

CONTROL UNIT STORES
DESCRIPTION OF SYSTEM OPERATION
NO. 101 ELECTRONIC SWITCHING SYSTEM

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1. GENERAL

1.01 Two types of stores are used in the control unit: the ferrite sheet temporary store and the twistor semipermanent store.

1.02 Ferrite sheet stores come in two sizes. The 512-word stores are used for data and digit storage, and 4,096-word stores are used for call status records. Both have 16 bits per word and both operate on an 8- μ sec read/write cycle.

1.03 The permanent magnet twistor store is used for the program and line information stores. The program store contains 32,768 words and the line information store contains 16,384 words. The line information store consists of a single equipment unit. The program store, however, consists of two equipment units operated as a single store. Either unit has 22 bits per word. The read cycle is 8 μ sec. Writing into the twistor store is done externally by indexing a set of magnet heads over small bit magnets and arranging to magnetize for a zero and demagnetize for a one.

2. FERRITE SHEET STORE

A. General

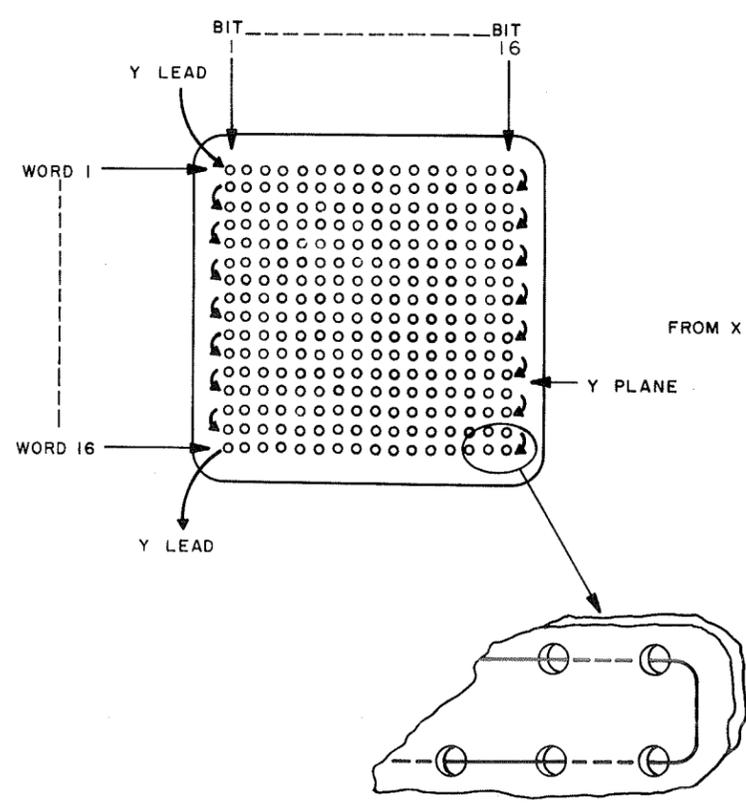
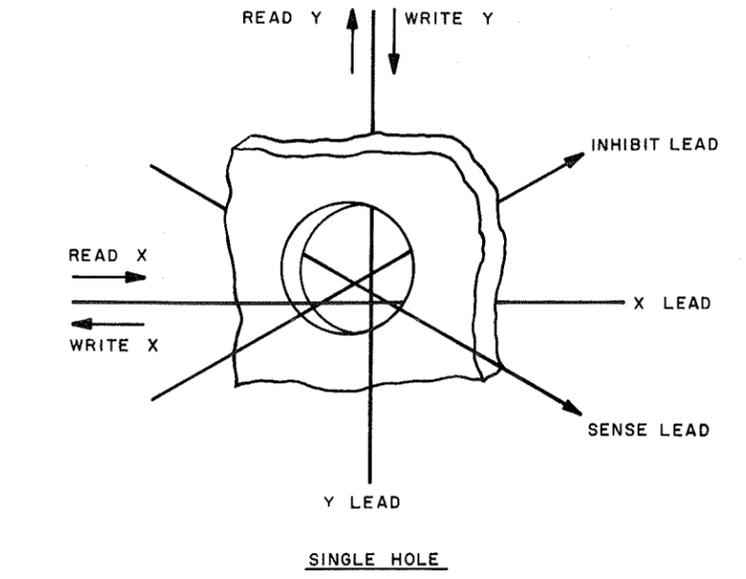
2.01 There are two ferrite sheet stores in the system, the data and digit store and the call store. The purpose of these stores is to provide a scratch pad memory for 16-bit words. The words are written into the store and held for future use. Each word has a definite location (address) in the store. This address is presented by the address register, and it is used to read the word from the store into an output register. In the process of reading, the word is erased in the store. It must be written back into the store in order to continue storing it.

