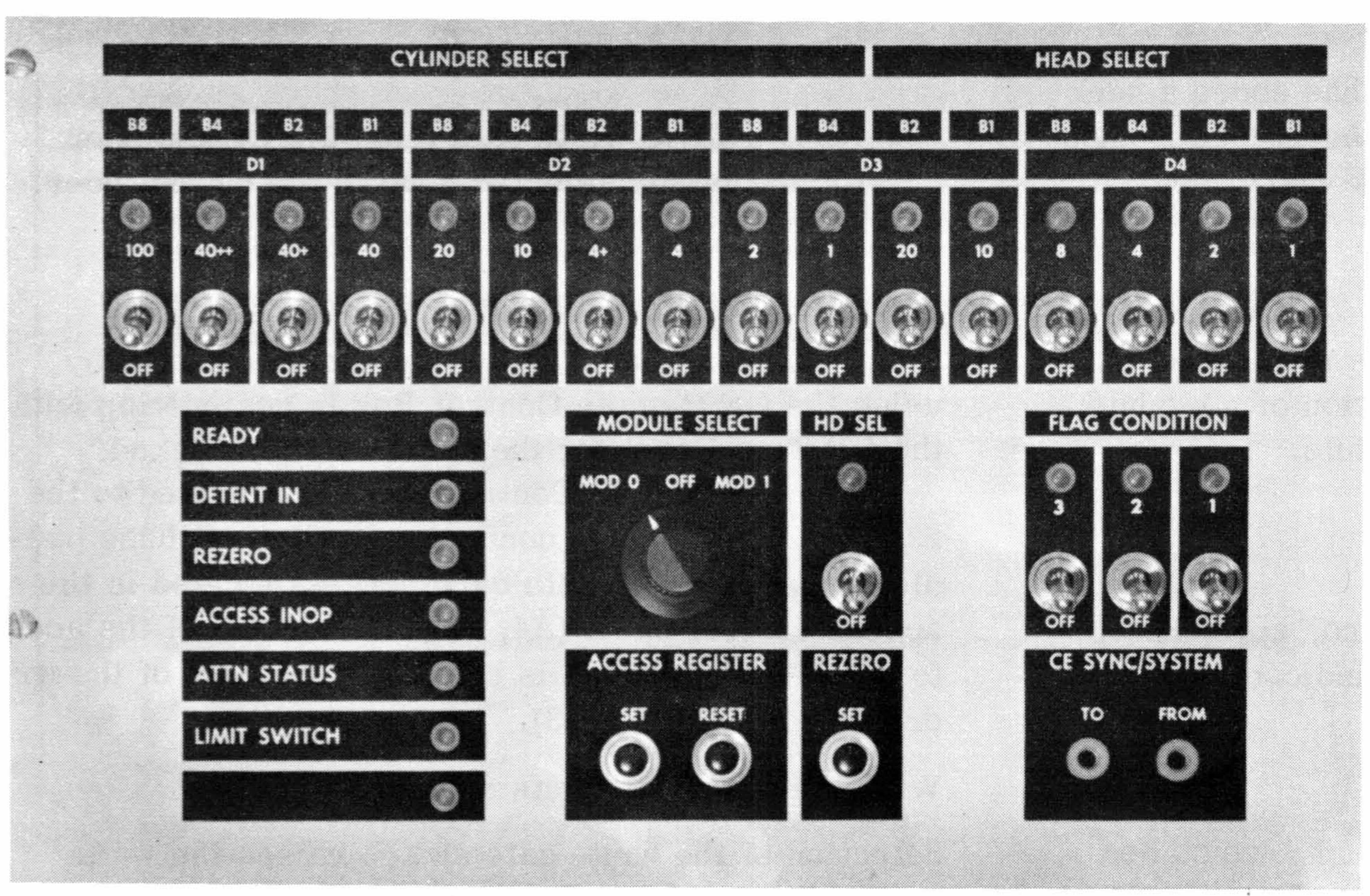
Six head select lights indicate the head to be selected. These indicators are driven from the access register. Above each light is the binary and decimal equivalent number represented by the light.

Cylinder and Head Select Switches

These 16 switches can be used to select any cylinder-head address including the inner CE cylinder which is located at cylinder position 250.

Access Register Set-Reset

The address selected by the cylinder and head select switches is set into the access register by depression



15520

Figure 8-1. CE Test Panel

of the set button. Additional access register latches can be set without a reset. However, none can be turned off without a total reset. The access register is reset by depression of the reset button. This button also resets rezero.

Resetting the access register puts the actuator at cylinder 0 and gates head 00.

Rezero Set Switch

Two functions are performed by this switch: rezero, and locate outer cylinder. The outer cylinder is about one and one-half cylinders out from cylinder 0. Rezero is in the same position. This position is not detented, and as long as the actuator is in rezero, the actuator can be moved manually with a small amount of force. Rezero can be reset by depression of the access register reset switch.

Flag Condition Select Switches

These three switches allow the CE to gate the three flag latches which allow selection of any of the six alternate (flag) surfaces with access register set.

Limit Switch Light

This light indicates that the CE inner or outer cylinder rezero has been located.

Attention Status Light

This light indicates that the access has ended a seek operation initiated by the FCU. If the access is Inop, a signal is not sent to the FCU at the end of seek.

Module Select Switch

This switch selects the module to be monitored or operated from the CE panel. Selection of a module also selects the access for that module.

Condition Indicator Lights

Head select, ready, detent in, rezero, access Inop, and limit switch are the conditions indicated by lights.

CE Sync Hubs

These convenience hubs are serviced by wires between the FCU and the 2302. The line from the FCU is terminated in the 2302. The line to the FCU is driven from the 2302.

POWER SEQUENCE PANEL

- All power sequence functions are controlled from this panel.
- This panel and its functions are described in Section 7, Power Control.

MARGINAL VOLTAGE CHECK JACK

- Marginal voltage checks of the logic circuitry are made by placing the portable marginal voltage supply plug into the jack receptacle.
- The +12 marginal voltage can then be raised to +15 volts or lowered to +9 volts.

CE LATCH AND LIGHT

This CE aid is used for intermittent troubleshooting and consists of an electronic latch with an indicator attached. The latch has a 4-way ANDed (Plus) input and 1 reset (Minus) line. Any inputs not used may be left floating. The indicator is attached to the On side of the latch. The AND circuit may be used to develop synchronization for an oscilloscope.

CE REMOTE CONTROL BOX (Figure 8-2)

- Allows CE to repeatedly seek an actuator between two selected addresses.
- Allows CE to write data from the CE cylinder format to any selected head in the CE cylinder.

Data writing and access motion can be checked by using the CE Remote Control Box in conjunction with the CE Test Panel for the access to be checked.

The CE Remote Control Box is connected to the 2302 via three paddle connectors. Two of these paddle connectors plug into card sockets located in the access control panel (A4, A6, B4, or B6) of the access to be checked and one is connected into A10 of the write driver box (Figure 8-3).

Write Bits — Write Gate Switches

Selection of the write gate switch raises the write gate if the access is located at the CE inner cylinder. Selection of the write bits switch allows data (provided by the 1 mc oscillator) to be put on the

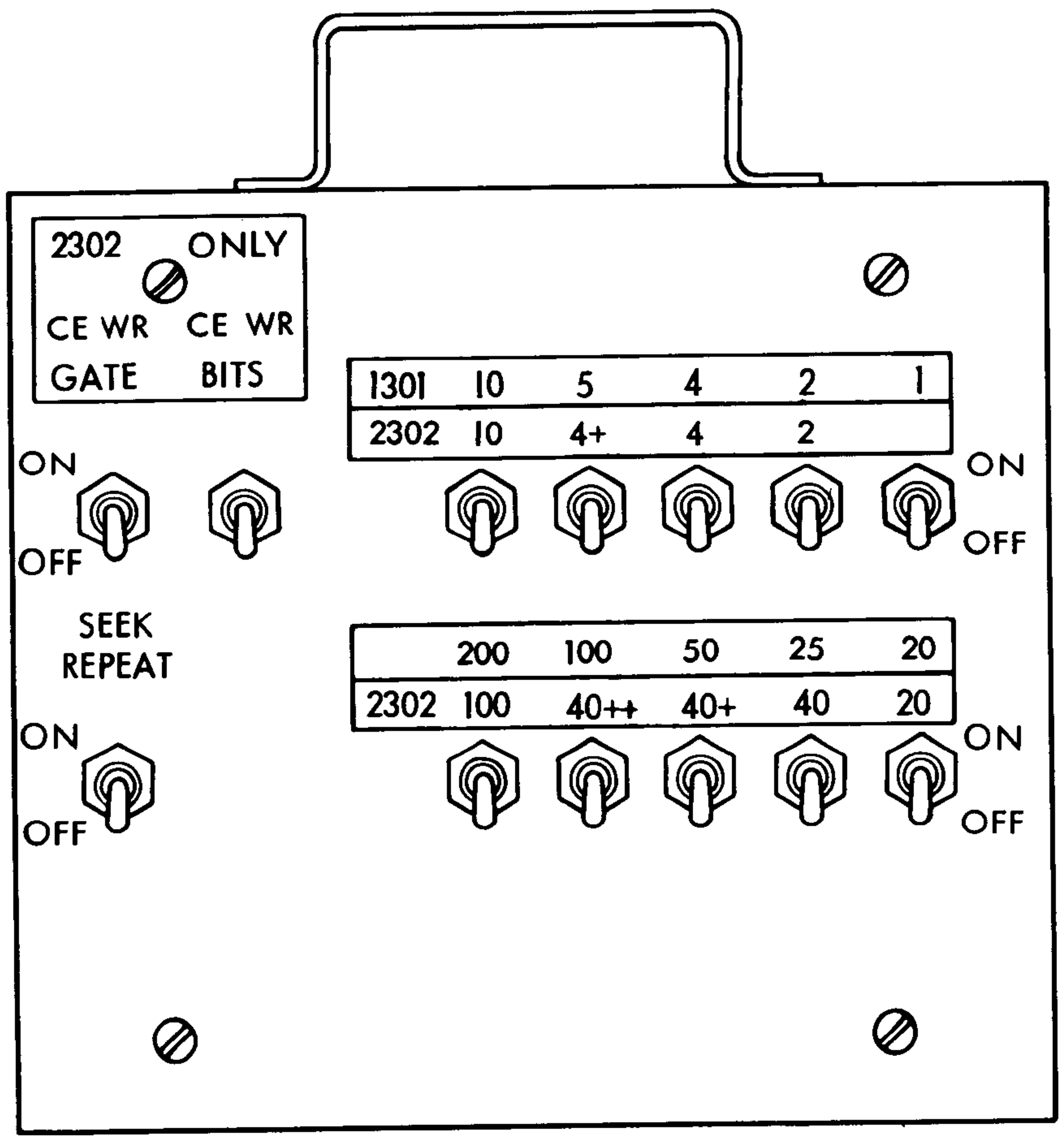


Figure 8-2. CE Remote Control Box

write data line. This data will then write on the head selected (by the CE Remote Box switches) within the CE cylinder.

Seek Repeat

Turning this switch to the Seek Repeat position causes the selected actuator to repeatedly seek between the cylinder specified by the address in the access register and the cylinder specified by the address set into the address select switches on the Remote Control Box.

Access	Plug Locations	Write Driver Box Cable
M0A0	A6F02 and A6F03	C3A10B
M0A1	B6F02 and B6F03	D3A10B
M1A0	A4F02 and A4F03	C2A10B
M1A1	B4F02 and B4F03	D2A10B

15547

Figure 8-3. CE Remote Control Box Connection

SEEK

- A 4-digit (16 bit) access register holds cylinder-head address requested by the File Control Unit.
- Timing of access motion is controlled by an adjustable oscillator (about 4.3 milliseconds per cycle).
- Access motion is caused by a change in the cylinder portion of the access register.
- Got-to-go differentiators detect access register change to start motion sequence.
- Detent safety transducer, mounted on top cover of actuator, monitors actuator speed.
- Detent detector circuit monitors position of the detent.

When a disk storage module is selected for a seek operation, a 4-digit address is sent from the FCU to indicate the cylinder and head desired. This 4-digit, cylinder-head address is decoded by a decoder network in the "E" gate and is then set into the 2302 access register (Figure 9-1). The access register is divided into two portions, one portion for the cylinder address and one portion for the head address. The output of the access register is sampled for a change of address (Figure 9-2). If a change in cylinder address is indicated, the access mechanism will seek the new address. If a change in head address only is indicated, the access mechanism will not move but a different head will be gated.

	CYLINDER		HEAD	
	Digit 1	Digit 2	Digit 3	Digit 4
Bit 1→	40	4	10	1
Bit 2→	40'	4'	20	2
Bit 4→	40"	10	1	4
Bit 8→	100	20	2	8

15548

Figure 9-1. Access Register

The timing for all access motion operations is controlled by an oscillator whose normal output signal is 4.3 ms from leading edge to leading edge. The frequency of the oscillator can be adjusted by a potentiometer mounted on the card. The oscillator output is gated by a not-long-count signal and a not-end-rezero-count signal to drive a 6-position binary counter. The oscillator is gated (CEILD #3).

A normal motion operation starts when the cylinder address is set into the access register (Flow Diagram #1). The change in the register is monitored by Got-To-Go differentiators. The differentiators outputs are divided into three basic time delays (50 ms, 120 ms, and 180 ms), but with four basic-timing considerations depending on the actuator solenoids that must be picked or dropped to move the actuator from its present address to its new address (Figure 9-3).

The four groups are:

1. An address which requires the picking or dropping of the 1, 2, 4, or 4' solenoids, singly or together is considered a short motion operation and is allowed a 12 count.
2. An address which requires the picking or dropping of the 10, 20, or 40 solenoids, singly or together, is considered a medium motion operation and is allowed a 16 count. The detent must be pulled on a 20 or 40 solenoid change.
3. An address which requires the picking or dropping of the 40+, 40++, or 100 solenoids singly or together, is considered a long motion operation and is allowed a 28 count. The detent must be pulled on this operation also.
4. An address with a change of 10 provides a unique situation. The motion involved does not require pulling the detent, since only piston action is involved. However, in order to provide adequate damping time, a longer count than 12 is required. For this purpose, a condition of Got-To-Go 10, leading edge of 9,and detent still in signals a true Got-To-Go 10. This is ORed with the 40+, 40++, and 100 to provide a count of 28 before the count 10 is complete. Since no detent delay is involved, but only a total count of 28, the

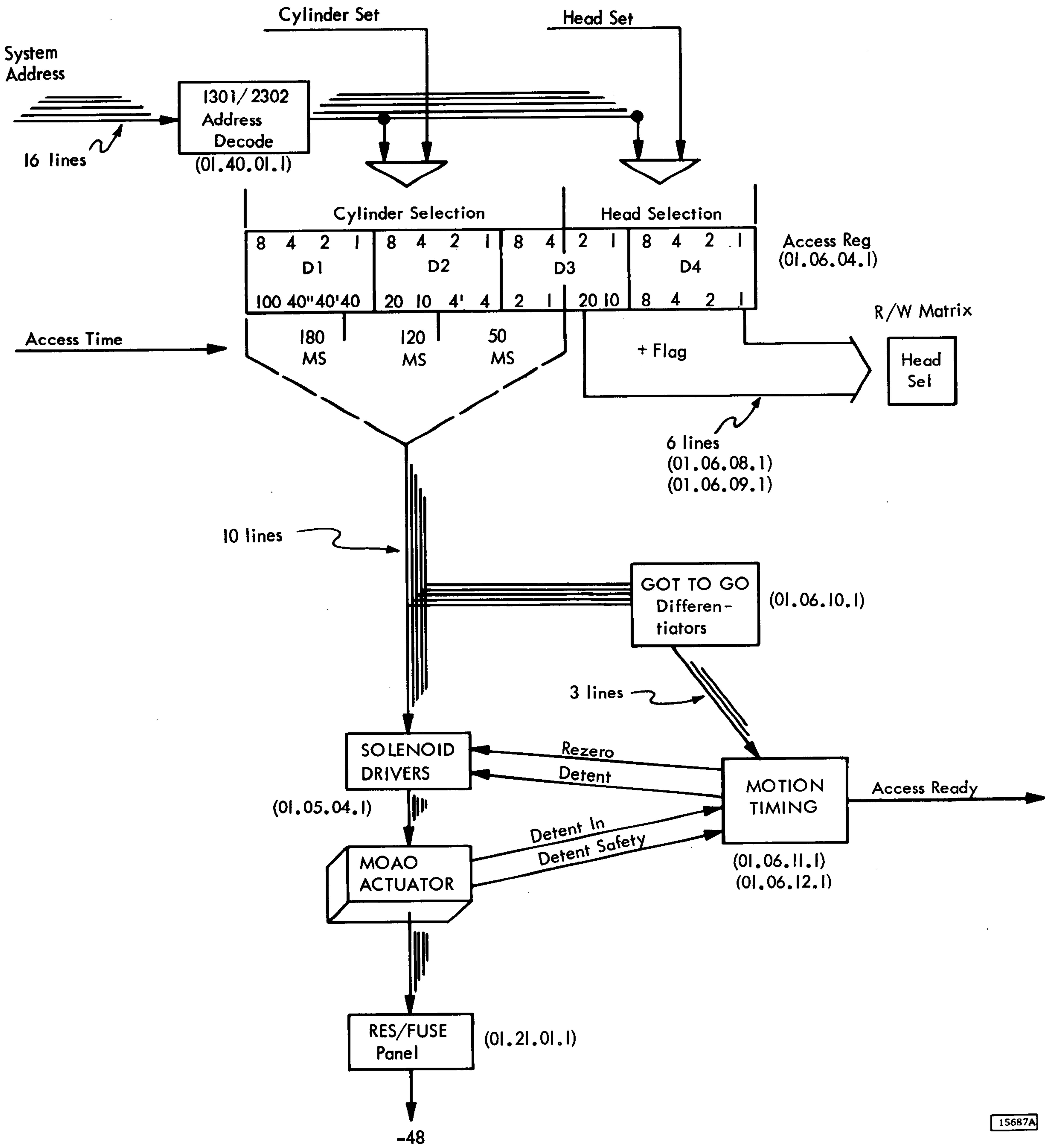


Figure 9-2. Access Register Decode (M0 A0)

ultimate total time is approximately 118 ms. This is very close to the total time required for the 20-40 globs, using a count of 16 with detent delays. Thus there are four timing considerations, but only three basic timing groups, 50 ms, 120 ms, and 180 ms.

The Got-To-Go differentiator outputs set the proper motion-count trigger, reset the detent trigger if necessary, drop access ready, and allow the motion counter to start running. The detent trigger goes off to allow the detent to be pulled out by its solenoid driver. The solenoids for the new address are picked by solenoid drivers directly from the access register. If only glob solenoids are picked, motion starts as soon as the detent is out. In the case of piston adder motion only, it is unnecessary to pull the detent, therefore, motion starts right after the solenoids are picked.

Type of Movement	Maximum Access Time
Small Pistons (only) 1, 2, 4, 4'	50^{+0}_{-1} M.S.
Large Piston (with or without 10 small pistons)	120^{+0}_{-3} M.S.
Small Globs (with or without 20-40 pistons)	120^{+0}_{-2} M.S.
Large Globs (with or without small globs 40', 40", 100 and/or pistons)	180^{+0}_{-2} M.S.

878558 15352

Figure 9-3. Access Times

Motion is monitored by a detent safety transducer mounted on the top cover of the actuator. It receives an input signal from a rack mounted on the moving carriage. This signal is integrated to form a motion gate. The motion gate will be broken if the actuator is traveling less than 10" per second. This broken gate is Detent Safety.

Detent position is also monitored. A slug coupled to the detent moves within the field of a differential transformer to generate a detent-in or detent-out signal.

When the motion counter reaches the proper count, it turns off the motion-count trigger previously turned on by one of the Got-To-Go differentiators. If actuator motion is less than 10" per second when the count trigger goes off, it sets the detent trigger which drives the detent in. The Detent-In signal from the detent detector resets the motion counter. The motion counter is then advanced to nine and the detent-delay trigger is reset if there is no motion. At this time, the Access-Ready signal comes up if all conditions are satisfactory. The access-ready line together with M0 A0 indicates to the FCU that the desired R/w head is positioned at the cylinder address contained in the access register. The access is now ready to respond to a read or write (or another seek) command.

Access ready also raises an end-of-seek signal which samples the attention status latch to develop an M0 A0-attention-status signal.

Each access mechanism has its own access control electronics to allow one access mechanism to move while the others are reading, writing, or moving.

The access-control electronics control the access positioning, retain the assignment of each access, check that the access has arrived at a cylinder location, and allow manual control for CE aids.

Circuit Description (Figures 9-1 and 9-4)

To facilitate the description of a seek operation, assume that a seek to cylinder 40 HD1 using Module 0 Access 0 is called for by the using system. The following objectives must be accomplished.

1. Set new address in access register (40 HD1).
2. Pick the digit 1 bit 1 solenoid driver and the 40 solenoid.
3. Control the motion of the access mechanism.
4. Establish Access Ready.
5. Establish Attention Status.

Set New Address in Access Register (ILD #1)

1. Drive system address lines to panel A1 in the 2302. These lines are then driven to panel A6 on gate On the access register latches.
2. Raise M0 A0 SELECT.
3. Turn on all gated access register cylinder latches (in this case D1 B1).
4. Turn on all gated access register head latches (in this case D4 B1).
5. Turn off all access register latches that are not gated on.