B. Data and Digit Store

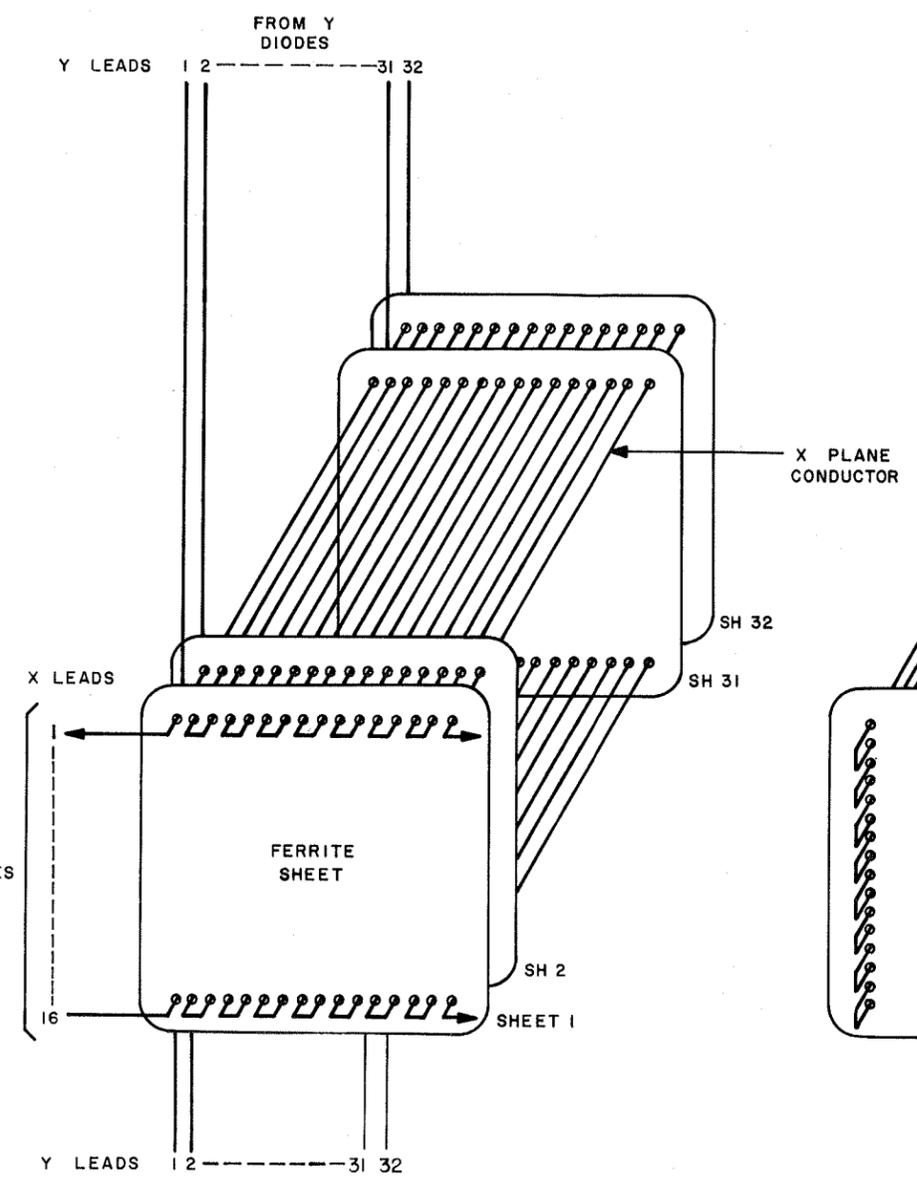
2.02 The data and digit store contains 512 words (see Fig. 1). Each word contains 16 bits and occupies a horizontal row of holes on a ferrite sheet. Each bit consists of a hole and a small area of ferrite material around the hole. A diagram of a single hole is shown in Fig. 1. Four leads pass through each hole. The Y lead actually consists of printed wire. The other leads are wire conductors.

2.03 In order to read the bit from a hole, currents are pulsed through the X leads and the Y leads in the read direction. Read X and read Y currents work together to produce a flux in the read direction. If the state of the hole is a zero, the residual flux is already in the read direction. No change of flux takes place. If the state of the hole is a one, the flux is in an opposite direction to the read flux. Both read Y and read X currents are necessary to change the flux to the read direction. This change of flux induces a voltage into the sense lead. This voltage is amplified and used to set the corresponding flip-flop in the memory register (output register).

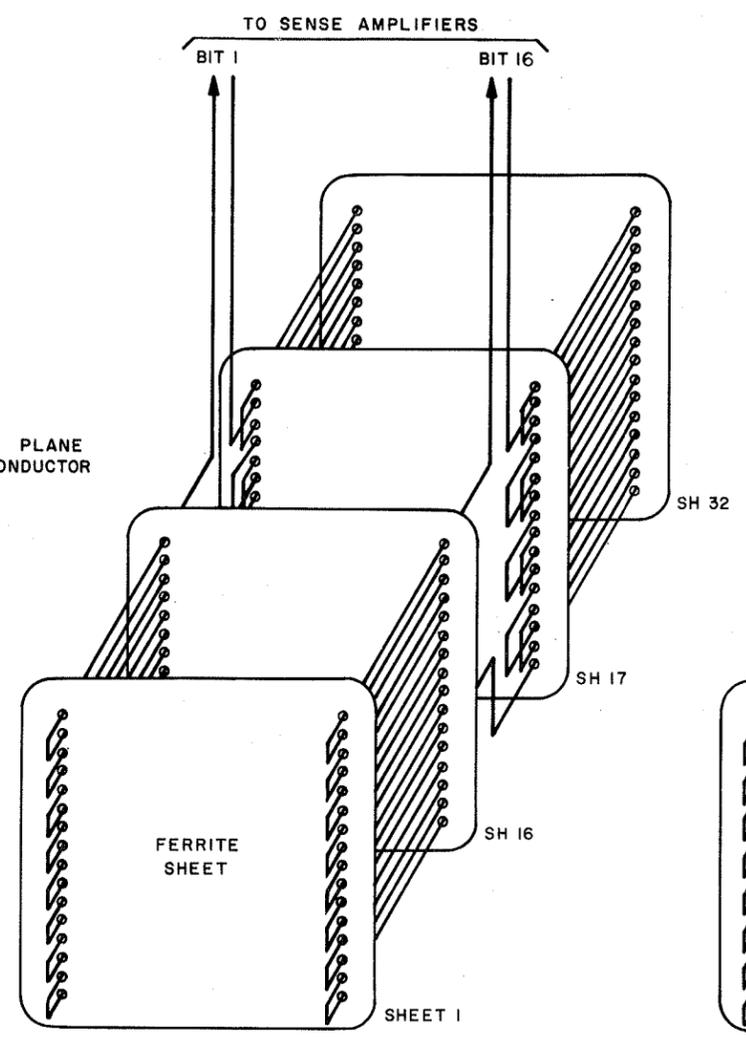
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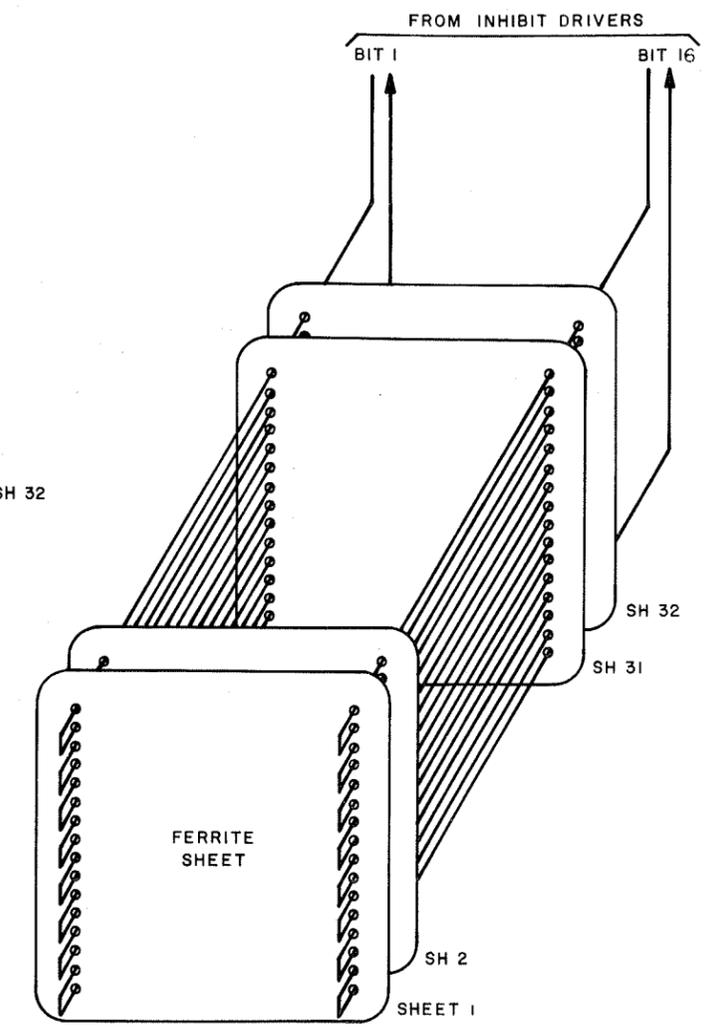
FERRITE SHEET SHOWING Y WIRING