Pick the Digit 1 Bit 1 Solenoid Driver and the 40 Solenoid Driver (ILD #1).

1. Pick the 40 solenoid driver directly from the output of the D1 B1 access register latch.
2. The driver is connected directly to the solenoid coil.

NOTE: One side of all solenoid coils is fused to -48 volts.

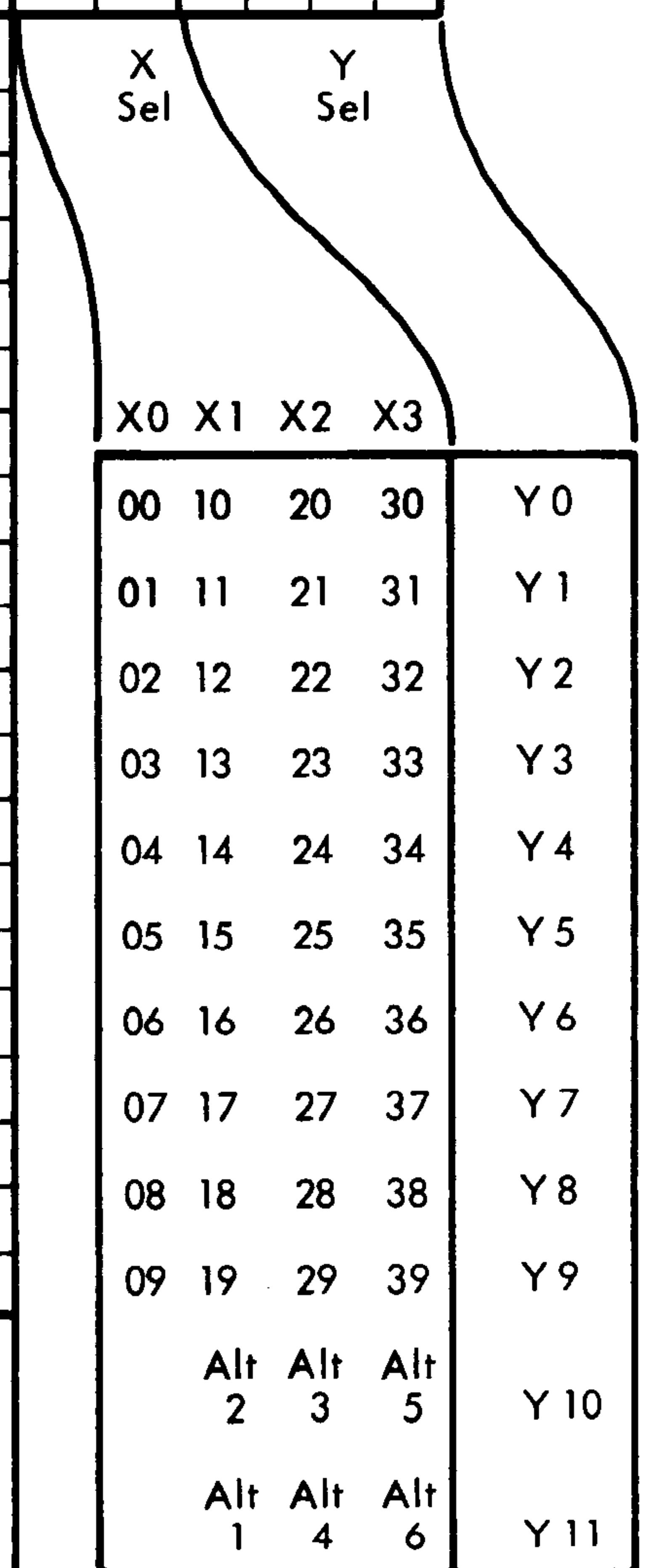
Control the Motion of the Access Mechanism (ILD #2).

1. The on and off sides of the access register cylinder latches are monitored by the Got-To-Go circuit differentiators. The differentiators emit a pulse when any access register latch changes state. There are three basic differentiator circuits: 1, 2, 4, 4F, 10, Got-To-Go; 20, 40 Got-To-Go; and 10, 40+, 40++, 100 Got-To-Go. The glob outputs 20, 40 Got-To-Go and 40+, 40++, 100 Got-To-Go, are ORed to raise Glob Got-To-Go.

xxx Cylinder
40) Track Address

-----
xx Head

		Cylinder Select										Head Select					
		GLOB Adder					PISTON Adder					X Sel		Y Sel			
		8	4	2	1	8	4	2	1	8	4	2	1	8	4	2	1
		D 1				D 2				D 3				D 4			
System File Addresses	Cylinder	100	40"	40'	40	20	10	4'	4	2	1	20	10	8	4	2	1
0000-0039	0	NOT USED															
0040-0079	1										X						
0080-0119	2									X							
0120-0159	3									X	X						
0160-0199	4								X								
0200-0239	5								X		X						
0240-0279	6								X	X							
0280-0319	7								X	X	X						
0320-0359	8							X	X								
0360-0399	9							X	X		X						
0400-0439	10						X										
0440-0479	11						X				X						
0480-0519	12						X			X							
0520-0559	13						X			X	X						
0560-0599	14						X		X								
0600-0639	15						X		X		X						
0640-0679	16						X		X	X							
0680-0719	17						X		X	X	X						
0720-0759	18						X	X	X								
0760-0799	19						X	X	X		X						
0800-1599	20-39					X	USE APPROPRIATE PISTONS										
1600-2399	40-59				X												
2400-3199	60-79			X		X											
3200-3999	80-99			X	X												
4000-4799	100-119	X															
4800-5599	120-139	X				X											
5600-6399	140-159	X			X												
6400-7199	160-179	X		X		X											
7200-7999	180-199	X		X	X												
8000-8799	200-219	X	X	X		X											
8800-9599	220-239	X	X	X	X												
9600-9999	240-249	X	X	X	X	X											
9#00-9#99	250	X	X	X	X	X	X										



Alt	Flag Latch
1	1
2	2
3	3
4	1,3
5	2,3
6	1,2,3

Note: C E Track, 9#20-9#59

15549A

Figure 9-4. Access Register Decoding

A change of 10 is reflected in two of these groups. This provides a delay count of 28 without Glob Got-To-Go (and thus without detent delay) and results in a total delay time near the 20, 40 Got-To-Go group.

2. Access register latch D1 B1 has changed state. The 20, 40, Got-To-Go differentiator turns on the 16-count trigger.
3. The differentiator output also turns off the detent trigger (ILD #4) which drops the detent solenoid to pull out the detent.
4. The detent trigger goes off to drop access ready.
5. When the detent comes out, a not-power-detent-in signal turns on the detent-delay trigger.
6. Dropping access ready allows the motion oscillator (ILD #3) to drive the motion counter by removing the reset hold from the counter trigger.

   As the motion oscillator advances the motion counter, the actuator moves and the 2302 maintains a not-access-ready condition. The change in the access register was a digit 1 bit 1 (a 40-cylinder change). This change requires a 25-count, or approximately 103 ms, composed of a 16 count for actuator motion and a 9 count for the detenting operation.

   The motion counter is a straight binary counter. The first pulse turns trigger 1 on. The second pulse turns 1 off and 2 on. The third pulse turns 1 on. The fourth pulse turns 1 and 2 off and 4 on, etc.
7. The motion counter advances until the 16 trigger is on. Trigger 16 is decoded to raise 16 count.

NOTE: The output of the decoder is not always "true". For example, trigger 16 raises a "true" 16 count. Any other combination including a 16 will raise a "false" 16 count. Either of these will fill the requirements of a 16 count. Therefore, if a function fails at a "true" 16 count, it has another chance at 17, 18, 19, 20, etc.

8. A 16 count turns off the 16 trigger (ILD #2).
9. The actuator should have arrived within the 16 count (66 ms). However, to make certain, it is checked for motion by the detent safety transducer.
10. The transducer signal is fed through an integrator to determine if motion exists. If motion is less than 10" per second raise detent safety (ILD #4).
11. If the detent can be inserted safely and the 16 and 28 (ILD #2) count triggers are off, the detent trigger is turned on to enable the detent solenoid driver to pick and hold the detent solenoid (ILD #4).
12. As the detent goes in, its position is detected by the detent detector to raise a detent-in signal. The motion counter will count to 19 or 20 before detent-in comes up.
13. The detent-in signal resets the motion counter but the counter starts counting again because access ready is not present (ILD #3).

Establish Access Ready (ILD #4).

1. If a detent-safety condition is still present when the motion counter reaches a 9 count, the detent delay trigger is turned off and access ready is raised.
2. Access ready turns on the access ready light, prevents the motion counter oscillator from stepping the motion counter by holding the motion counter reset and samples the status condition latch to develop attention status.

   With access ready raised, the 2302 is ready to receive additional instructions from the system.

Establish Attention Status (ILD #5).

1. The Attention Status latch is reset when the system selects the module and access to be used and end of seek is present.
2. When the cylinder address is set in the access register, the Attention Status latch is turned on if the access selected is not Inop.
3. As previously explained, a successful seek operation is signaled by the development of an access ready signal. Access ready raises end-of-seek. End of seek samples the output of the Attention Status latch to develop an M0 A0 attention status signal to the system.
4. If for any reason access ready is not generated by the time the motion counter reaches a 56 count, an arrival failure condition is raised to start a rezero operation. At the completion of a successful Rezero operation, the hydraulic fluid will have been recalibrated and the access mechanism will be at the extreme outer limit. Attention Status is then sent to the system. Rezero is not reset until the FCU sends the next Seek command. When the Seek command is received, the

actuator is detented at cylinder zero. If the Rezero operation fails, or if for any other reason a 60-count is reached, the Access is set Inop and the count-60 raises End-of-Seek, and samples the Attention Status latch to develop the M0 A) Attention Status signal to the system.

REZERO (FLOW DIAGRAM #2)

A rezero operation causes the access to move on its outermost limit for the primary purpose of recalibrating the hydraulic fluid in the actuator mechanism.

Rezero is caused by any one of the following conditions:

1. Access cover door open or off.
2. Power on sequence (Solenoid dc And not file ready).
3. Arrival failure (count 56 and not access ready).
4. Invalid address (address greater than 251).
5. Inner limit switch closed when not addressed to cylinder 250.
6. Inner limit switch not closed when addressed to cylinder 250.

When a rezero operation is initiated, the cylinder portion of the access register is reset to zero, and the rezero solenoid is energized. The detent is held for a "long" 16 count then the detent is pulled.

The actuator stays at the outermost limit for a 56 count. After the 56 count, attention status is sent to the system. The system will recognize a rezero and send another seek command. The detent is then driven in, the rezero latch is reset and access ready is generated.

Circuit Description (ILD #6)

For the following description, assume that the rezero latch is turned on by an arrival failure. The following objectives must be accomplished:

1. Reset the access register.
2. Energize the rezero valve.
3. Hold the detent for a long 16 count.
4. Pull the detent.
5. Move to outer cylinder.
6. Develop attention status.

The following conditions are established by a Seek Command:

1. Set the detent.
2. Reset the rezero latch and develop access ready.

Reset the Access Register (ILD #6). As soon as the rezero latch is set, rezero resets the cylinder portion of the access register.

Energize the Rezero Valve (ILD #6). The rezero valve is energized as soon as the rezero latch is set. The rezero valve provides additional oil to push the actuator to the outer stop and allows recalibration of the glob adder.

Hold the Detent for a Long 16 Count.

1. A differentiated Rezero signal turns on the 16-count trigger (ILD #2). This trigger produces a Glob-Got-To-Go to turn off the detent trigger (ILD #4). However, the detent solenoid is held by Rezero until the motion counter counts to 16 (ILD #4).
2. Rezero, Detent trigger Off, and 16 Count triggers On develop Long Count (ILD #3).
3. Early Index flips a binary trigger (Alternate Revolution) every cycle. The trigger goes on with the first revolution of the array, off with the second, on with the third, etc. The on side shifts positive once every other revolution (when the trigger goes on). This positive shift and the Long Count signal (developed in step 2) develop Long Count Drive. Long Count Drive steps the motion counter once every 68 ms until a 16 count is reached and the detent is pulled.

Pull the Detent.

1. When the 16 count trigger goes off, the detent solenoid turns off and pulls the detent, thus allowing the actuator to go to the outer position under rezero force (ILD #4).
2. When the detent comes out, the detent delay trigger is turned on by a Not-Detent-In signal (ILD #4).
3. Closing the outer limit switch causes a reset of the motion counter, drops long count, and allows the counter to be advanced by the motion oscillator once every 4.3 ms (ILD #3).
4. At count 56, the end rezero condition is recognized and attention status is developed.

Develop Attention Status (ILD #5).

1. The Attention Status latch is turned on at the beginning of a Seek Operation, as long as the access is not Inop.
2. After a full 56 count at the outer CE cylinder, End Rezero Count is raised to block

the motion counter advance and develop End of Seek. Count 56 remains available until the counter is reset. End of Seek samples the Attention Status latch to develop Attention Status to the system.

NOTE: Access Ready and Count 60 also sample the Attention Status latch. Count 60 allows system Attention Status to develop in case the access goes Inop.

Set the Detent.

1. During a rezero operation, the End of Seek condition is raised by End Rezero Count. Following an Attention Status, the FCU recognizes a rezero and may issue another seek command. Any address at this time is valid.

   A subsequent seek command resets rezero and resets the motion counter to allow the counter to time the detenting operation (ILD #6).
2. Rezero latch off turns the detent trigger on if the actuator motion is less than 10 in./sec to power the detent solenoid driver (ILD #4).
3. When the detent is seated, a differentiated Detent In pulse resets the motion counter. However, the motion counter begins to step again because the access is not ready (ILD #3).

Develop Access Ready (ILD #4)

1. With the motion counter set to a 9 Count, the Detent Delay trigger is turned off.
2. When the Detent Delay trigger is turned off, all of the conditions required for the development of Access Ready are established (ILD #4). Access Ready holds the motion counter reset and raises the Attention Status to signal the system that the file is ready for the next instruction.

When the detent is set after a rezero operation, the access is at Cylinder 0. Therefore, another seek is required if a different cylinder is desired.

ACCESS INOP

The access inoperative (Inop) circuits have been incorporated into the 2302 to disconnect the 2302 from the system. The system cannot cause an access that is Inop to perform a read, write, or seek function.

An access can be set Inop by any of three methods (ILD #7):

1. System Programming (Set Access Inop).
2. Automatically by 2302 circuitry if any of the following conditions exist.
   a. Access cover open or off.
   b. Heads not loaded at head load check time.
   c. Access not retracted at access retracted check time.
   d. Motion counter reaches 60 count.
3. Manually by switch from power sequence panel (CE set access Inop switch).

An access that is Inop can be reset in only one way: manually from the Power Sequence Panel.

- 2302 uses double-frequency horizontal NRZI recording method.
- Conventional horizontal recording device is a ring with a gap and a coil wound at some point on the way.
- During a write operation, a bit is recorded when the flux direction in the ring is reversed by rapidly reversing the current in the coil.
- During a read operation, a bit is sensed when the flux direction in the ring is changed as a result of a flux reversal on the disk surface.

Description

The IBM 2302 Disk Storage unit uses the double-frequency horizontal NRZI (nonreturn to zero IBM) method of magnetic recording. NRZI recording recognizes a change in flux pattern to indicate a bit while no change represents a NO bit. Thus, each transition of magnetization from plus to minus or minus to plus polarity represents the storage of a bit.

Double frequency is the term given to the recording system that inserts a clock bit at the beginning of each bit cell time thereby doubling the frequency of recorded bits. The horizontal recording device is a ring with a gap and a coil wound at some point on the ring. When current flows through the coil, the flux induced in the ring fringes at the gap (Figure 10-1). As a magnetic recording surface passes by the gap, the fringe flux magnetizes the surface in a predominantly horizontal direction.

During a write operation, a bit is recorded when the flux direction in the ring is reversed by rapidly reversing the direction of the current in the coil. The fringe flux is reversed in the gap, and hence the portion of the flux flowing through the recording medium is reversed. If the flux reversal is considered instantaneous in comparison to the motion of the recording surface, and the gap is observed at the moment of reversal, it can be seen that the portion of the surface that just passed the gap is magnetized in one horizontal direction while the portion directly under the gap is magnetized in the opposite direction. Between these two areas, the flux must reverse 180°; this recorded flux reversal represents a bit (Figure 10-2).

During a read operation, the gap first passes over an area that is magnetized in one horizontal direction, and a constant flux flows through the ring and the coil. The coil registers no output voltage. However, when the recorded bit (180° horizontal flux reversal) passes the gap, the flux flowing through the ring and coil must also go through a 180° reversal. This means that the coil sees a change in flux which results in a voltage output pulse (Figures 10-3 and 10-4).

2302 READ/WRITE HEAD

- The 2302 read/write head is a 4-terminal device containing three coils.
- The 2302 writes a wide band, then "tunnel" erases the recorded data to leave a narrow band.

Description

The 2302 read/write head is a 4-terminal device containing three coils (Figure 10-5). One coil is used exclusively for magnetically erasing data from the

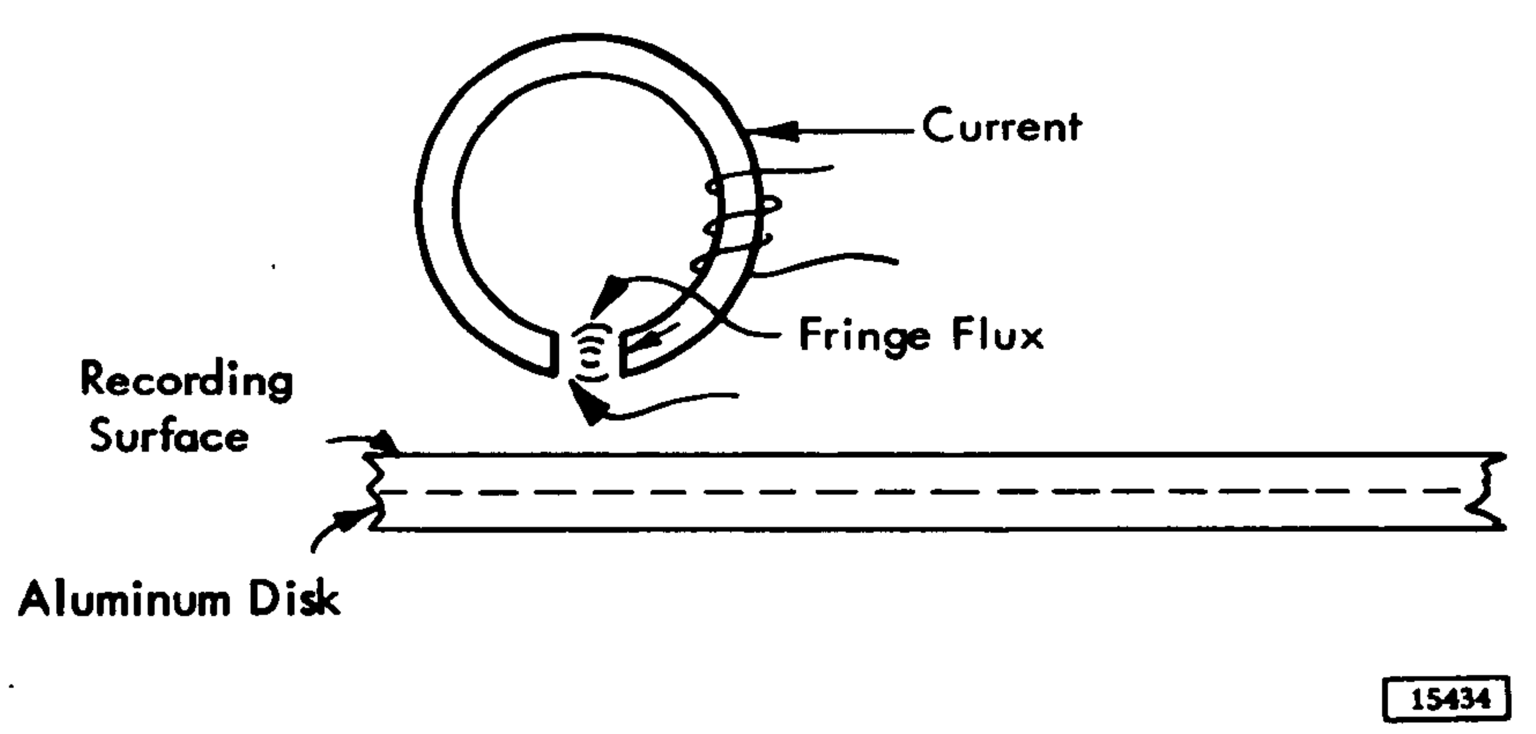


Figure 10-1. Basic Ring Head

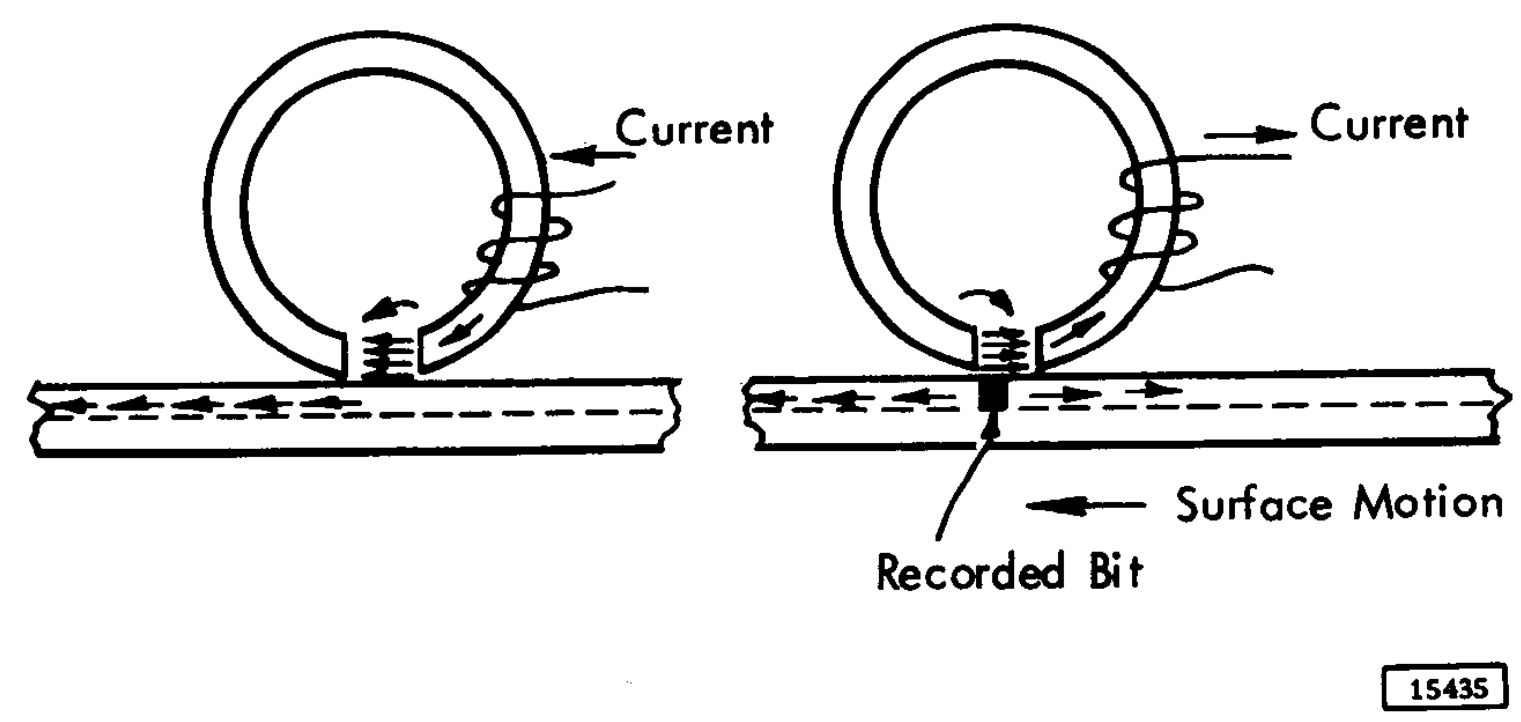


Figure 10-2. Horizontal NRZI Recording

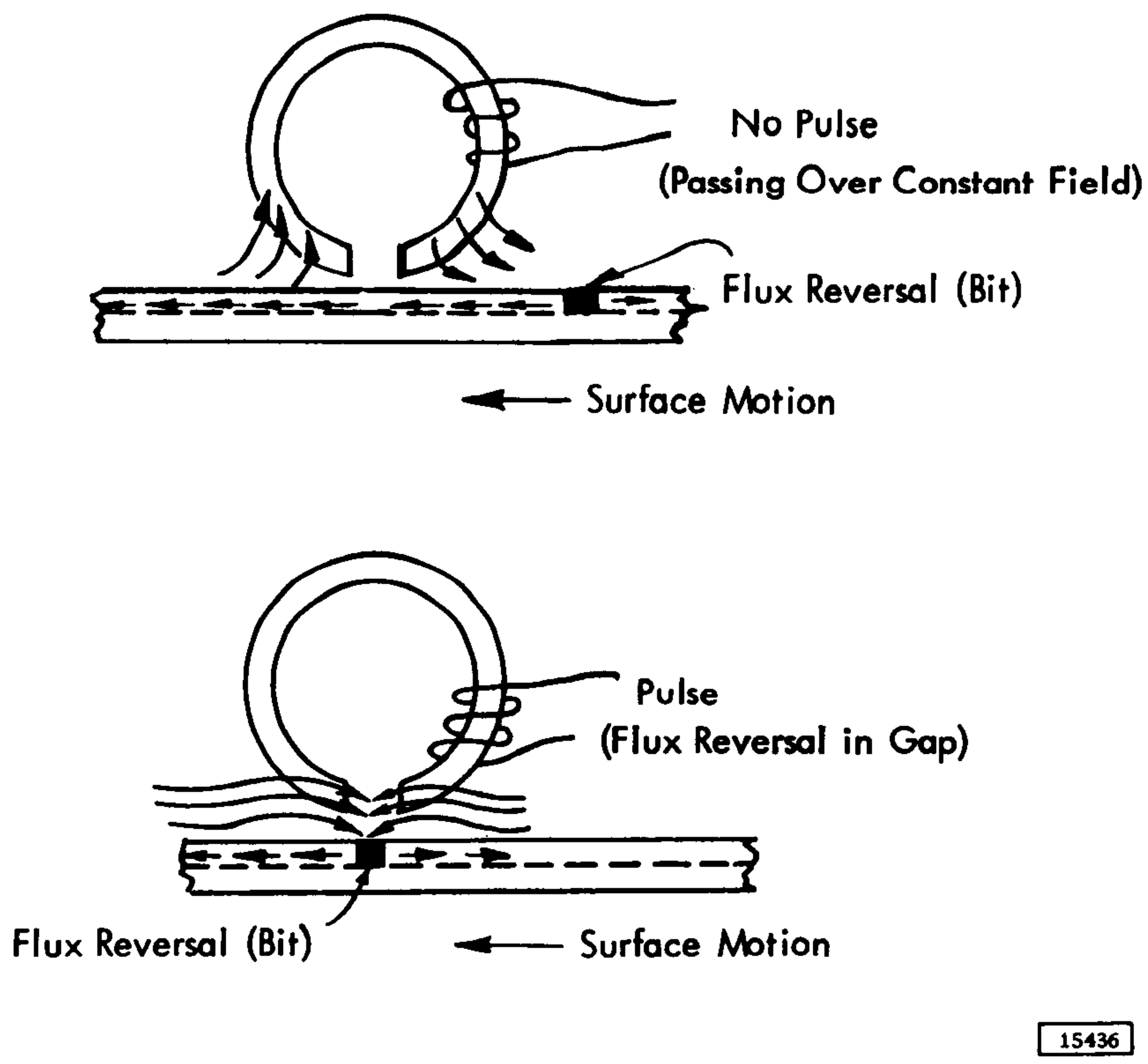


Figure 10-3. Reading Horizontal Fields with Ring Head

disk. The remaining two coils are connected in series and are used for reading and writing on the disk surface.

The 2302 head is designed with the read/write core ahead of a split erase core (Figure 10-6). This unique design (called tunnel erase) allows the 2302 to write a band of data 0.008" wide then immediately erase it to 0.005" wide. The difference in erase and write width allows for minor deviations in head positioning during subsequent read operations.

The current through the write coil erases the old data as new data is recorded.

Head Selection

- Y selection gates the common connection to all three coils in the head.
- X selection gates the read amplifier or the write driver and the erase coil.
- Head gating can be done as part of a seek command, a read command, or a write command.

Description

The common connection to all three coils of the read/write head is called "Y" select (Figure 10-5). Each 2302 access mechanism has twelve Y select lines (System Diagram 01.00.04.0). Each of the first ten Y select lines (Y0 to Y9) connects to four data read/write heads in parallel. Each of the last two Y select lines (Y10 and Y119 connects to three alternate (flag) surface read/write heads in parallel. The units digit of the head address is decoded to select Y0 to Y9. The flag line inputs from the 7631 are decoded to select Y10, Y11, and the proper X select line.

The remaining three connections to the read/write heads are "X" select lines. The tens digit of the head address and the flag lines are decoded to select X0 to X3. Each X select line (except X0) is connected to ten data read/write heads and two alternate read/write heads in parallel. X0 is connected only to ten data heads in parallel.

NOTE: The remaining read/write heads required to complete the 12 x 4 (12 Y select lines and 4 X select lines) matrix are spare heads or unused positions.

Erase X select activates the erase coil of the selected head. The read/write X select connections are connected both to the input of the read amplifier and to the output of the write driver. By selecting a specific Read X select line or Write X select line, a specific Write Driver or Read Zone is selected.

Complete head selection requires one of the four X-select lines (X0 to X3) to gate the read zone or the

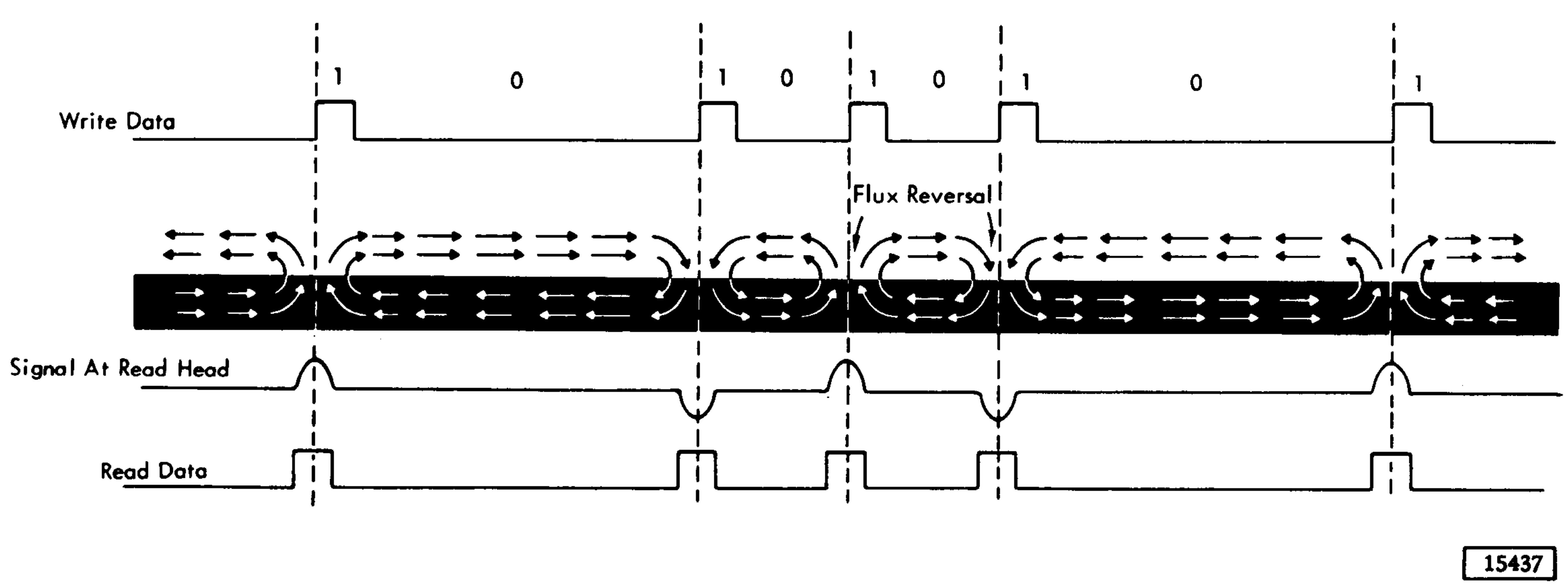


Figure 10-4. Flux and Pulse Relationship

to gate the common side of the read/write coil. If writing is required, the erase coil must also be activated. Figure 10-7 shows a simplified X-Y select matrix and Figure 10-8 shows the complete selection matrix.

The tens digit of the head address (or flag lines from 7631 if alternate head is required) controls the X select lines:

X0 selects data heads 0 through 9
X1 selects data heads 10 through 19 and alternate heads F1 and F2
X2 selects data heads 20 through 29 and alternate heads F3 and F4
X3 selects data heads 30 through 39 and alternate heads F5 and F6

If more than one X-select line is on, an error condition is detected by the multiple X-select circuit.

The units digit of the head address (or flag lines from the 7631 if alternate head is required) controls the Y select line:

Circuit Objectives

Raise Y2 Select for Head 22 (read or write) CEILD #8:

1. Head select, module 0 select, and access 0 select are sent to the 2302 from the FCU.
2. Module 0 select and access 0 select AND to raise M0 A0 select.
3. M0 A0 select ANDs with head select to raise M0 A0 head select. M0 A0 head select ANDS with not flag select to raise condition head select.
4. Condition head select ANDS with the output of the units position of the head portion of the access register to raise Y2 head select.
5. The read/write Y select (YSEL) card enables Y2 select which is tied directly to the common coil tap of the four read/write heads involved (CEILD #10).

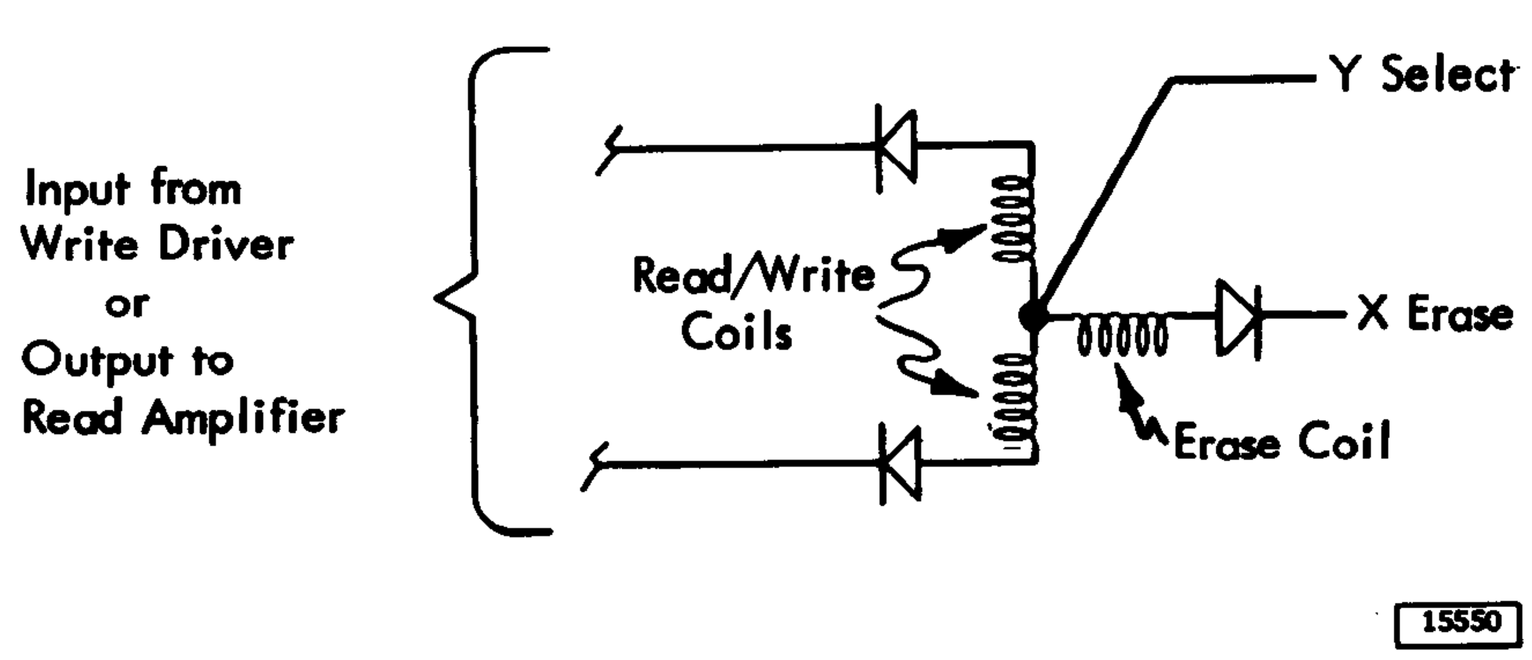


Figure 10-5. Read/Write Head Circuit

Raise X2 Select for Head 22 (read or write) CEILD #8:

1. Condition head select is developed the same as in Y select.
2. Condition head select ANDs with not M0 A0 store format. (M0 A0 store format prevents a data read or write while in a format write operation.)
3. Condition head select and not M0 A0 store format AND with acc reg D3 B2 and not acc reg D3 B1. If a read operation is required this output is ANDed with not M0 A0 erase gate to raise X2 read select. If a write operation is required,this output is ANDed with M0 A0 write gate to raise X2 write select and with M0 A0 erase gate to raise X2 erase select (ILD #10).