MODULE SHOWING X WIRING



MODULE SHOWING SENSE WIRING



MODULE SHOWING INHIBIT WIRING

Fig. 1 - Wiring of Data and Digit Store Modules

2.04 After the read currents have been applied, the hole is in a zero state. The word must be written back into the store if its storage is to be continued. The X and Y leads are used to write the state of the memory register back into the store. The write X and write Y currents are used to switch the flux from the zero state back to the one state. Both currents must be present to do this. If it is desirable to write a zero back into the hole, an inhibit current which is opposite in direction to the write currents is also generated. The sum of the write X, write Y, and inhibit currents is not strong enough to switch a flux, and the hole is left in the zero state.

2.05 The X and Y leads are used to address the bits in a particular hole. As was mentioned before, a current on both leads is necessary to switch the flux around a hole. There are 32 Y leads, one for each ferrite sheet. The Y lead weaves in and out of every hole in the ferrite sheet. There are 16 X leads, one for each horizontal row of holes on the sheets (see Fig. 1). The X leads are woven through the holes of a particular horizontal level in all 32 sheets. We can think of a Y lead as describing a single plane, this plane being coincident with a particular ferrite sheet. We can think of the X leads as describing planes through a particular word in all sheets. The intersection of these planes describes the location of a single, 16-bit word. By sending current through 1 of 32 Y leads and 1 of 16 X leads, one word will contain both the X and Y currents necessary for reading or writing.

2.06 The sense wiring describes a plane through a particular bit in all words. There are 16 sense planes. When read X and Y currents switch the flux in a particular bit, a voltage is induced in the sense lead associated with that bit. Therefore, all the bits in the word which are one will cause a sense voltage to be induced on the sense leads. The inhibit leads describe the same planes as the sense leads, and are used in conjunction with the write currents. Notice the section in Fig. 1 labeled Module Showing Sense Wiring. It can be seen that the sense wires weave through each hole but do so in a rather strange fashion. The pattern which the sense leads form is used so that random noises and unwanted disturbances from nonselected holes in the store tend to cancel themselves out.

This is comparable to the transposition used in cable pairs and in open wire leads to reduce noise.

C. Operation of the Data and Digit Store (See Fig. 2)

2.07 We have seen that one X wire and one Y wire must be selected to describe a particular word. The selection of these wires is determined by the address of the word which is contained in the address register. The X wire is selected from bits 1 through 4 of the address register. The Y wire is selected from bits 5 through 9 of the address register. Bits 1 and 2 of the address register are fed into a 1-out-of-4 translator activating one of four possible leads. This translation activates one of four switches (see X plane selection on the left-hand side in Fig. 2). Bits 3 and 4 are fed into a 1-out-of-4 translator that activates one of four possible switches (see X plane selection on the right-hand side in Fig. 2). Therefore, we have two switches activated of a possible eight. The diodes allow current to flow in one X lead of a possible 16. Bits 5 and 6 of the address register activate one of four switches on the bottom in Fig. 2. Bits 7 through 9 activate one of eight switches on the top in Fig. 2. The diodes allow current to flow in one of 32 Y leads. The X and Y drivers send a current pulse through the activated switch, through the selected lead, out the other activated switch, and back to the driver. The X and Y currents produce 16 separate outputs on the sense leads. The sense amplifiers are strobed to select the strongest part of the signal and thereby reduce noise interference. Sixteen output leads are fed from the sense amplifiers to the memory register. Each lead will set its corresponding bit flip-flop if a one condition had existed in the store.