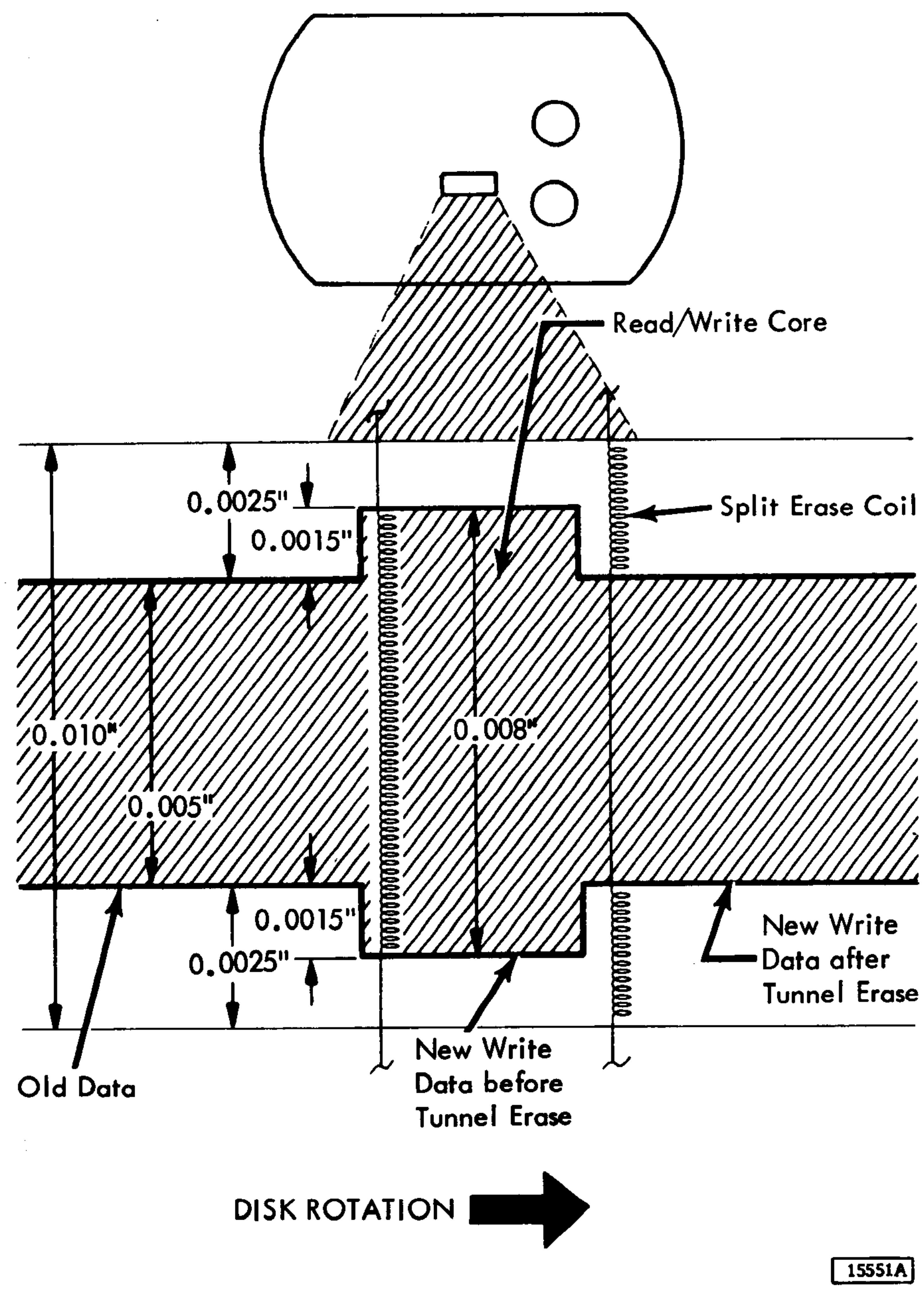


Figure 10-6. Magnetic Head-to-Disk Relationship

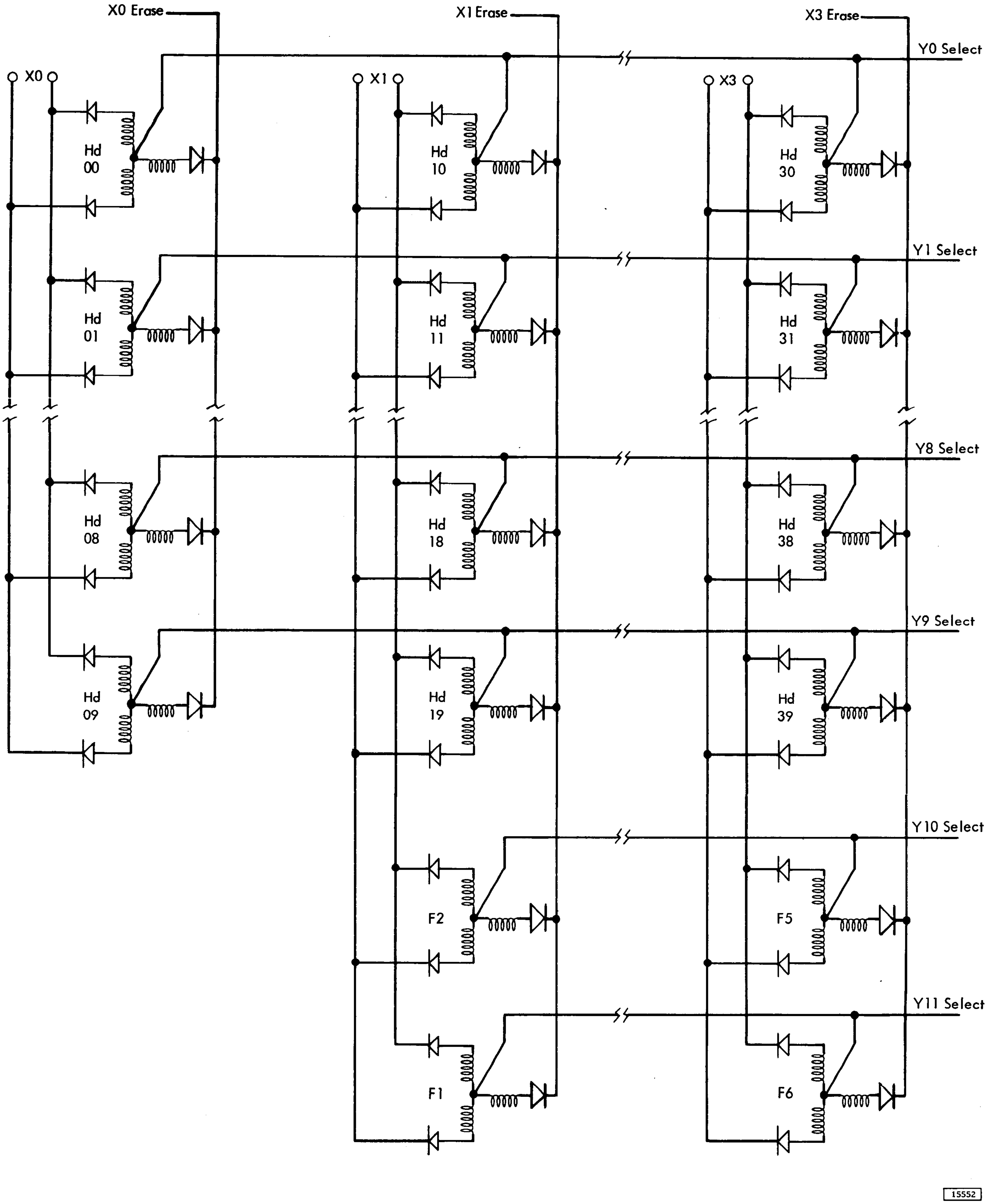


Figure 10-7. Read/Write Head Matrix

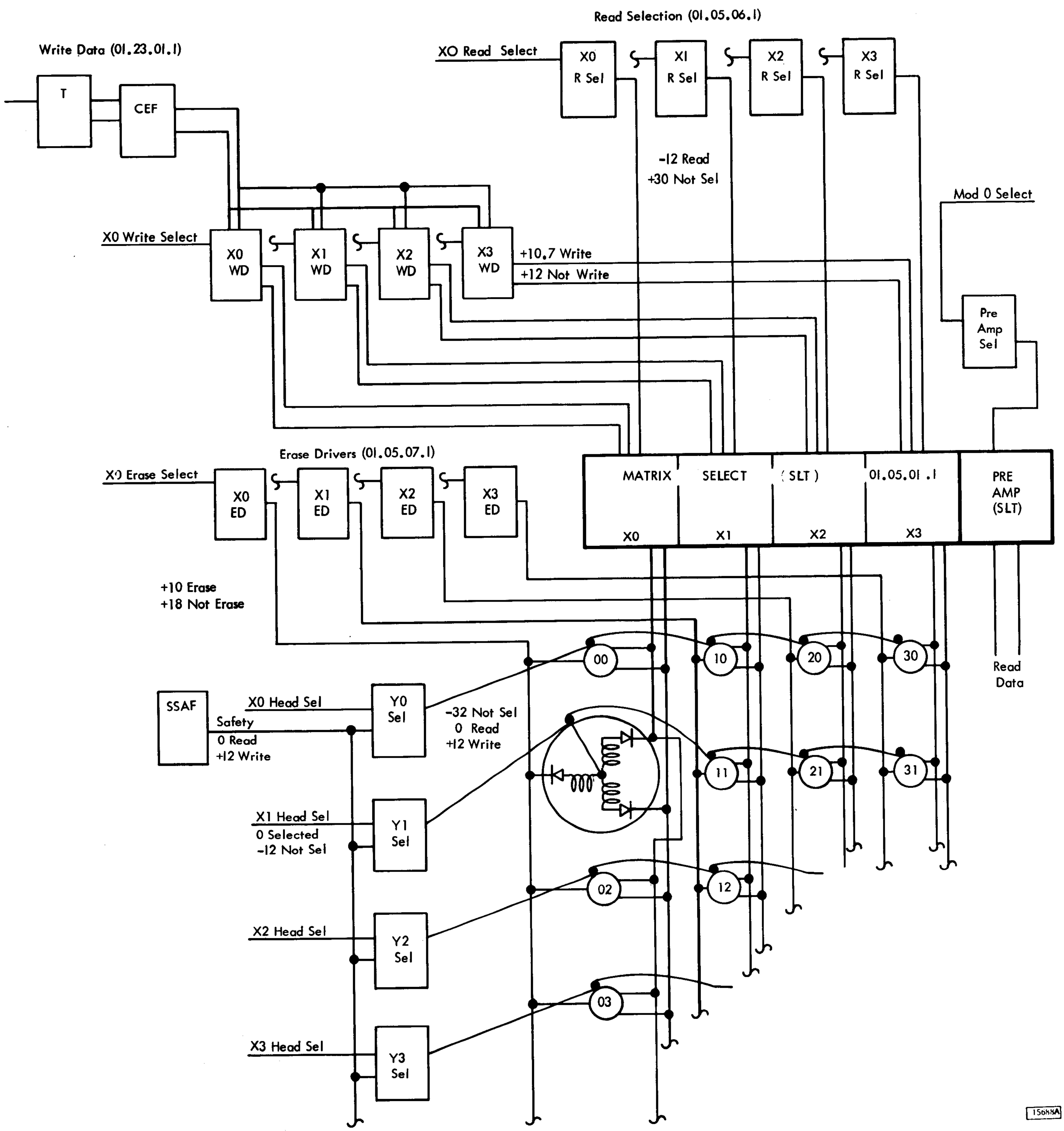


Figure 10-8. Read/Write Selection (M0 A0)

SAFETY CIRCUITS

- Prerecorded address associated with each record provides a location check before new data is recorded. This check must be made by the file control unit.
- Safety circuits indicate error condition if an improper condition exists in the write driver, write gate, or read/write head areas.
- The voltage (Select) safety (SSAF) circuit deselects the Y select line to the head if an improper voltage level exists that could interfere with read or write operations.
- The multiple X select and write driver safety circuits indicate an error condition if more than one head is selected or if no write driver is selected when writing. (CEILD #9)
- Double Y select detection during reading is dependent upon FCU read data checking. Read data will not be good.
- SMS cards and their functions are described in the special circuits section of the system diagrams.

WRITE DATA RECORD

- A Write command allows write data to be transmitted from the system and recorded in the disk storage unit.
- Data is transmitted serially by bit and serially by character.
- The writing process is under complete control of the processing system.
- Verification by the system of the record address should be made prior to the initiation of the write operation.

Description

When the proper head is selected and the write gate is established, the write driver and the write and erase coils are receptive to data pulses (CEILD #9). When the write gate is established, current flows through the write coil and causes all previous data to be erased even though no write data is transmitted.

Write data pulses are supplied from the FCU to the selected module and access write trigger (CEILD #9). The write trigger "flips" with each pulse. The on and off outputs of the write trigger are fed to a complimentary emitter follower that has in-phase outputs for both the on and off condition of the write trigger. These outputs allow the write driver to conduct through one half of the read/write coil to the Y select circuit. When the write trigger "flips," the write driver provides a circuit to allow conduction through the other half of the read/write coil to the Y select circuit.

Because the core of the write coil is physically wider and placed in front of the erase core, a constant current through the write coil causes a width of 0.008" to be magnetized in a constant direction. If there are no flux changes, this width is erased. The erase coil following the write coil erases part of the write pattern to leave a band that is 0.005" wide.

Format read data and early and late index pulses are transmitted to the processing system during the entire time the access and module are selected. This data is used to control the timing for the record address and the record data. In addition, clock signals are also transmitted to the processing system whenever a valid module is selected. The clock signals are used to synchronize write data with motor speed variations.

READ DATA OPERATION

- A read data command allows read data to be transmitted from the desired cylinder-head address to the processing system.
- Data is transmitted serially by bit and serially by character.
- The reading process is under complete control of the processing system and the FCU.
- Verification by the system of the record address should be made prior to the initiation of the read operation.
- 2302 is conditioned to read when a head is selected and the erase gate is absent.

Description

When a head is selected to read, the recorded data induces read signals into the R/W coil. These signals are then fed to the read amplifier where their amplitude is increased. Detection circuitry senses the peaks of the amplified head signals that exceed a specified voltage level. The resulting pulses are fed through a shaper to produce output data bits of standard amplitude and duration.

Format read data and early and late index pulses are transmitted to the processing system during the entire time the access and module are selected. This data is used to control the timing for the record address and the record data. In addition, clock signals are also transmitted to the processing system whenever a valid module is selected. The clock signals are used to synchronize read data with motor speed variations.

Data Read Amplifier (CEILD #13)

The 2302 has two data read amplifiers. One for the two accesses on the front of the machine and another for the accesses on the rear of the machine. The inputs to the amplifiers are gated by module and access and the outputs are ORed together into a single file read data line to the system. The read amplifier consists of a pre-amplifier, a filter differentiator, a linear amplifier, an overdriven amplifier, and a bit detection and shaping circuit (Figure 10-9).

Functional descriptions of the special circuit cards used in the read amplifier along with wave shapes are included in the component circuits section of the system diagrams.

The input leads from the heads connect to the read X select (SLT) card (01.80.43.0). These lines carry a double-ended signal of about 10 millivolts, with a minimum of 1 millivolt, peak-to-peak. A double-ended signal is a signal taken from opposite ends of a center tapped coil. The actual read signal processing begins in the SLT pre-amplifier (01.80.44.0) where a voltage gain of three is obtained and common mode rejection is achieved. The amplifier's resistance to a signal (noise) that causes both input lines to go in the same direction (up or down together) is called common mode rejection. The amplifier amplifies only the difference between the two signal input line levels.

The filter differentiator card provides additional amplification, filtering, and detection of the read signal.

The output of the filter is connected to a linear amplifier which further amplifies the read signal. The output of this card is about 4.5 volts peak to peak.

The output of the linear amplifier is connected to the overdriven amplifier. The overdriven amplifier has three stages which produce an overall gain of about 80.

The output of the overdriven amplifier is connected to the detector card. This card "clips" the amplified signal to produce a standard output pulse

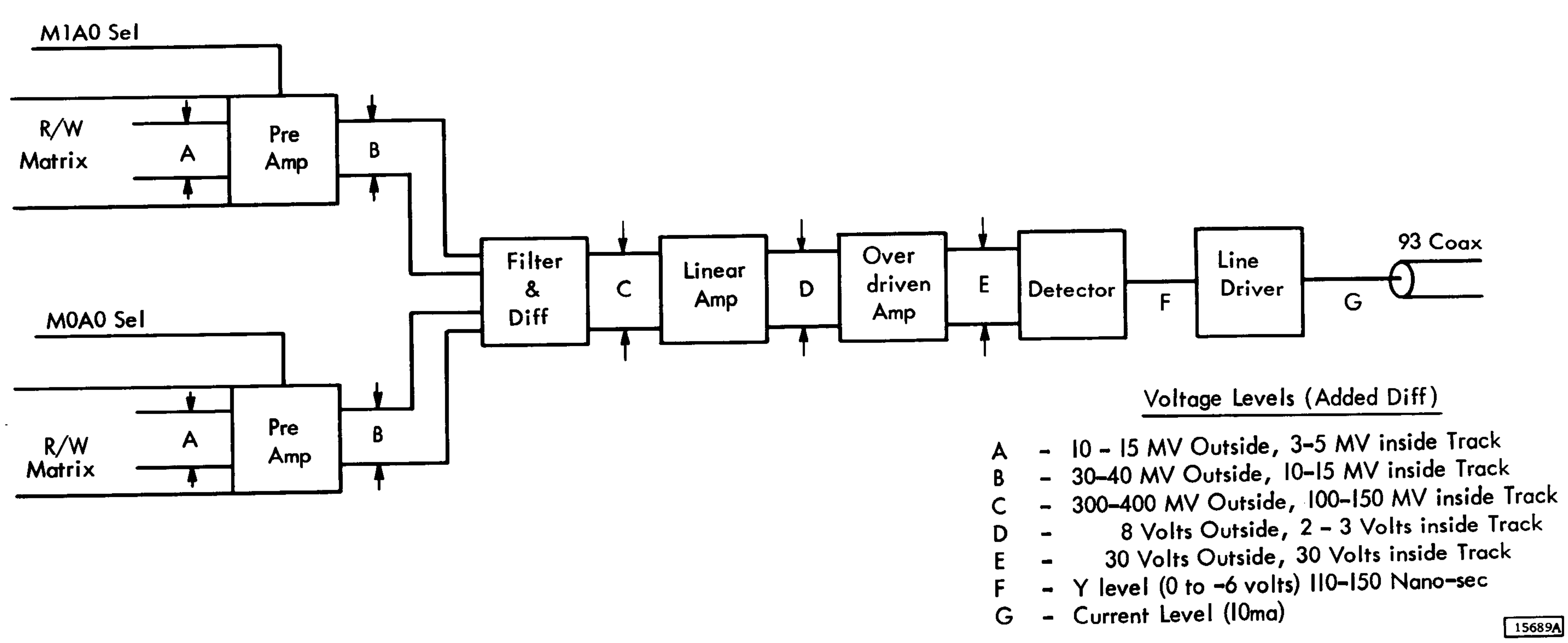


Figure 10-9. Read Amplifier (M0 A0/M1 A0)

of 110 to 190 nanoseconds for each change in the input signal.

The output of the detector in the A0 amplifier is ORed with the output of the detector in the A1 amplifier. This output is sent to the system.

WRITE FORMAT OPERATION

- A write format command refers to the operation that instructs the file to accept write data from the processing system and to write this data on the format disk.

- Verification by the system of the position of the format head should be made prior to the initiation of the write format operation.

- The 2302 has two format write triggers and two format write drivers.

Description

The write gate, erase gate, and write data perform the same functions as during a normal write operation. The write format operation proceeds in the same manner as a write operation except that the write current path is from the write driver through the reed relay to the format head. The format switch and reed relay reduce the possibility of accidentally altering the format data (CEILD #11).

The M0 A0 and M1 A0 share a single format write trigger and a single format write driver and M0 A1 and M1 A1 share a single format write trigger and a single format write driver.

Safety circuits are incorporated to prevent writing if the wrong format head is selected or if critical voltages fail.

Circuit Objectives

Select the M0 A0 Format Head for Writing (CEILD #11)

1. M0 A0 select ANDs with store format to develop M0 A0 store format.
2. M0 A0 store format prevents the development of read X1, X2, X3, (X0 may Read), or write X select (CEILD #8). It also ANDs with Erase gate to develop format erase selected.
3. Format erase select (this takes the place of normal X selection) activates the format write driver and the erase coil. Lack of format write (erase gate) causes a format read.
4. Y Selection is made by the Format Select latch (CEILD #11). Mod 1 select turns on the latch to select the Mod 1 format head. Mod 0 select turns off the latch to select the Mod 0 format head.

Develop Format Write Data. Format write data is developed as follows: The actual data input to the write driver is developed in the same manner as that used in a data write operation. Write data gated by store format "flips" the write trigger to drive the complimentary cathode emitter follower (CEF). The CEF output is available to the format write driver and both format heads. However, only the format write driver and that is Y selected will draw write current.

READ FORMAT OPERATION

- A read format command refers to the operation that allows format data to be transmitted from the selected cylinder to the processing system.

- 2302 has two format read amplifiers.

Format read is a direct result of a not format erase condition. The format head is always reading except when instructed to write.

The 2302 has two format read amplifiers. One for the two accesses on the front of the machine and another for the two accesses on the rear of the machine.

The inputs to the amplifiers are gated by module select (Y head selection) and access selection (format read select). The outputs of the two amplifiers are dot ORed together into a read select). Safety circuits, ensure that format read data cannot be gated to the 7631 File Control unit if the wrong format head is selected, and any read operation on any surface is blocked. The safety circuits make it impossible to read from one format head while the other module is selected.

Simultaneously with read data, format data is read from the format disk, amplified by its own amplifier, and driven to the FCU to control record and address length.

Format Read Amplifier (CEILD #12). Leading particulars of the Format Read Amplifier are as follows: The format read amplifier consists of a pre-amplifier, a low pass filter, linear amplifiers, automatic gain control (AGC) circuits, and a bit detection and shaping circuit.

Functional descriptions of the special circuit cards used in the read amplifier along with wave shapes are included in the component circuits section of the system diagrams.

The input leads from the heads connect to the read preamplifier cards. These lines carry a double-ended signal ranging from 16 to 50 millivolts, peak-to-peak. The double-ended signal is a signal taken from opposite ends of a center tapped coil. The actual read signal processing begins in the pre-amplifier where a voltage gain of two is obtained and common mode rejection is achieved. The amplifier's resistance to a signal (noise) that causes both input lines to go in the same direction (up or down together) is called common mode rejection. The amplifier amplifies only the difference between the two signal input line levels.

The low-pass filter card provides the ac load and dc biasing for the pre-amp. It is a lossless network acting as a low-pass filter. Its purpose is to reject high frequency noise signals (above 370 kc) that might appear in the output of the pre-amp.

The output of the filter is connected to a variable gain amplifier (VGA). This circuit, working with the automatic gain control (AGC) feed back, provides a variable output to effectively set the input signal to the succeeding stages at a constant level. Thus, the variable gain control circuit compensates for the variation in input signal amplitude due to the change from inside to outside tracks, radial misalignment, or minor inherent differences between heads (see AGC Circuits).

Two fixed-gain linear amplifiers receive and amplify the output of the VGA. The linear amplifier is a two-stage, direct-coupled, differential amplifier.

The output of the second linear amplifier branches to feed the AGC circuit (CLPA) and the bit detection and shaping circuit (CLPD). The clipper amplifier is a linear amplifier (CLPA) having a gain of four. The emitter follower output stage is designed to match the low impedance input and voltage level requirements of the OR circuit and the AGC detector. The output stage provides and ac couple to the AGC detector, and a direct couple to the special OR circuit.

The output of the second linear amplifier is capacitively coupled to the input of the clipper differentiator circuit. The input bias network will clip off the positive signal excursions. It also causes a small amount of base line clipping on the negative signal excursions. The differentiator will also cause full wave rectification of the signal. This output is sent to another fixed-gain linear amplifier which feeds the over-driven limiter amplifier (ODLA). The two stages of the ODLA are used to shape the differentiated and amplified signal. These stages drive into saturation to produce a pulse with steep leading and trailing edges and a flat crown. This shaped pulse is gated through the AND/OR circuit by the CLPA output.

The single shot standardizes pulse width and maintains an accurate timing of the pulse leading edge. The output of the single shot is directed to the switching panel and driven to the FCU.

AGC

Only one format read amplifier is available for each pair of accesses. However, there are 250 distinct format tracks serviced by each of the accesses. Since no two tracks or heads are exactly alike, it is possible to have a varying signal from the format read head. The purpose of the automatic gain control (AGC) circuit is to ensure that pulses of a uniform amplitude are driven to the system. This is done by varying the gain amplifier (VGA).

When the file control unit selects a module, the 2302 develops a format AGC Squelch signal for 350 microseconds. This squelch sets the VGA to maximum amplification. This is done because the amplification of the VGA can be rapidly decreased by recorded data, but the amplification can be increased rapidly only by a squelch signal.

Recorded format data enters the pre-amp and is sent to the VGA where it is amplified. This signal is again amplified through two linear amplifiers and a clipper amplifier. The clipper amplifier output goes to the AGC detector where it is converted to a control signal that adjusts the variable gain amplifier. The VGA then raises or lowers its output and starts the cycle over again.

The delay involved in going from the VGA through the amplifiers and AGC detector does not change the effectiveness of the AGC circuits for they are designed to follow a trend. If the signal gets weak, the AGC must assume this is a trend and follow it. Obviously, AGC will not correct for single extremely high or low pulses. If a blank record was being read, the VGA would gradually increase its amplification to a point where it would read even the smallest noise, therefore, AGC bits are written prior to each record address and each record to re-establish the current gain on the VGA.

Circuit Objectives

<u>Select the M0 A0 Format Head for Reading (CEILD #11)</u>

1. A not store format signal condition causes format read select to gate the format read amplifier.
2. Format Y selection is accomplished by a latch which is turned on by module on select,

and turned off by module zero select. One or the other of the format heads is always selected in order to maintain the proper gain of the amplifier. The format amplifier AGC is squelched by a 350 μsec single shot at module select time each time the format latch changes state.