2.08 A short time later the X and Y drivers send a current through the same wires but in the opposite direction. The output of the memory register flip-flops is used to produce inhibit currents for those bits which are zero. These inhibit currents flow from the inhibit drivers through the stores at the same time that the X and Y currents are present. Therefore, the word is written from the memory register back into the store.

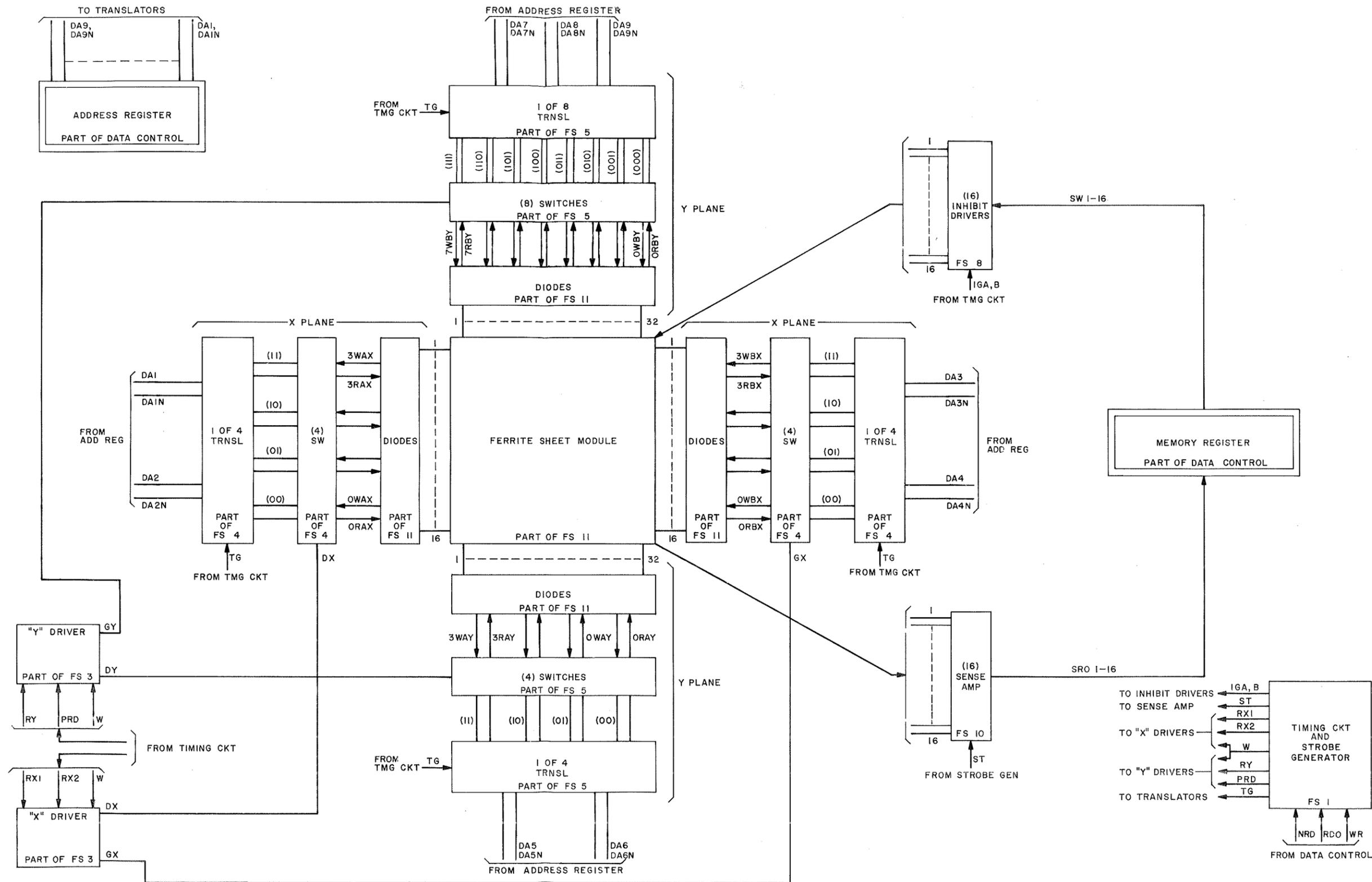


Fig. 2 - Data and Digit Store Block Diagram

D. X Plane Selection (See Fig. 3)

2.09 The translation process for the X plane selection is shown in more detail in Fig. 3. Here we see the switches on the left- and right-hand sides of the diagram. Translators are used to activate one switch on each side of the module. The read current supplied by the read driver is forced into the WAX wires. However, it is met by a back-biased diode and it continues no further unless the switch is fired. Let us assume that the top switch is fired. Here the current enters on the 3WAX wire through the fired transistor and down to the 3RAX wire. The 3RAX wire connects through forward-biased diodes to leads 1, 2, 3, and 4 which go through the store. Each of these leads goes through a diode arrangement to one of the four switches on the right in Fig. 3. One of the switches will be activated. Let us assume it is the top switch. The current goes out on lead 1 through the ferrite sheet module up through the diode into lead 3 RBX, from the 3 RBX lead through the fired transistor to lead 3 WBX, out through the diode, and back to the read driver. Therefore, only one lead forms a continuous path from the driver out through the store and back to the driver.

2.10 The diode bridge arrangement is used so that a current can be produced in the opposite direction through the store. The write function is much the same except that now the current goes over to the right-hand set of switches, through one switch into a WBX lead, through the ferrite sheet on one lead of 16, out into a WAX wire, through a switch to a RAX wire, and back down to the driver. In this way two 1-out-of-4 translations are used to produce a 1-out-of-16 translation. The 1-out-of-16 translation is done in such a way that current can be pulsed over this wire in either direction.

2.11 The Y plane selection uses the same principle. The only difference is that one set of switches contains eight switches instead of four, and the translation is one of 32 instead of one of 16. Otherwise, the job is performed in exactly the same way.

E. Store Timing (See Fig. 4)

2.12 The data and digit store is operated so that each read/write cycle takes exactly 8 μ sec. The read/write cycles are repeated one after the other. The data control circuit fur-

nishes read and write signals. There are two modes of reading. One (the NRO lead) causes the store to operate in the normal fashion. The RDO lead causes a destructive read of the store. The word is addressed but the sense amplifiers are not strobed. The result is that all zeros are read into the memory register.

2.13 Either read signal starts at zero time and lasts for 1 μ sec. This time period is called T0 in the data control circuit. Read commands are fed into the timing circuit and strobe generator. This circuit activates the X and Y drivers to produce the read current. It also supplies the sense amplifiers with the strobe voltage. Notice that the X and Y drive currents are started at a staggered interval. This is done to reduce noise effects in the store. Notice that the strobe voltage takes place after the X and Y drive currents have settled down. At this time the sense leads are at the most favorable point for sampling. At T4, the write signal from the data control circuit activates the timing circuit to generate X and Y write currents. It also activates the inhibit drivers. The inhibit current is started a little before the X and Y drive currents for the bits which are equal to zero.

2.14 The address register must present its address to the store throughout the read/write cycle. At the start of phase T7 the next address is double-rail gated into the address register and is held for another 8 μ sec. The memory register is reset at the beginning of cycle. The word from the store is read into it around T1 or T2 through the action of the sense amplifiers. This word remains in the memory register until it is reset at time T7. The word must be present in the memory register while the writing function takes place. Therefore, phase T3 is the only time available to alter the word. External circuitry must change the memory register by setting or resetting its flip-flops during the time T3 if the word is to be changed. Examples of changing the word are writing the word into the store initially and erasing the store after the word is no longer needed.

F. Call Store

2.15 The call store contains 4,096 words. Each word is 16 bits wide. Four modules (stacks of 64 sheets each) are used to do the job. The horizontal plane of holes spanning two modules

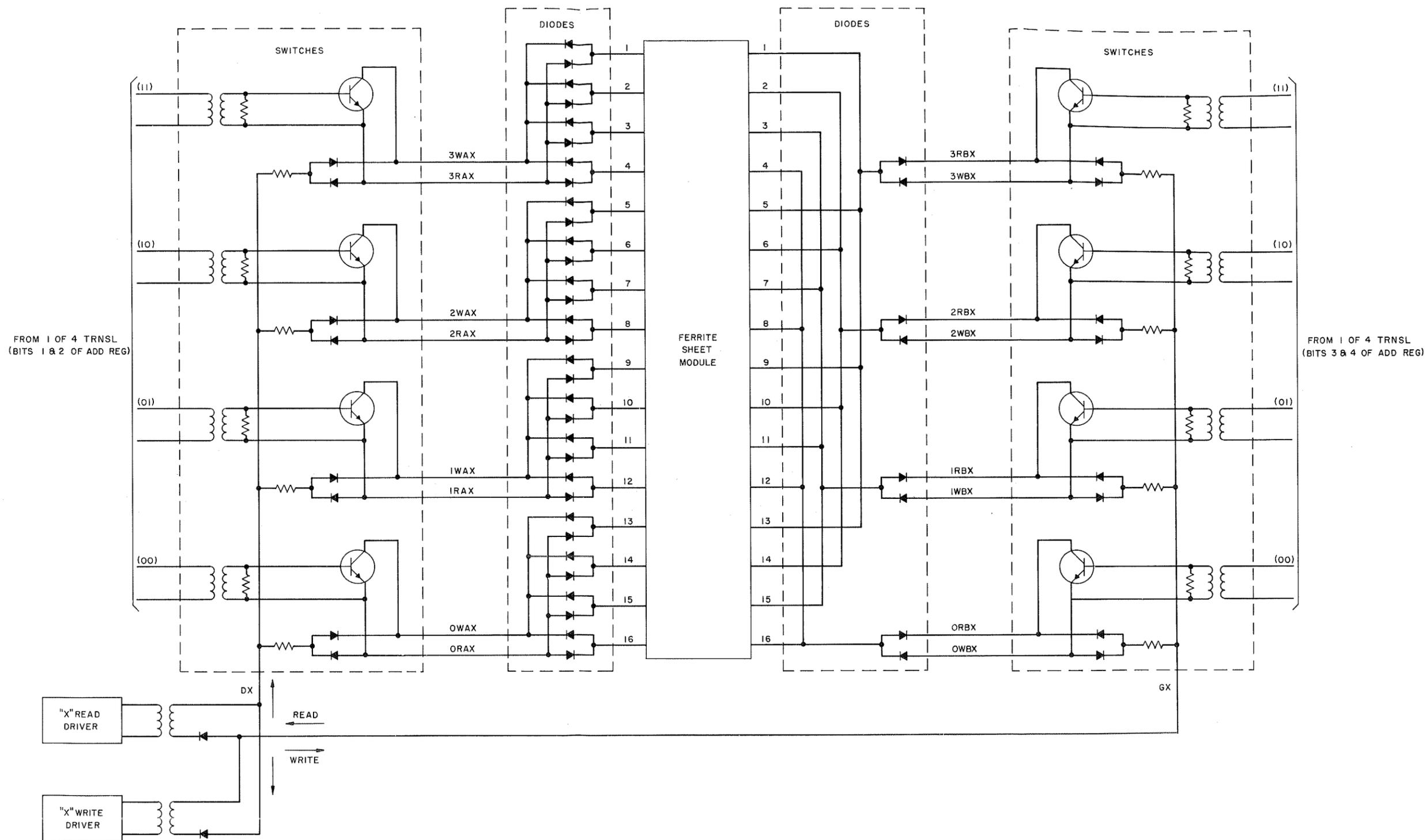
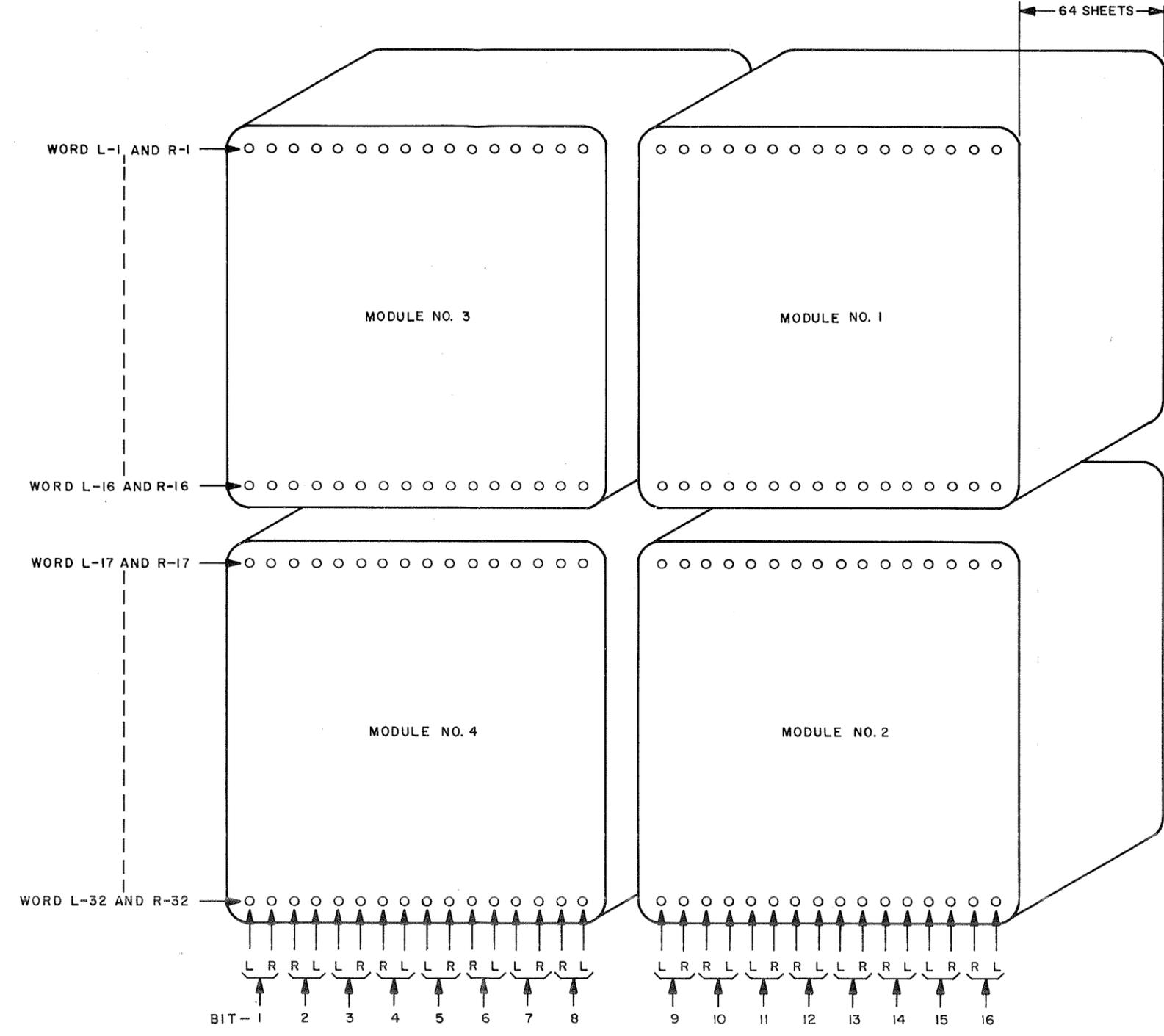