Develop Format Read Data (CEILD #11)

1. Format data is read from the format disk simultaneously with read data.
2. The differential signal from the format head goes directly to the format amplifier where it is amplified and sent to the system.

ALTERNATE

- (Flag) Surfaces each module has six flag surfaces which are available to substitute for impaired data disk surfaces.

- If a data track is found to be impaired, the CE must "flag" this track.

- A flag address is written in modified binary form in the fifth address digit position of home address one (HA-1) on the defective track.

Flag Surface Addressing

The CE must determine the flag address and write it in HA-1 of the defective track. This address digit is coded to indicate the alternate surface that is to be used in place of the impaired track. For example, a 1-bit in this address position indicates alternate surface 1, a 4-bit in this position indicates alternate 3, a 1-bit, a 2-bit, and a 4-bit in this position indicates alternate 6. The 8-bit is no flag. The alternate surface must be within the same cylinder as the surface it replaces (same cylinder number 7).

This flag address is read by the 2302 every time the impaired surface is addressed by the FCU. The FCU must interpret this flag address and raise the proper flag condition lines (CEILD #14). The flag condition lines gate the proper flag head latches to allow selection of the desired alternate surface read/write head. The latches are set with the same set pulse that sets the access register head portion.

Circuit Objectives

For this example, assume there is a flag bit in the third bit position of the fifth digit of HA-1.
This will select Flag head three (F3).

Develop X2 Head Select.

1. The impaired surface read head reads, amplifies, and drives the flag bits to the FCU through the same circuitry used for all other read data.
2. When the FCU receives the flag bit, the FCU returns flag condition signals to the 2302.
3. Flag condition 3 ANDs with pwr acc reg head adr set to turn on the flag 3 latch. The latch is reset by not flag condition 3 and pwr acc reg head adr set or by access reg head reset.
4. The flag latch outputs are ANDed with M0 A0 head select. The resulting outputs are decoded by five AND circuits to raise the Y and X select circuits required to select a specific head. Flag 3 select and not flag 2 select raises X2 select.

Develop Y10 Select

1. The On outputs of the flag latches are ORed to raise flag select.
2. Flag select ANDs with the outputs of the Flag 1 latch to select Y10 or Y11. In this example, the Flag 1 latch is off therefore Y10 is selected.

The diagrams contained in this Section are for instruction purposes only. They do not necessarily reflect the latest engineering level of the 2302.

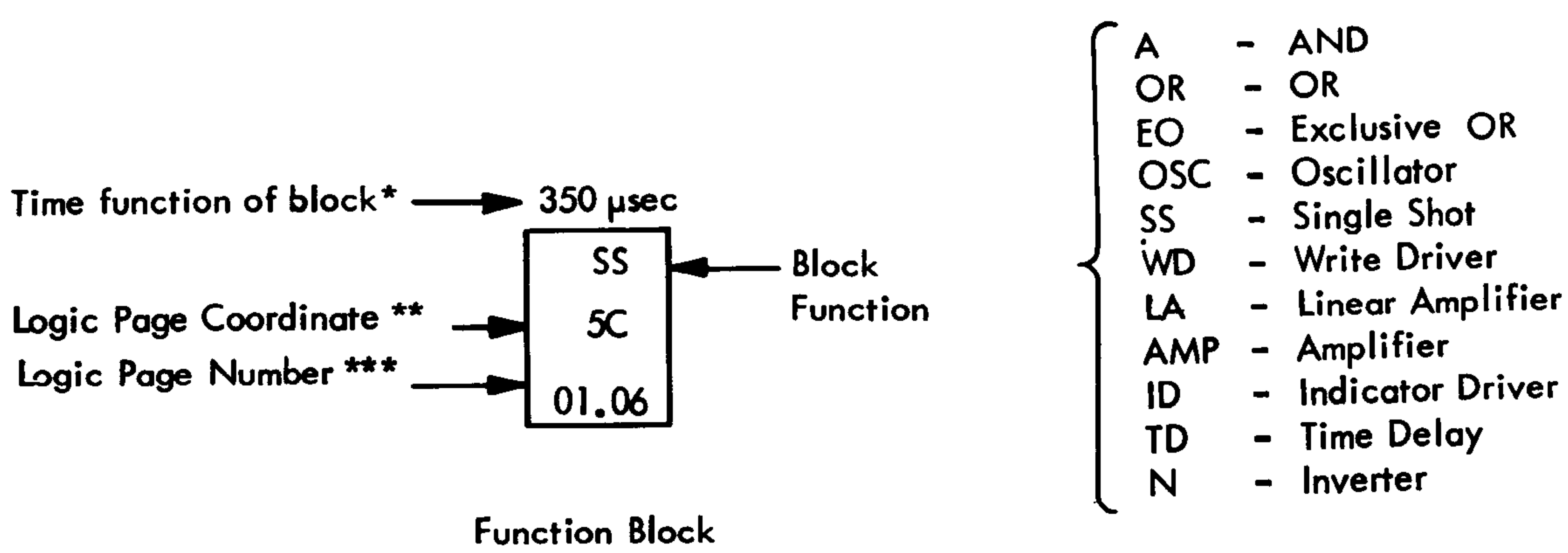
Lines on the diagrams in this section that are designated by an asterisk are those lines that are received from or transmitted to the system.

The outputs of one diagram are often the inputs to another figure and vice versa. To assist in locating these "tie-in" lines, the page-to-page connectors (9) give the ILD page number of the origin or destination of the line.

AND, OR, Flip Flops (latches) and miscellaneous functions have standard abbreviations to designate these functions.

Inverters are shown only where necessary to maintain the positive logic format for which these diagrams were constructed.

Figure 11-1 shows examples of logic blocks and definition of special symbols and labels.



* Used only on OSC, TD, and SS blocks.
** Blocks that are added only to maintain positive logic do not have a page number or coordinate.
*** The logic page number is the middle pairs of digits of the system diagrams page number (e.g. 01.06 = 01.01.06.1)

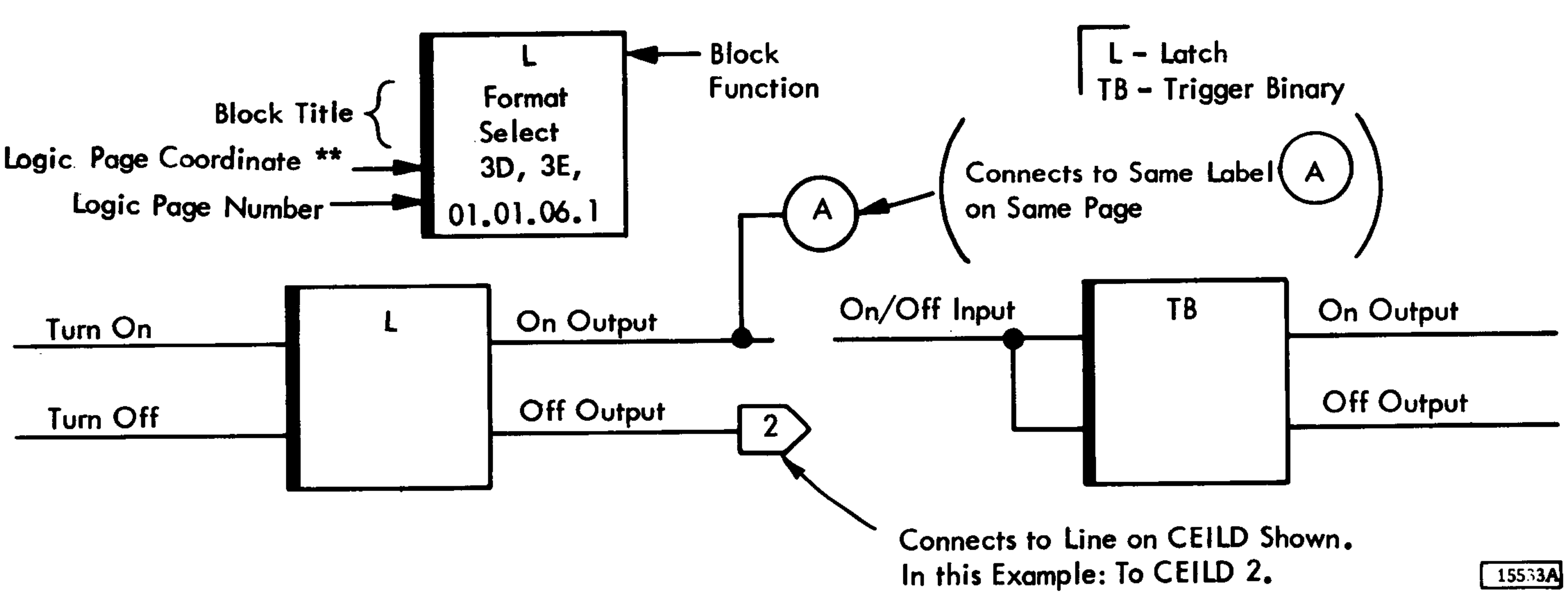
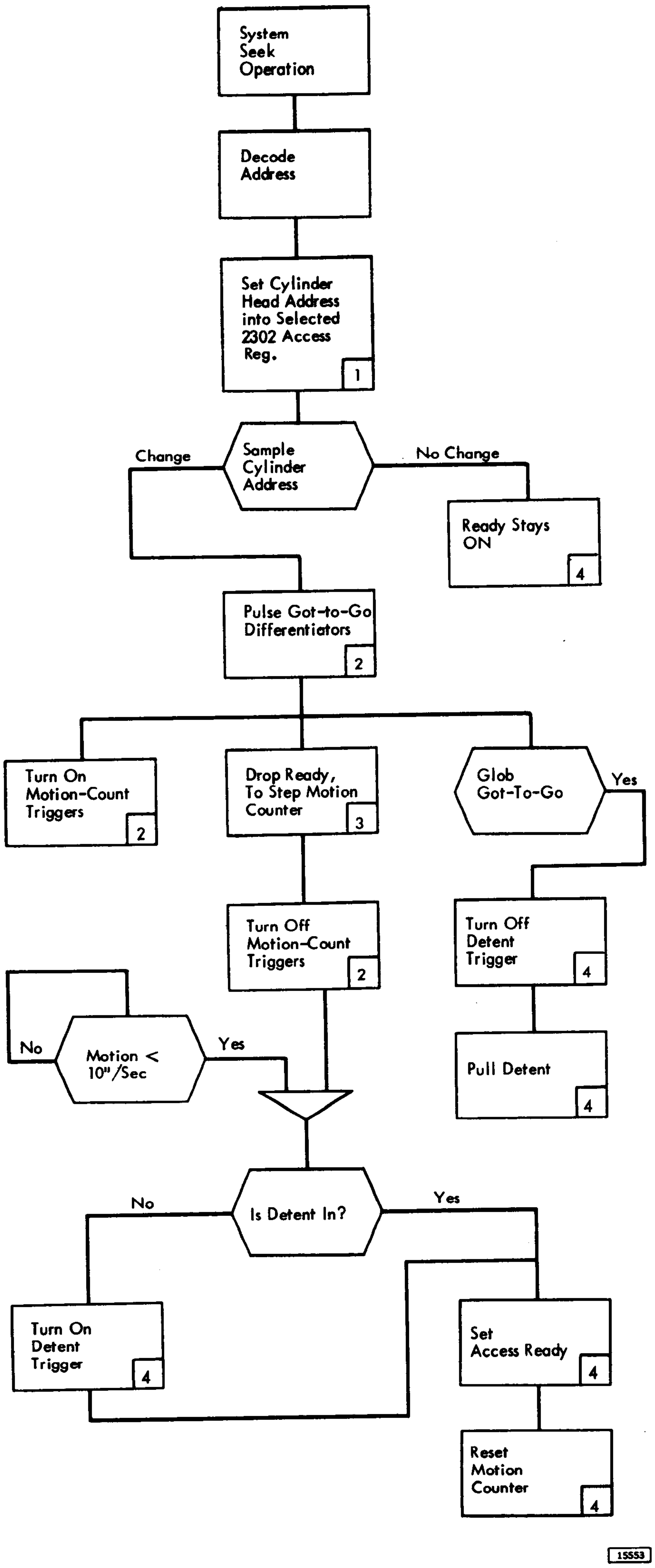
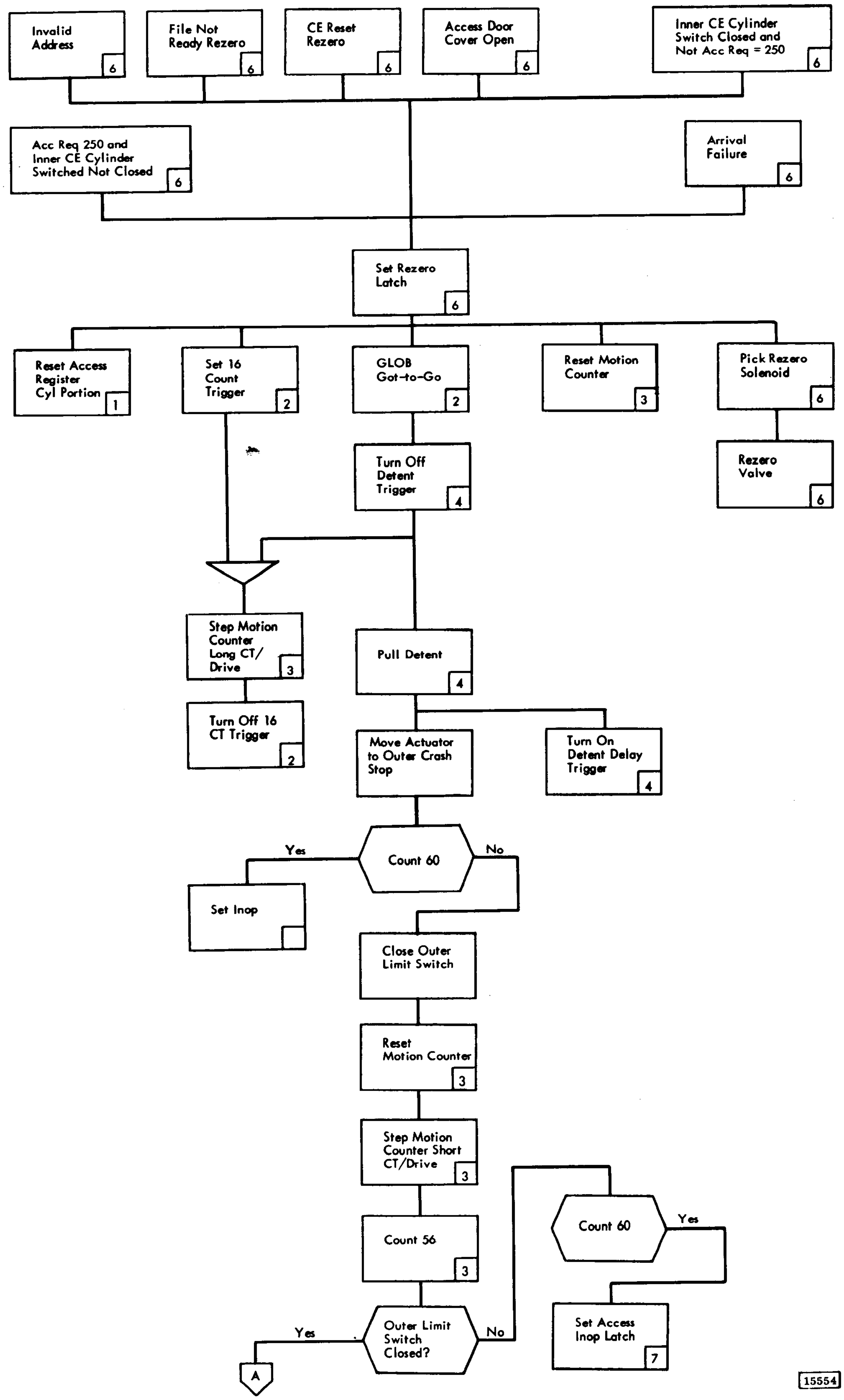
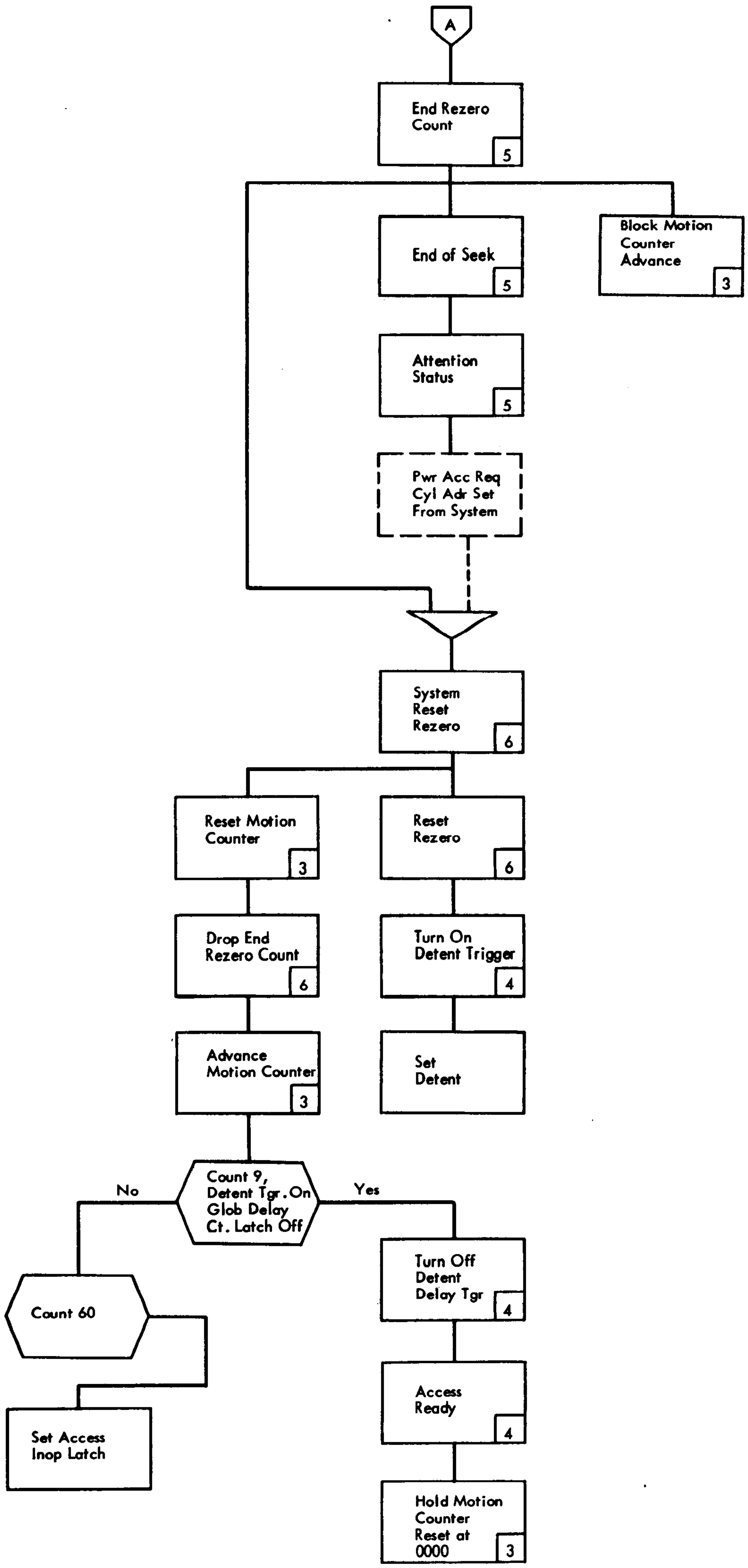