Fig. 3 - "X" Plane Selection

P. 13 missing



NOTE:
 A Y-PLANE CONSISTS OF 4 SHEETS - ONE IN EACH MODULE. THERE ARE 64 Y-PLANES.
 EACH HORIZONTAL ROW CONTAINS TWO X-PLANES: ONE "L" TYPE AND ONE "R" TYPE. THERE ARE 32 "L" TYPE X-PLANES AND 32 "R" TYPE X-PLANES FOR A TOTAL OF 64 X PLANES.

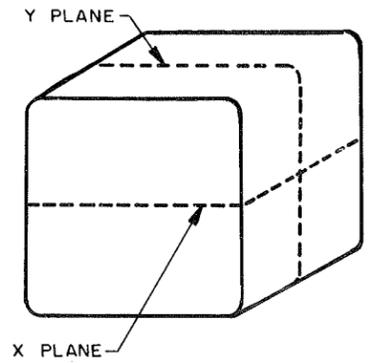


Fig. 5 - Call Store Modules

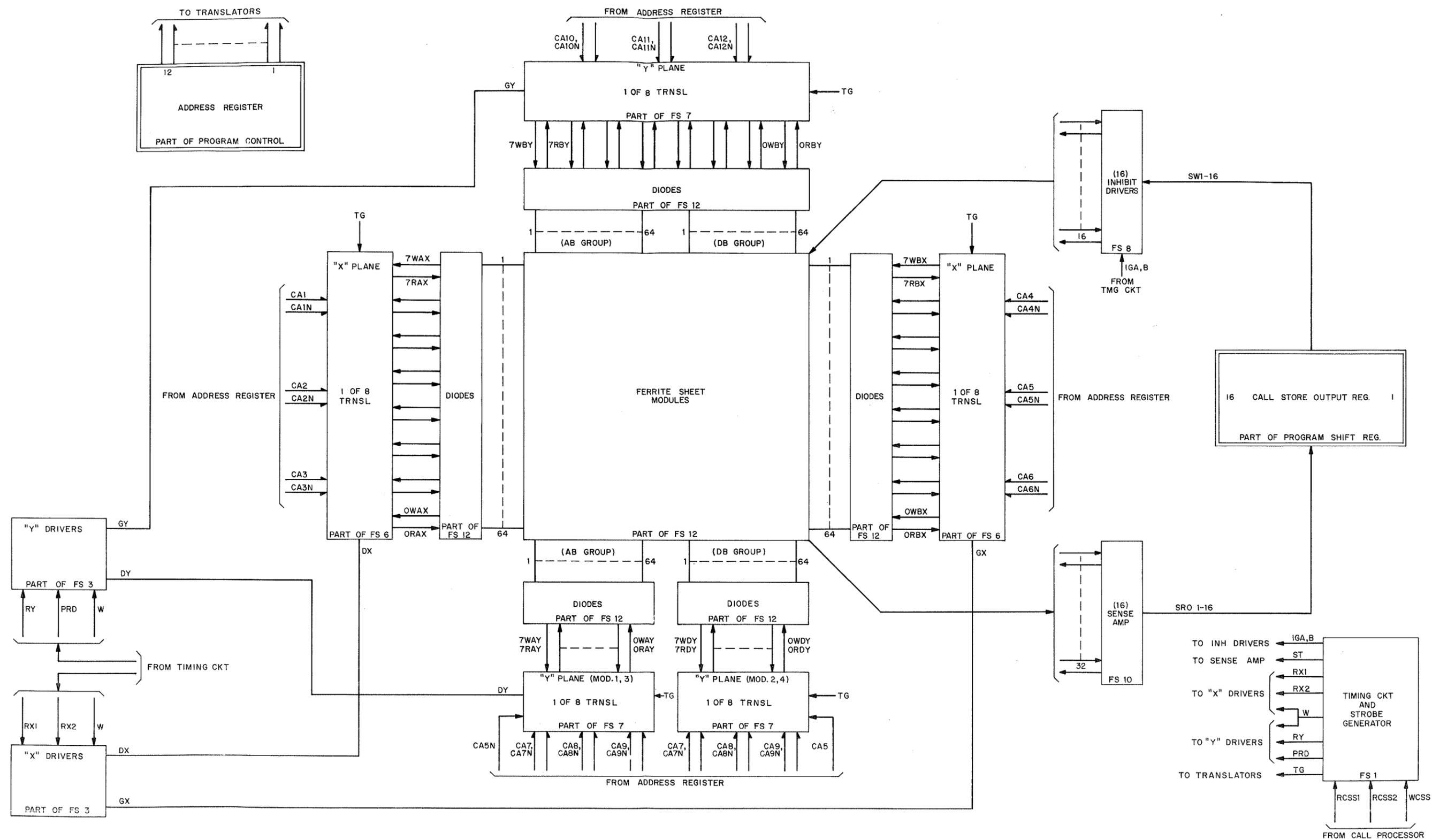


Fig. 6 - Call Store Block Diagram

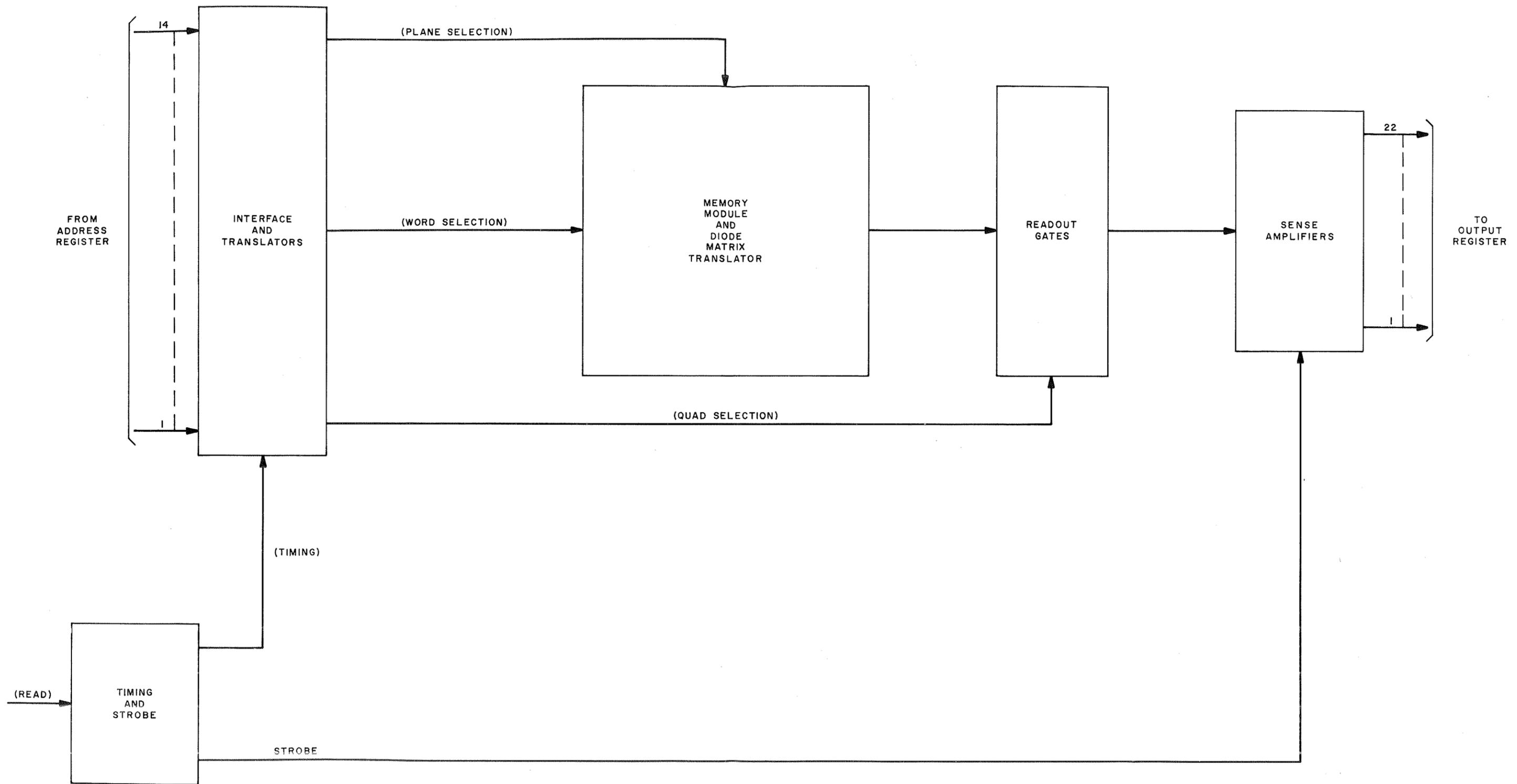


Fig. 7 - Twistor Store

transistor translators. Each pair of 1-out-of-8 translators is in turn used to select one of 64 X or Y windings through a diode matrix. Magnetic cores have been located at the 4,096 intersections of the 64 X and 64 Y windings. Thus, 12 of the address bits are used to select one of 4,096 magnetic cores by means of coincident current pulses in one of the X and one of the Y windings. The bias winding serves to restore the core to its normal magnetic state after it has been switched. As a result of switching the state of the addressed core, a pulse of current will flow in the solenoid associated with it. It should also be noted in Fig. 8 that address bits 7 and 8 are used in another translator to activate one of four groups of leads for quadrant selection.

C. The Solenoids, the Twistors, and the Bit Magnets

3.04 If we now examine Fig. 9, it may be seen that each solenoid crosses all 88 twistor wires at an angle of 90 degrees. The twistor is a copper wire wrapped with a ribbon of magnetic material called Permalloy. There can be very little coupling between the twistor wire and the solenoid except through the Permalloy ribbon which is at an angle of about 45 degrees with each of them. The twistor wires have been imbedded together with their associated return wires in two plastic belts. One belt containing 44 twistor pairs has been placed on each side of the solenoid. An aluminum card may be found next to each twistor belt. In other words, the twistors are sandwiched between an aluminum card and a plane of 64 solenoids. Also each plane of solenoids is associated with two twistor belts and two aluminum cards.

3.05 Each aluminum card has 44 rows of 64 magnets attached to it. Each magnet has been placed in close proximity to the intersection of a solenoid and a twistor wire. Each magnet represents one bit in the store and is referred to as a bit magnet. If the bit magnet has been magnetized, the bit is equal to zero; if it has not been magnetized, the bit is equal to one. In addition to the bit magnets there is a row of initializing magnets on that edge of the card which is first inserted into its slot in the store. The initializing magnets are poled in the opposite direction to those bit magnets which have been magnetized. When the magnet card is first pushed into its slot, the initializing magnets will magnetize the Permalloy ribbons as the magnets pass close to each twistor wire.