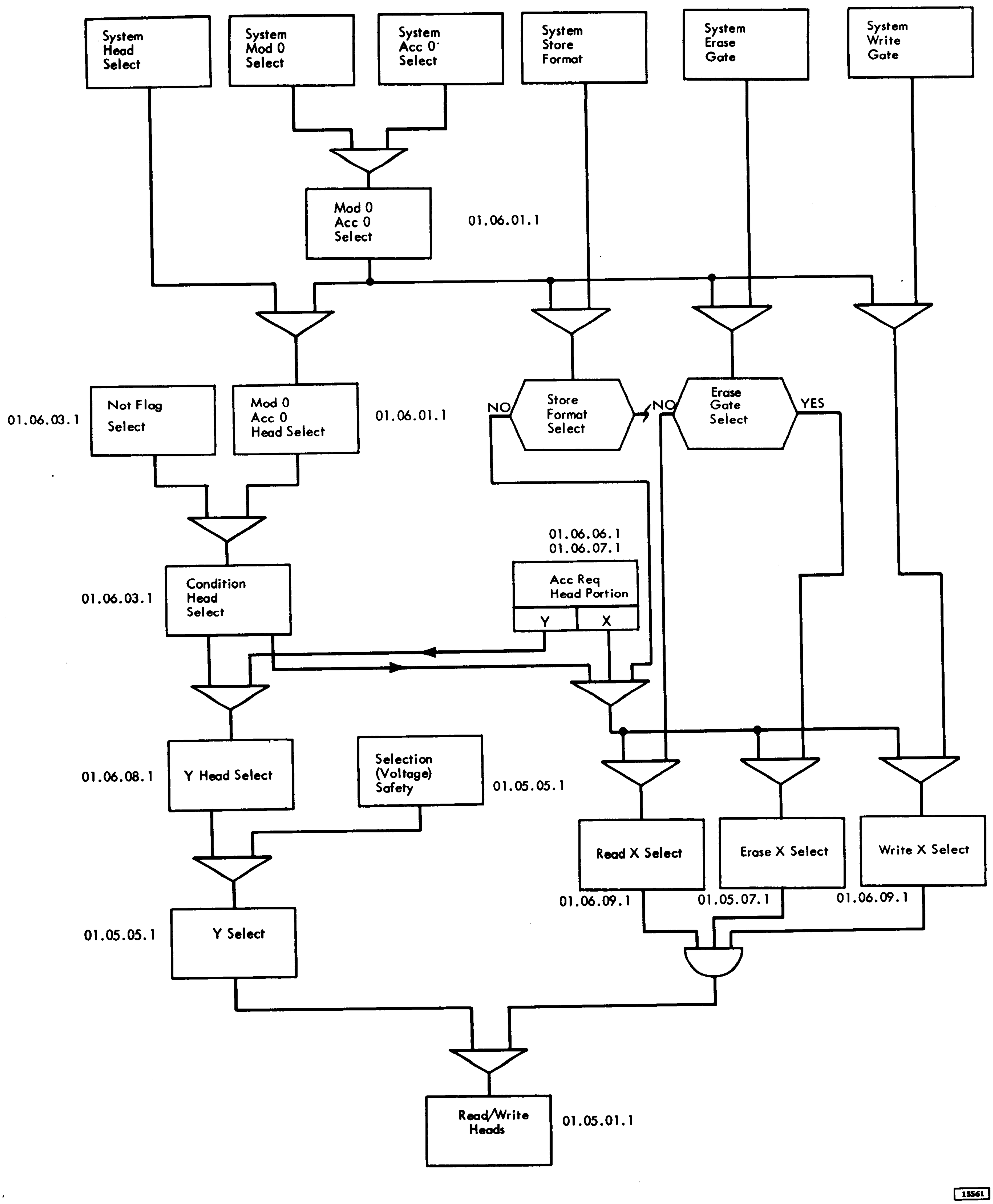
Figure 11-1. Intermediate Level Block Diagram Definition

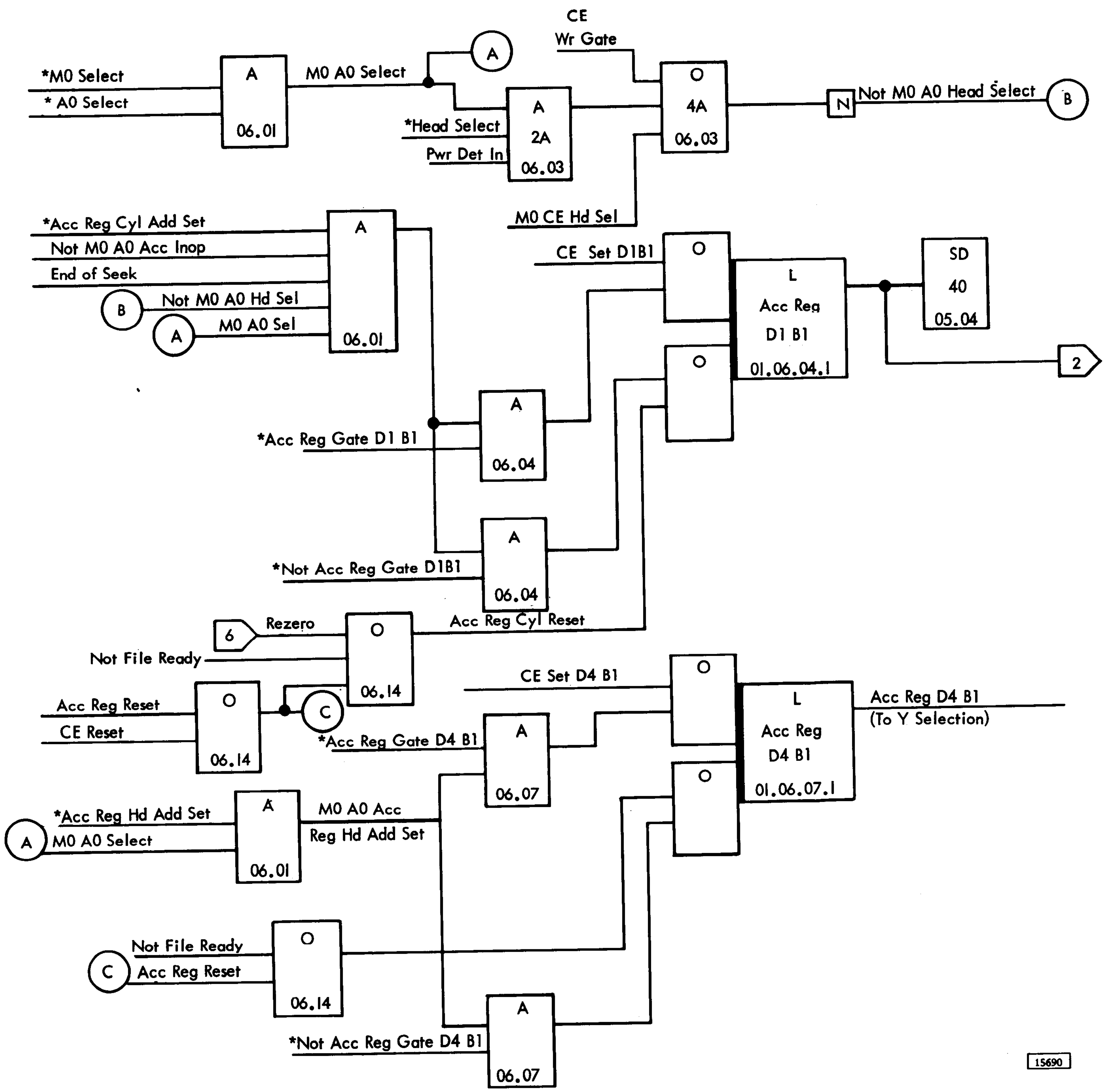
Flow Diagram #1



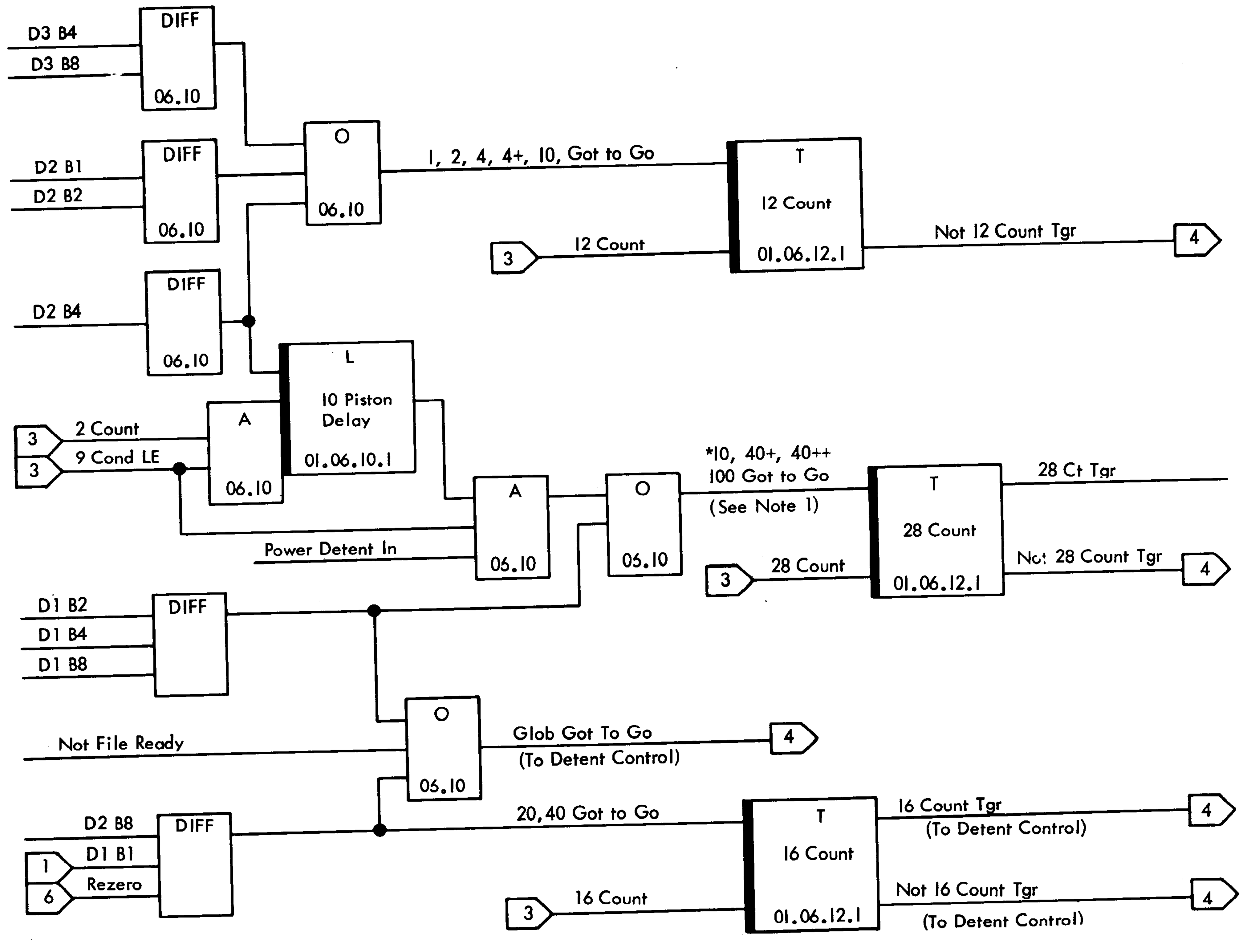

Invalid Address 6
File Not Ready Rezero 6
CE Reset Rezero 6
Access Door Cover Open 6
Inner CE Cylinder Switch Closed and Not Acc Req = 250 6
Acc Req 250 and Inner CE Cylinder Switched Not Closed 6
Arrival Failure 6
Set Rezero Latch 6
Reset Access Register Cyl Portion 1
Set 16 Count Trigger 2
GLOB Got-to-Go 2
Reset Motion Counter 3
Pick Rezero Solenoid 6
Rezero Valve 6
Turn Off Detent Trigger 4
Step Motion Counter Long CT/ Drive 3
Turn Off 16 CT Trigger 2
Pull Detent 4
Move Actuator to Outer Crash Stop
Turn On Detent Delay Trigger 4
Count 60
Yes
No
Set Inop
Close Outer Limit Switch
Reset Motion Counter 3
Step Motion Counter Short CT/Drive 3
Count 56 3
Outer Limit Switch Closed?
Yes
No
A
Count 60
Yes
Set Access Inop Latch 7
15554


A
End Rezero Count 5
End of Seek 5
Block Motion Counter Advance 3
Attention Status 5
Pwr Acc Req Cyl Adr Set From System
System Reset Rezero 6
Reset Motion Counter 3
Reset Rezero 6
Drop End Rezero Count 6
Turn On Detent Trigger 4
Advance Motion Counter 3
Set Detent
No
Count 9, Detent Tgr. On Glob Delay Ct. Latch Off
Yes
Count 60
Turn Off Detent Delay Tgr 4
Set Access Inop Latch
Access Ready 4
Hold Motion Counter Reset at 0000 3


System Head Select
System Mod 0 Select
System Acc 0 Select
System Store Format
System Erase Gate
System Write Gate
Mod 0 Acc 0 Select
01.06.01.1
01.06.03.1
Not Flag Select
Mod 0 Acc 0 Head Select
01.06.01.1
NO
Store Format Select
NO
Erase Gate Select
YES
01.06.06.1
01.06.07.1
01.06.03.1
Condition Head Select
Acc Req Head Portion
Y
X
01.06.08.1
Y Head Select
Selection (Voltage) Safety
01.05.05.1
Read X Select
Erase X Select
Write X Select
01.06.09.1
01.05.07.1
01.06.09.1
01.05.05.1
Y Select
Read/Write Heads
01.05.01.1
15561

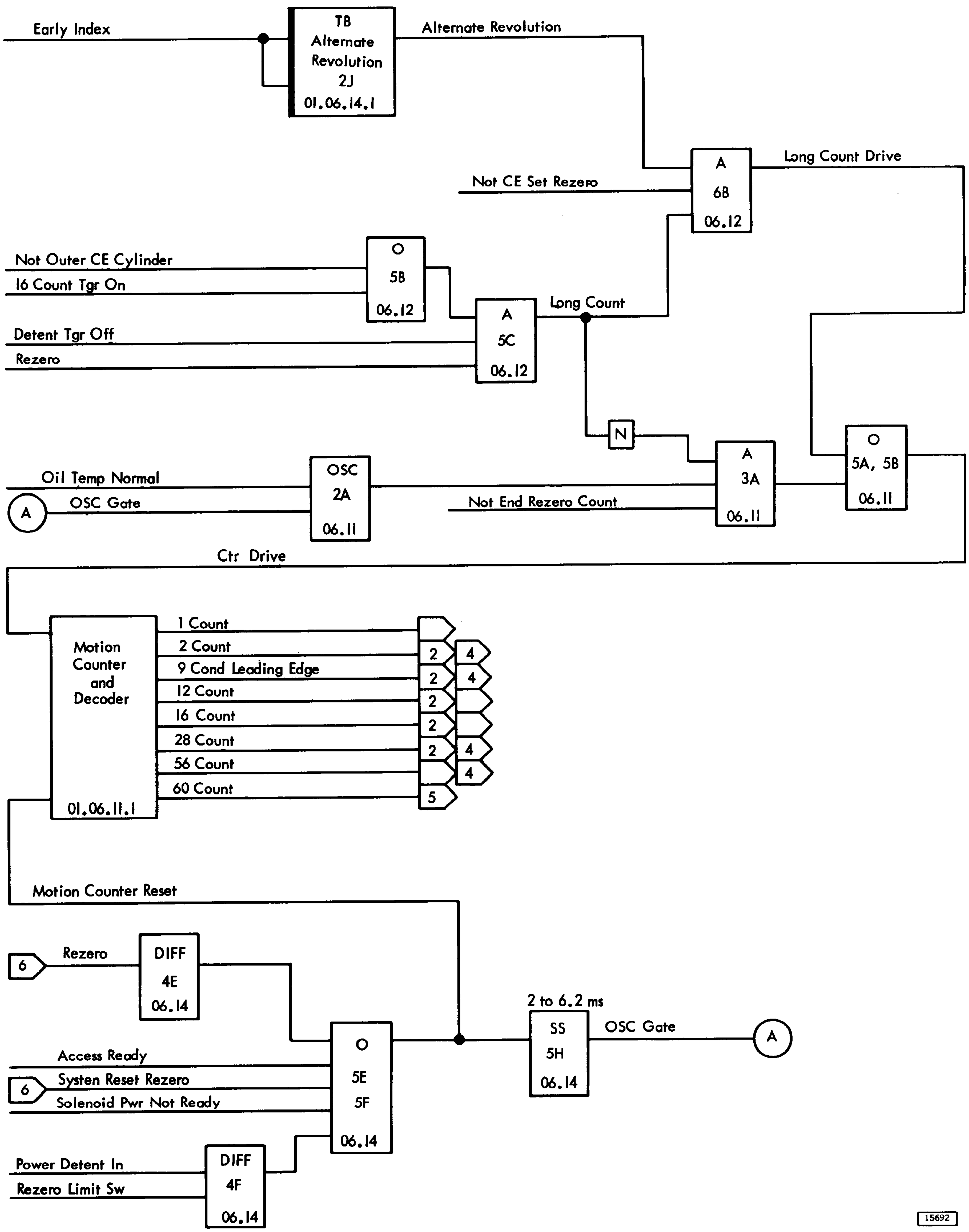

*M0 Select
* A0 Select
A
06.01
M0 A0 Select
A
CE
Wr Gate
A
2A
06.03
*Head Select
Pwr Det In
O
4A
06.03
N
Not M0 A0 Head Select
B
*Acc Reg Cyl Add Set
Not M0 A0 Acc Inop
End of Seek
B
Not M0 A0 Hd Sel
A
M0 A0 Sel
A
06.01
M0 CE Hd Sel
CE Set D1B1
O
O
L
Acc Reg
D1 B1
01.06.04.1
SD
40
05.04
2
*Acc Reg Gate D1 B1
A
06.04
*Not Acc Reg Gate D1B1
A
06.04
6
Rezero
Not File Ready
O
06.14
Acc Reg Cyl Reset
Acc Reg Reset
CE Reset
O
06.14
C
CE Set D4 B1
*Acc Reg Gate D4 B1
A
06.07
O
O
L
Acc Reg
D4 B1
01.06.07.1
Acc Reg D4 B1
(To Y Selection)
*Acc Reg Hd Add Set
A
M0 A0 Select
A
06.01
M0 A0 Acc
Reg Hd Add Set
Not File Ready
C
Acc Reg Reset
O
06.14
*Not Acc Reg Gate D4 B1
A
06.07
15690

Got-To-Go Controls

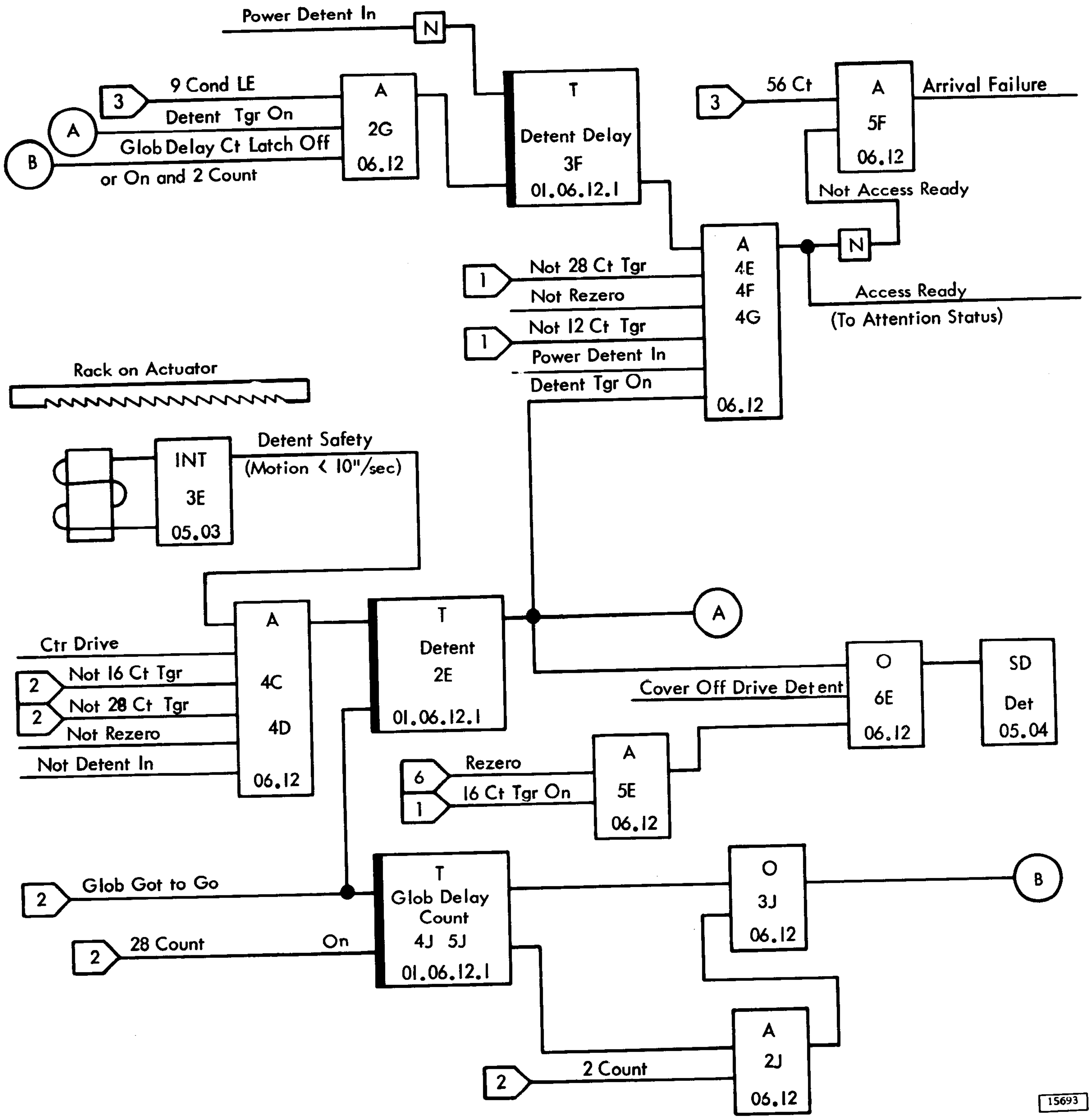


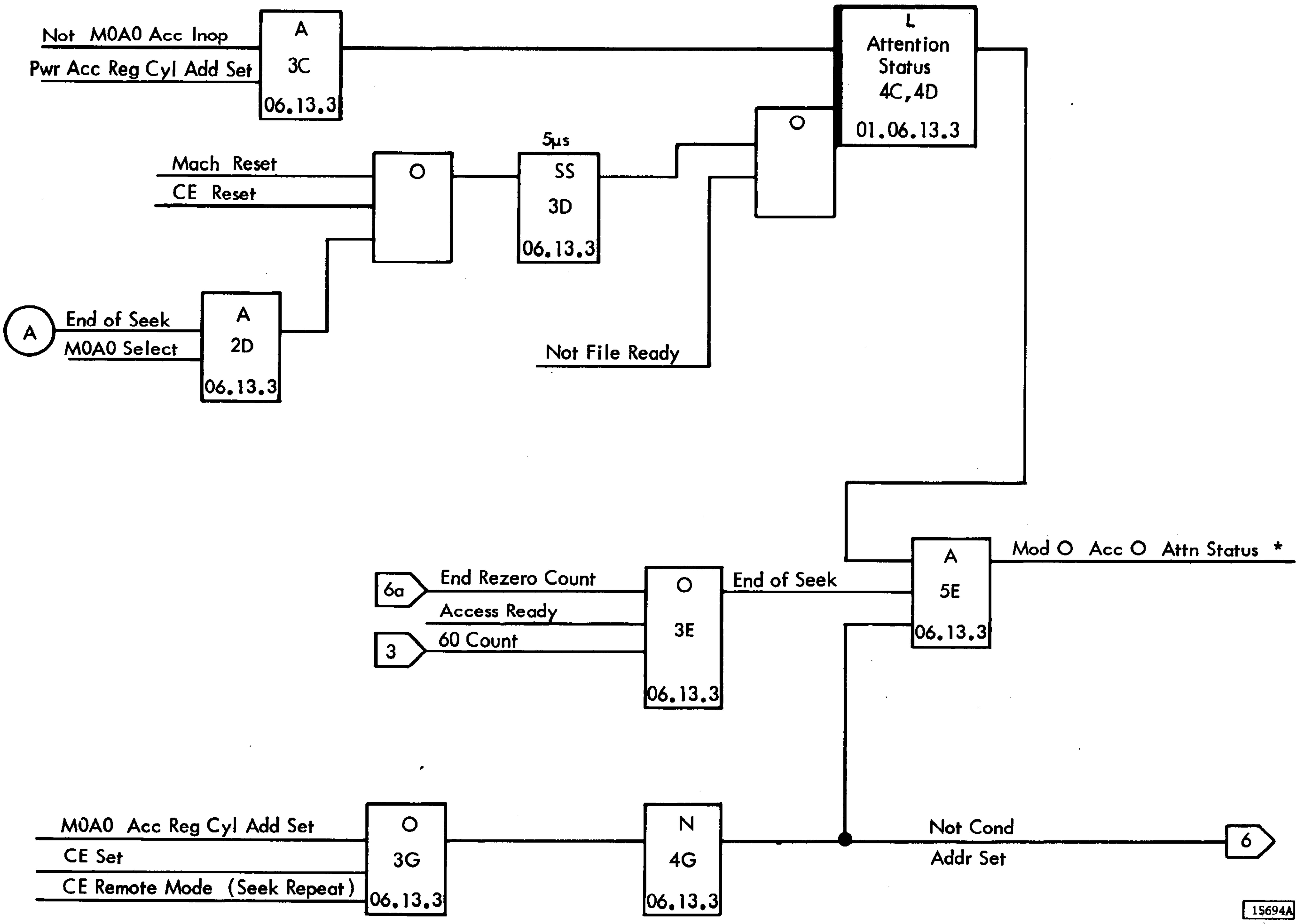
Note: 1 Conditioned 10 not 20, 40 Glob

227-5863 (2/65)

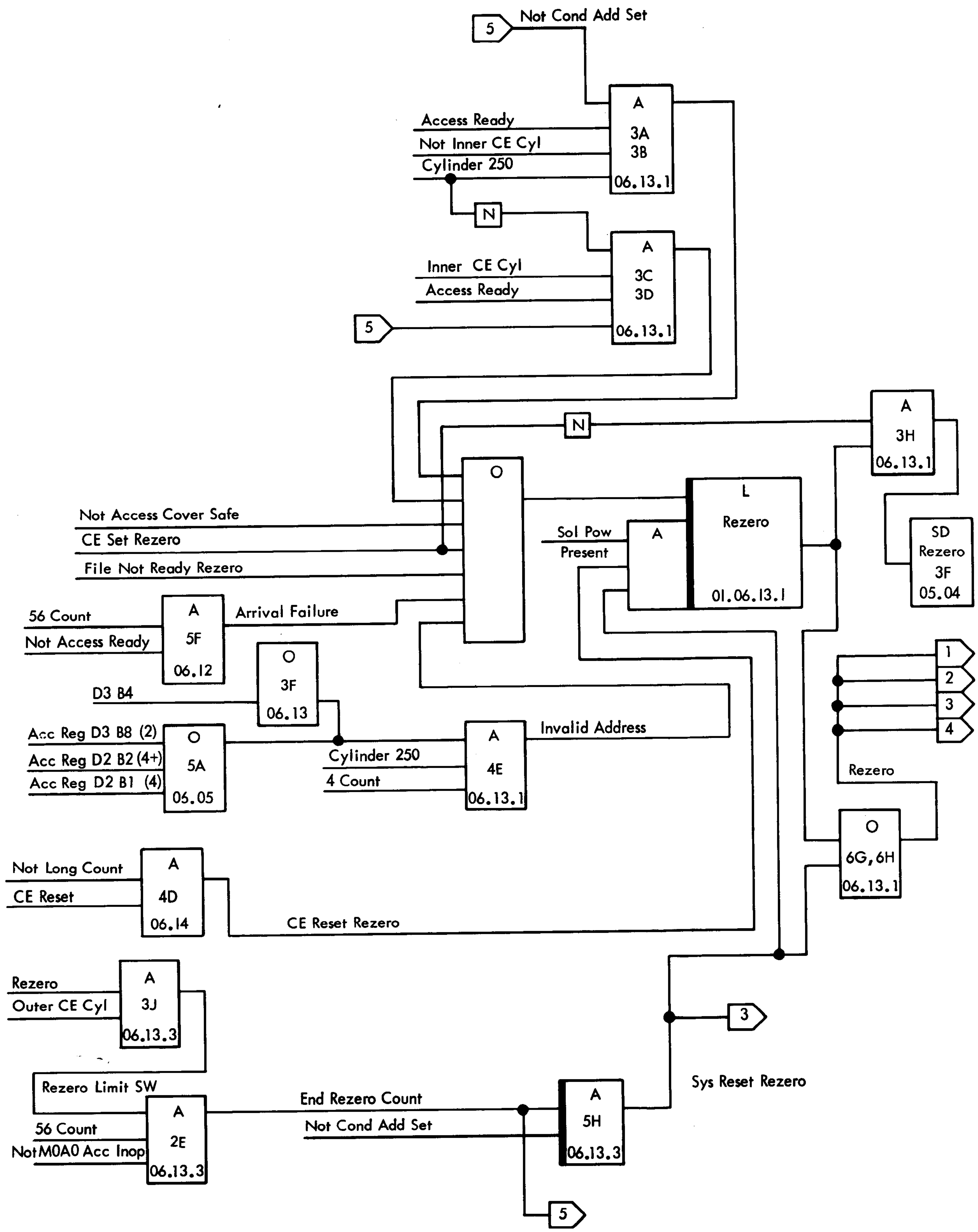

Early Index
TB
Alternate
Revolution
2J
01.06.14.1
Alternate Revolution
Not CE Set Rezero
A
6B
06.12
Long Count Drive
Not Outer CE Cylinder
16 Count Tgr On
O
5B
06.12
Detent Tgr Off
Rezero
A
5C
06.12
Long Count
N
Oil Temp Normal
A
OSC Gate
OSC
2A
06.11
Not End Rezero Count
A
3A
06.11
O
5A, 5B
06.11
Ctr Drive
Motion
Counter
and
Decoder
01.06.11.1
1 Count
2 Count
9 Cond Leading Edge
12 Count
16 Count
28 Count
56 Count
60 Count
2
4
2
4
2
2
2
4
4
5
Motion Counter Reset
6
Rezero
DIFF
4E
06.14
Access Ready
6
Systen Reset Rezero
Solenoid Pwr Not Ready
O
5E
5F
06.14
Power Detent In
Rezero Limit Sw
DIFF
4F
06.14
2 to 6.2 ms
SS
5H
06.14
OSC Gate
A
15692

Detent Control

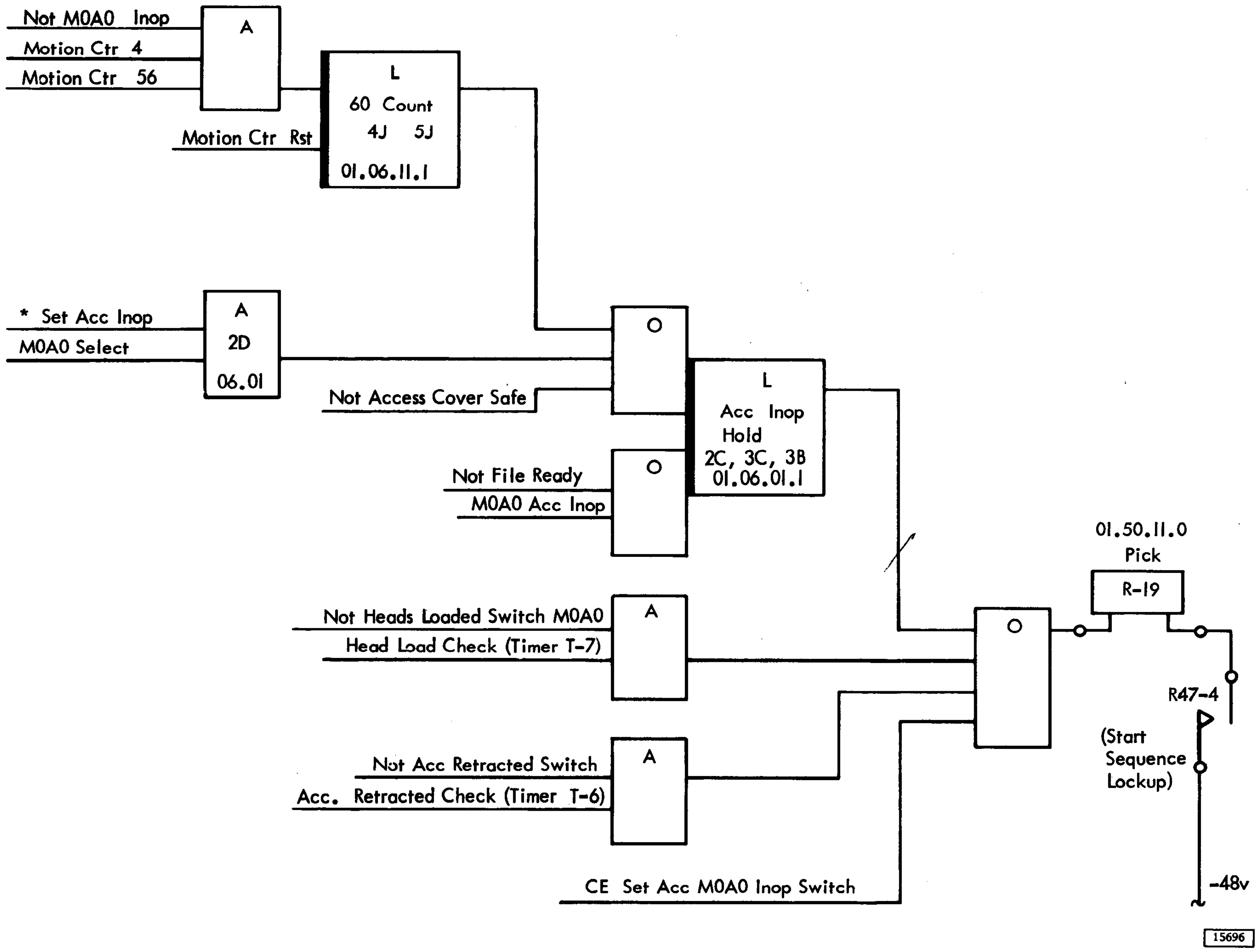



Not M0A0 Acc Inop
Pwr Acc Reg Cyl Add Set
A
3C
06.13.3
L
Attention
Status
4C,4D
01.06.13.3
O
Mach Reset
CE Reset
O
5μs
SS
3D
06.13.3
A
End of Seek
M0A0 Select
A
2D
06.13.3
Not File Ready
Mod O Acc O Attn Status *
6a
End Rezero Count
Access Ready
3
60 Count
O
3E
06.13.3
End of Seek
A
5E
06.13.3
M0A0 Acc Reg Cyl Add Set
CE Set
CE Remote Mode (Seek Repeat)
O
3G
06.13.3
N
4G
06.13.3
Not Cond
Addr Set
6
15694A

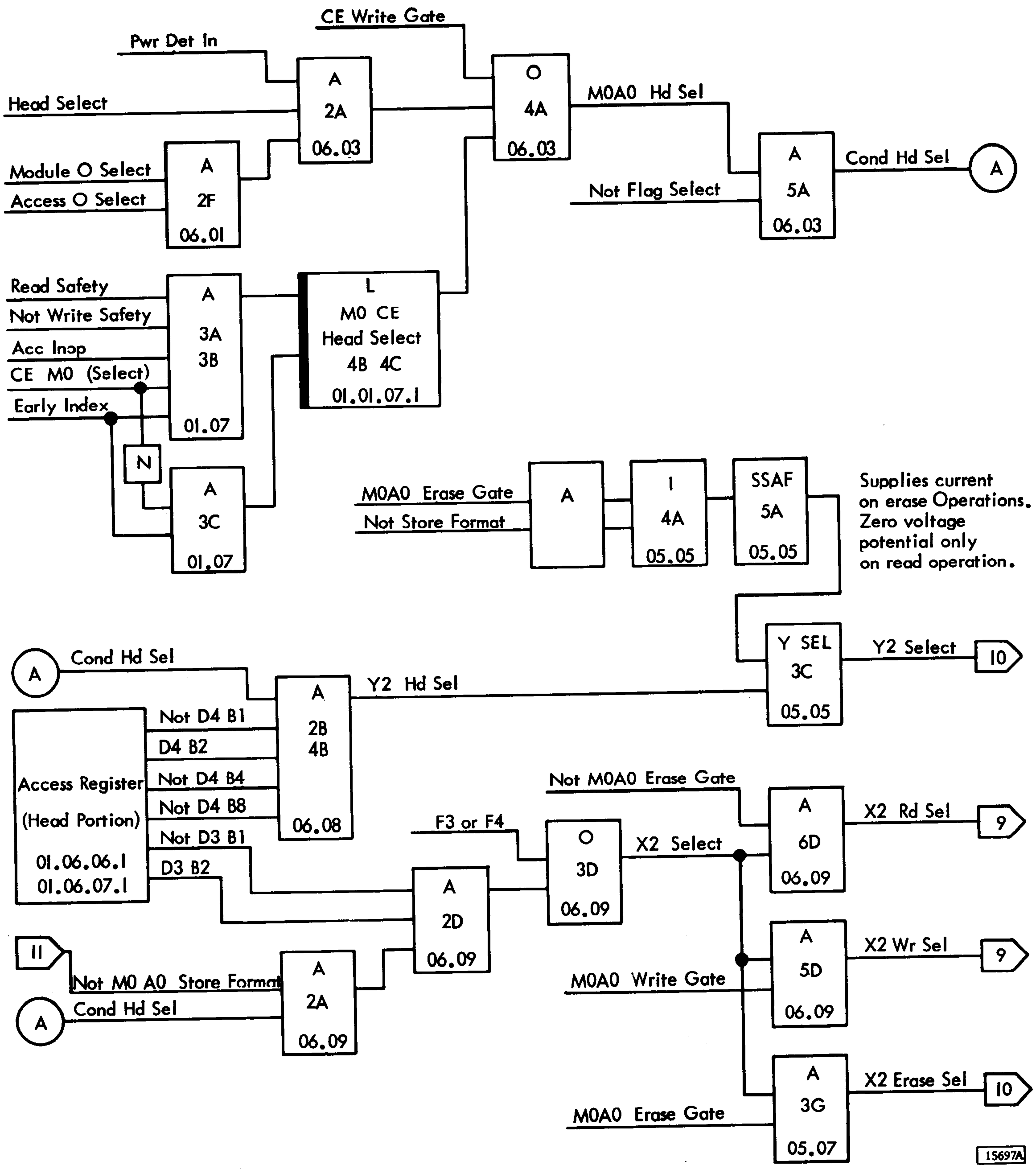
Rezero Control

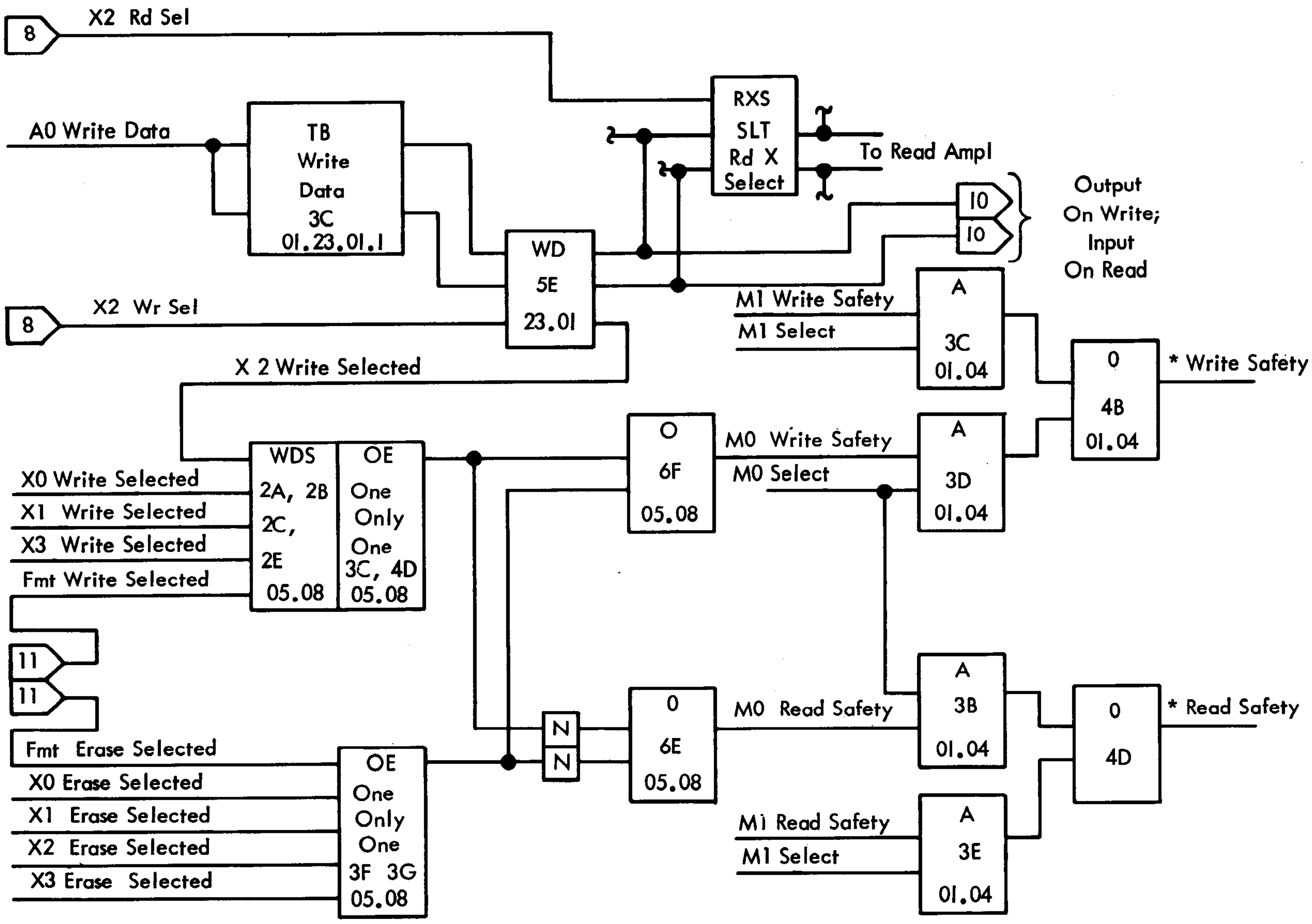


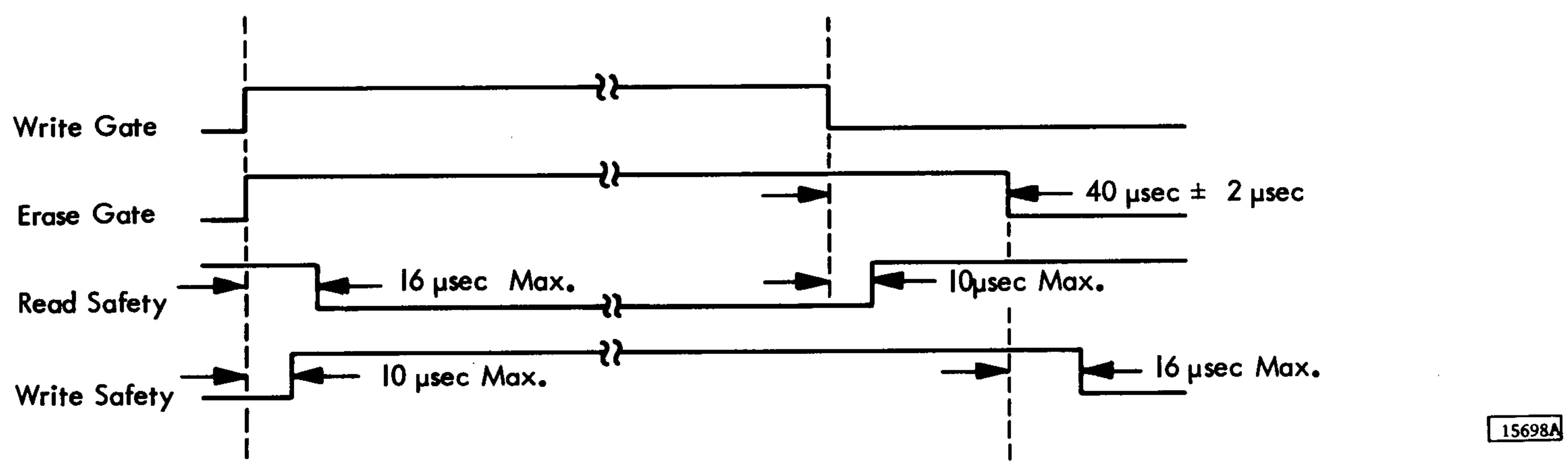
15695A

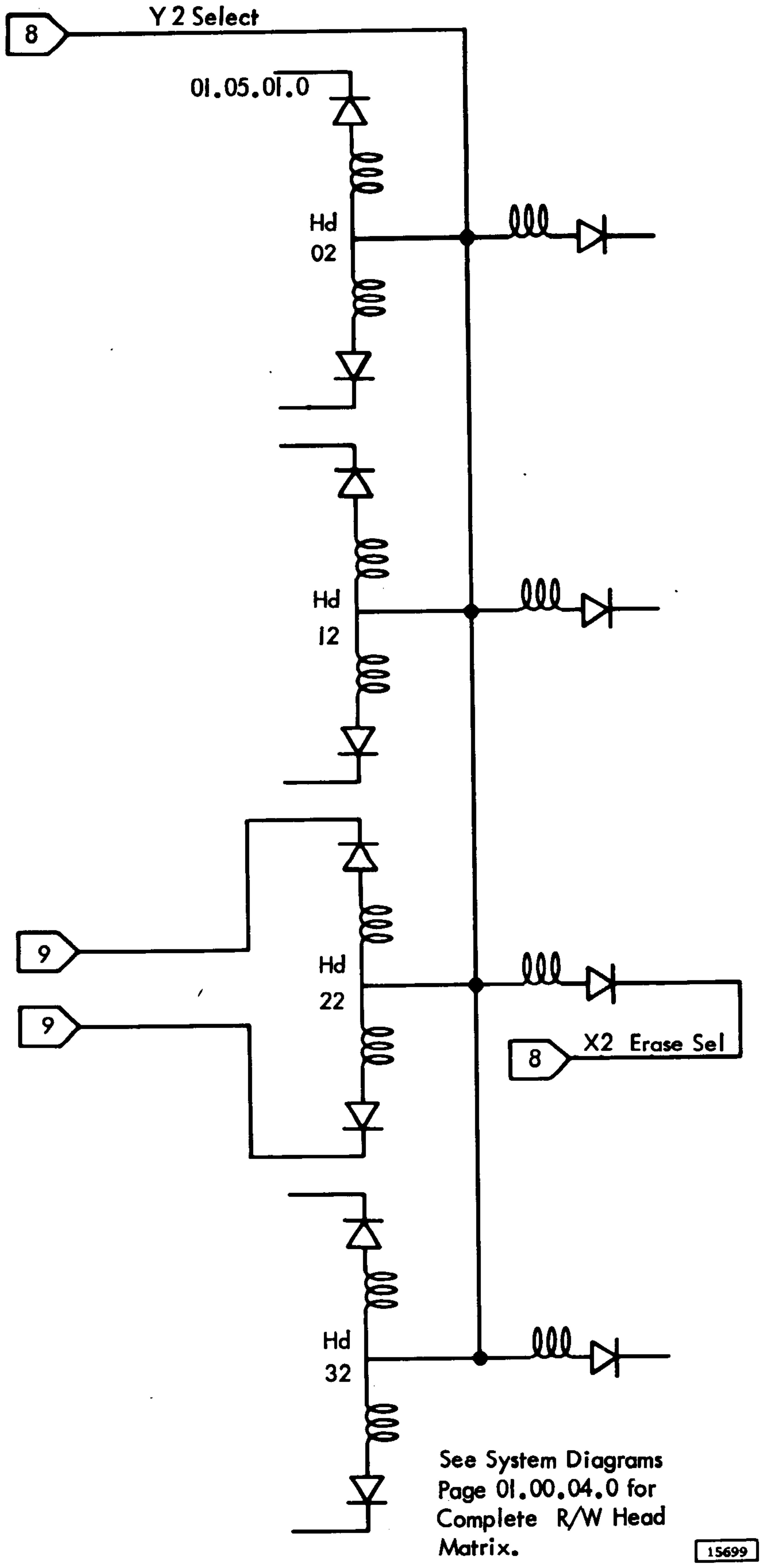

Not M0A0 Inop
Motion Ctr 4
Motion Ctr 56
A
L
60 Count
4J 5J
01.06.11.1
Motion Ctr Rst
* Set Acc Inop
M0A0 Select
A
2D
06.01
O
Not Access Cover Safe
L
Acc Inop
Hold
2C, 3C, 3B
01.06.01.1
Not File Ready
M0A0 Acc Inop
O
01.50.11.0
Pick
R-19
Not Heads Loaded Switch M0A0
Head Load Check (Timer T-7)
A
O
R47-4
(Start
Sequence
Lockup)
Not Acc Retracted Switch
Acc. Retracted Check (Timer T-6)
A
CE Set Acc M0A0 Inop Switch
-48v
15696

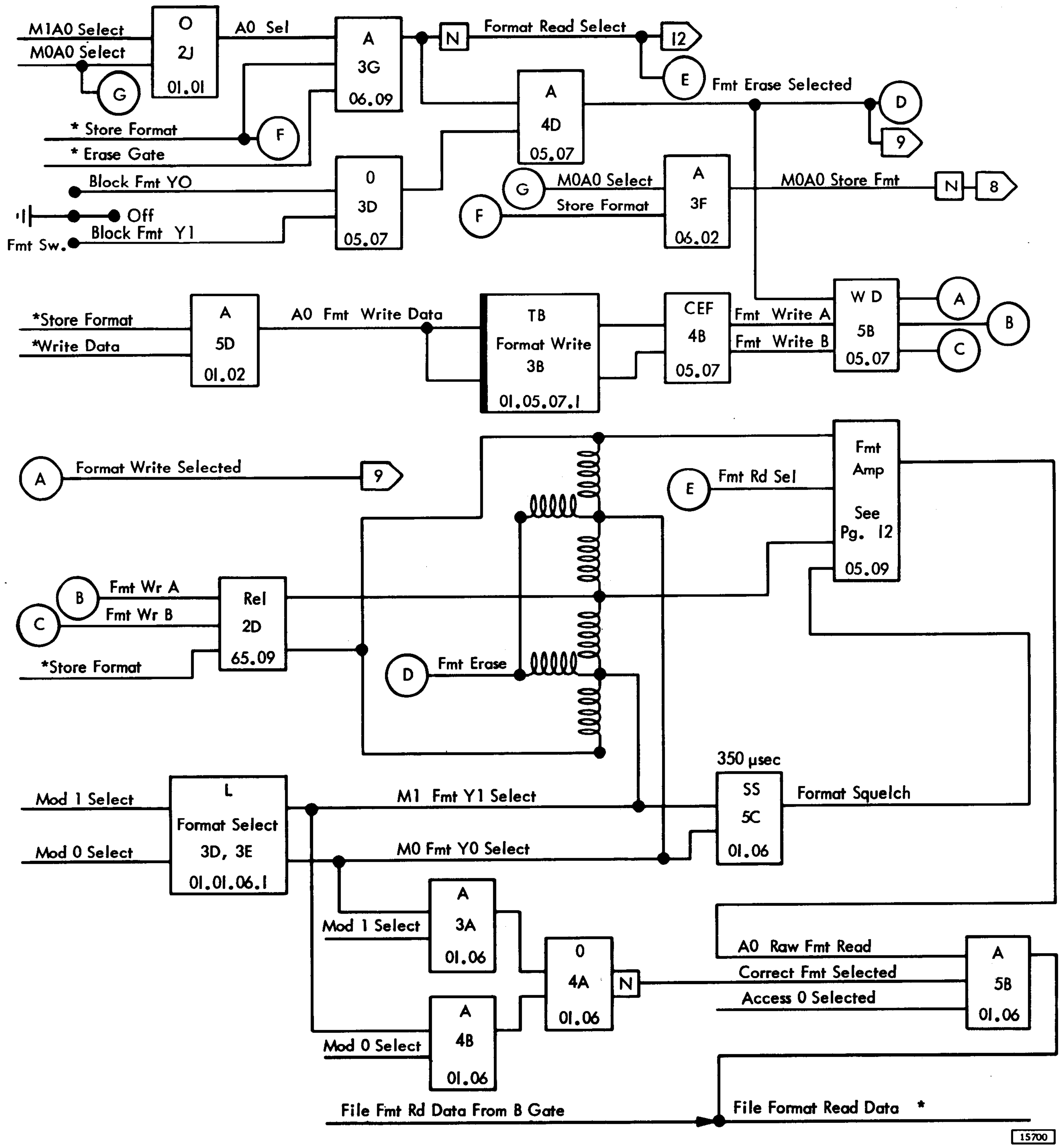
Read/Write Gating (Head 22)



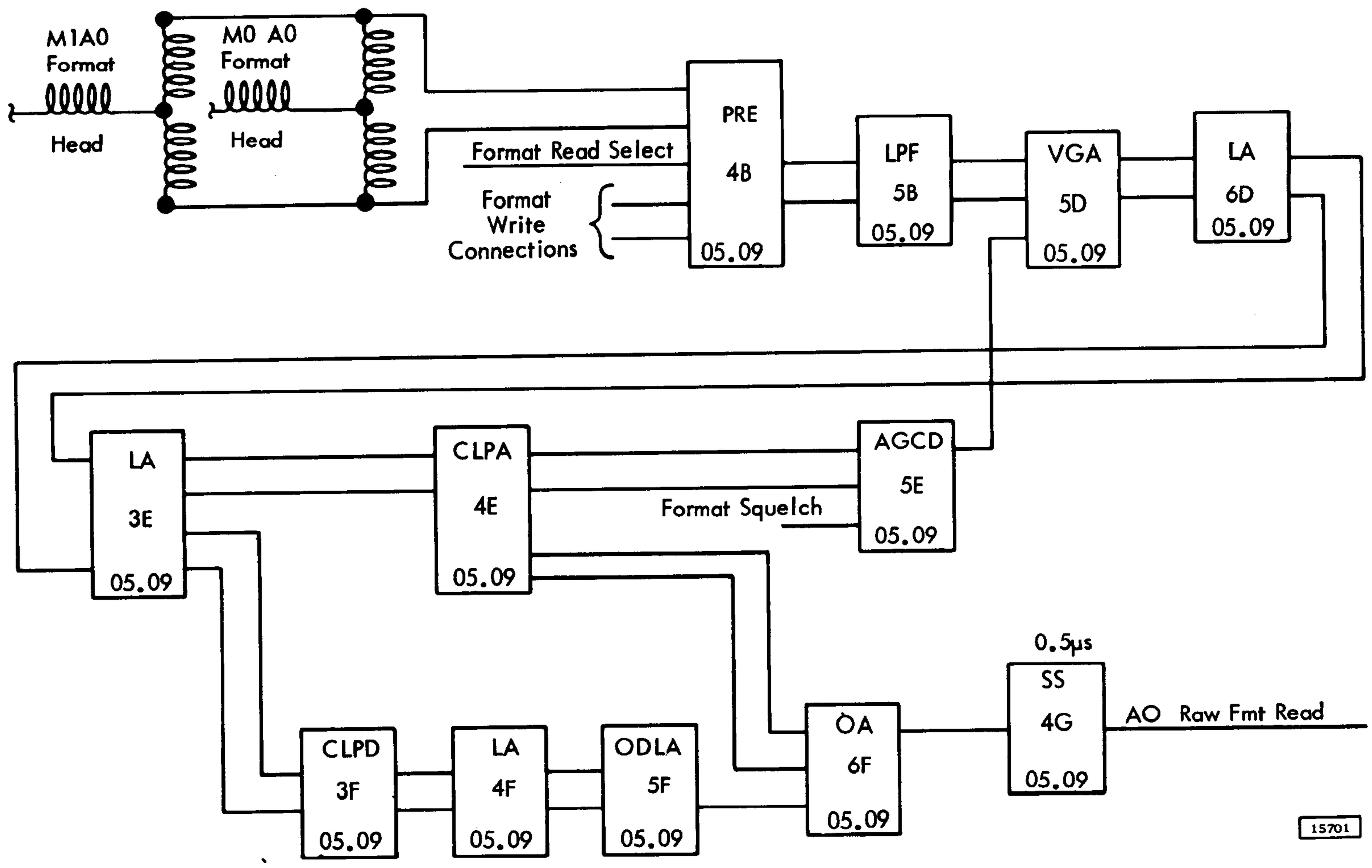

8
X2 Rd Sel
A0 Write Data
TB
Write
Data
3C
01.23.01.1
RXS
SLT
Rd X
Select
To Read Ampl
WD
5E
23.01
10
10
Output
On Write;
Input
On Read
8
X2 Wr Sel
M1 Write Safety
M1 Select
A
3C
01.04
0
4B
01.04
* Write Safety
X 2 Write Selected
WDS
2A, 2B
2C,
2E
05.08
OE
One
Only
One
3C, 4D
05.08
O
6F
05.08
M0 Write Safety
M0 Select
A
3D
01.04
X0 Write Selected
X1 Write Selected
X3 Write Selected
Fmt Write Selected
11
11
Fmt Erase Selected
X0 Erase Selected
X1 Erase Selected
X2 Erase Selected
X3 Erase Selected
OE
One
Only
One
3F 3G
05.08
N
N
0
6E
05.08
M0 Read Safety
A
3B
01.04
0
4D
* Read Safety
M1 Read Safety
M1 Select
A
3E
01.04

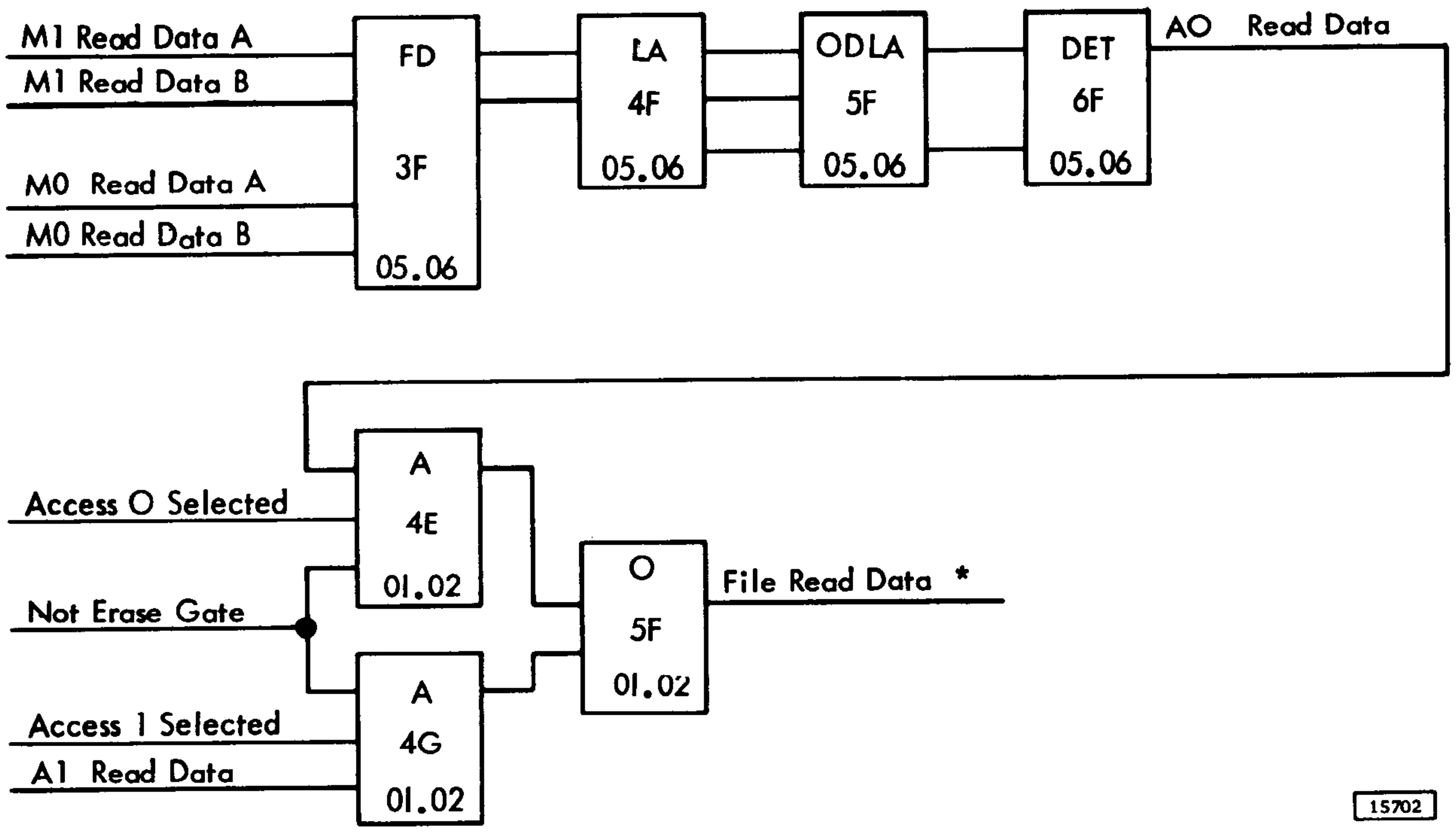

Write Gate
Erase Gate
Read Safety
Write Safety
40 μsec ± 2 μsec
16 μsec Max.
10μsec Max.
10 μsec Max.
16 μsec Max.
15698A


8
Y 2 Select
01.05.01.0
Hd
02
Hd
12
9
9
Hd
22
8
X2 Erase Sel
Hd
32
See System Diagrams
Page 01.00.04.0 for
Complete R/W Head
Matrix.
15699


M1A0 Select
M0A0 Select
O 2J 01.01
A0 Sel
A 3G 06.09
N
Format Read Select
12
E
Fmt Erase Selected
D
9
A 4D 05.07
* Store Format
* Erase Gate
F
G
Block Fmt YO
Off
Block Fmt Y1
Fmt Sw.
0 3D 05.07
M0A0 Select
Store Format
A 3F 06.02
M0A0 Store Fmt
N
8
*Store Format
*Write Data
A 5D 01.02
A0 Fmt Write Data
TB Format Write 3B 01.05.07.1
CEF 4B 05.07
Fmt Write A
Fmt Write B
W D 5B 05.07
A
B
C
Format Write Selected
9
Fmt Amp See Pg. 12 05.09
Fmt Rd Sel
Fmt Wr A
Fmt Wr B
*Store Format
Rel 2D 65.09
Fmt Erase
350 μsec
SS 5C 01.06
Format Squelch
Mod 1 Select
Mod 0 Select
L Format Select 3D, 3E 01.01.06.1
M1 Fmt Y1 Select
M0 Fmt Y0 Select
A 3A 01.06
A 4B 01.06
0 4A 01.06
A0 Raw Fmt Read
Correct Fmt Selected
Access 0 Selected
A 5B 01.06
File Fmt Rd Data From B Gate
File Format Read Data *
15700

Format Read Amplifier




M1 Read Data A
M1 Read Data B
M0 Read Data A
M0 Read Data B
FD
3F
05.06
LA
4F
05.06
ODLA
5F
05.06
DET
6F
05.06
AO Read Data
Access O Selected
Not Erase Gate
Access 1 Selected
A1 Read Data
A
4E
01.02
A
4G
01.02
O
5F
01.02
File Read Data *
15702

INDEX

READER'S COMMENT FORM

FROM:

NAME ______________________ DATE ______________________

OFFICE/DEPT. ______________________

CHECK ONE OR MORE OF THE COMMENT BLOCKS
AND EXPLAIN IN THE SPACE PROVIDED.

☐ ADDITION: PAGE(S) FIGURE(S)

☐ DELETION: PAGE(S) FIGURE(S)

☐ ALTERATION: PAGE(S) FIGURE(S)

FOLD

FOLD

EXPLANATION:

CUT ALONG LINE

FOLD

FOLD

NO POSTAGE NECESSARY
IF MAILED IN U.S.A.

FOLD ON TWO LINES,
STAPLE, AND MAIL

IBM 2302 Disk Storage, Models 1 and 2

Form 227-5863-3

STAPLE STAPLE

FOLD

FIRST CLASS
PERMIT NO. 2078
SAN JOSE, CALIF.

BUSINESS REPLY MAIL
NO POSTAGE STAMP NECESSARY IF MAILED IN U. S. A.

POSTAGE WILL BE PAID BY

IBM CORPORATION
MONTEREY & COTTLE RDS.
SAN JOSE, CALIFORNIA
95114

ATTN: PRODUCT PUBLICATIONS DEPT. 455

CUT ALONG LINE

FOLD

FE System Maintenance Library

System

— cut here —

227-5863-3

IBM

International Business Machines Corporation
Field Engineering Division
112 East Post Road, White Plains, N.Y. 10601

IBM 2302 Printed in U.S.A. 227-5863-3