3.06 There are two types of cards. They have been designated A and B. To determine whether a magnet card is an A or a B card, hold it with the bit magnets facing you and the notched edge up. If the notch is to the left, the card is an A type; and if the notch is to the right, it is a B card. All of the A cards are associated with one of the 44-bit twistor belts and all of the B cards with the other. The 88-bit words have been divided into four quadrants of 22-bit words. The A cards and their associated belts store quads 0 and 1. The B cards and belts store quads 2 and 3.

3.07 A plane is a vertical row of 64 solenoids together with its A and B magnet cards. There are, of course, 64 planes, and a given card is designated by its plane number and the letter A or B.

3.08 Information note 306 on SD-1H047 shows how the twistor belts are wrapped around the magnet cards and the solenoids.

D. Operating the Twistor

3.09 Disregarding for a moment the effect of the bit magnets, when a current pulse flows in a solenoid, the magnetic field of the Permalloy ribbon in the immediate vicinity of the solenoid is first reversed and then switched back to its original state under the influence of the bias current. These changes in the magnetic field will induce a current pulse in the twistor wire. In other words, the Permalloy ribbon will improve the magnetic coupling between the two loops of wire which we call a solenoid and a twistor pair. However, if the bit magnet which is near the junction of the solenoid and the twistor has been magnetized, the coupling between the solenoid and the twistor pair will be very poor, and little or no pulse will be found on the twistor due to a pulse on the solenoid. This is because the bit magnet will saturate that part of the Permalloy ribbon in its vicinity with a magnetic field of the same polarity that the solenoid pulse tries to produce. Therefore, with the bit magnet set, the magnetic field in the Permalloy ribbon cannot change appreciably, and there will be almost no current induced in the twistor due to a pulse in the solenoid.

E. Readout and Sensing

3.10 Referring once again to Fig. 8, it will be seen that the six high order bits of the address are used to select a plane. The six low order bits are used to select an 88-bit word. When the twistor module has been addressed and read, 88 ones or zeros will appear on the 88 twistor pairs. The ones will be represented by a pulse and the zeros by no pulse. Bits 7 and 8 of the store address are used to activate one of four groups of leads in the readout gates in Fig. 10. This is the quadrant selection. It should be noted that the selection of a quadrant is done at a very low signal level. Pulses which represent ones are only of an amplitude of about 5 mv. The switching noise in the readout gates is in the same order of magnitude. A small amount of time elapses before the noise dies out. Therefore,

when the quadrant is changed, it is necessary to wait for about 2 μ sec before reading the store. The selected quadrant is fed into the 22 sense amplifiers where a strobe pulse gates the ones and zeros into the 22-bit output register.

4. REFERENCES

4.01 The following SD drawings and associated circuit descriptions (CDs) give additional information. These are not attached.

Data and Digit Store or Call Store Circuit for Control Unit	SD-1H046-01
Program Store or Line Infor- mation Store Circuit for Control Unit	SD-1H047-01

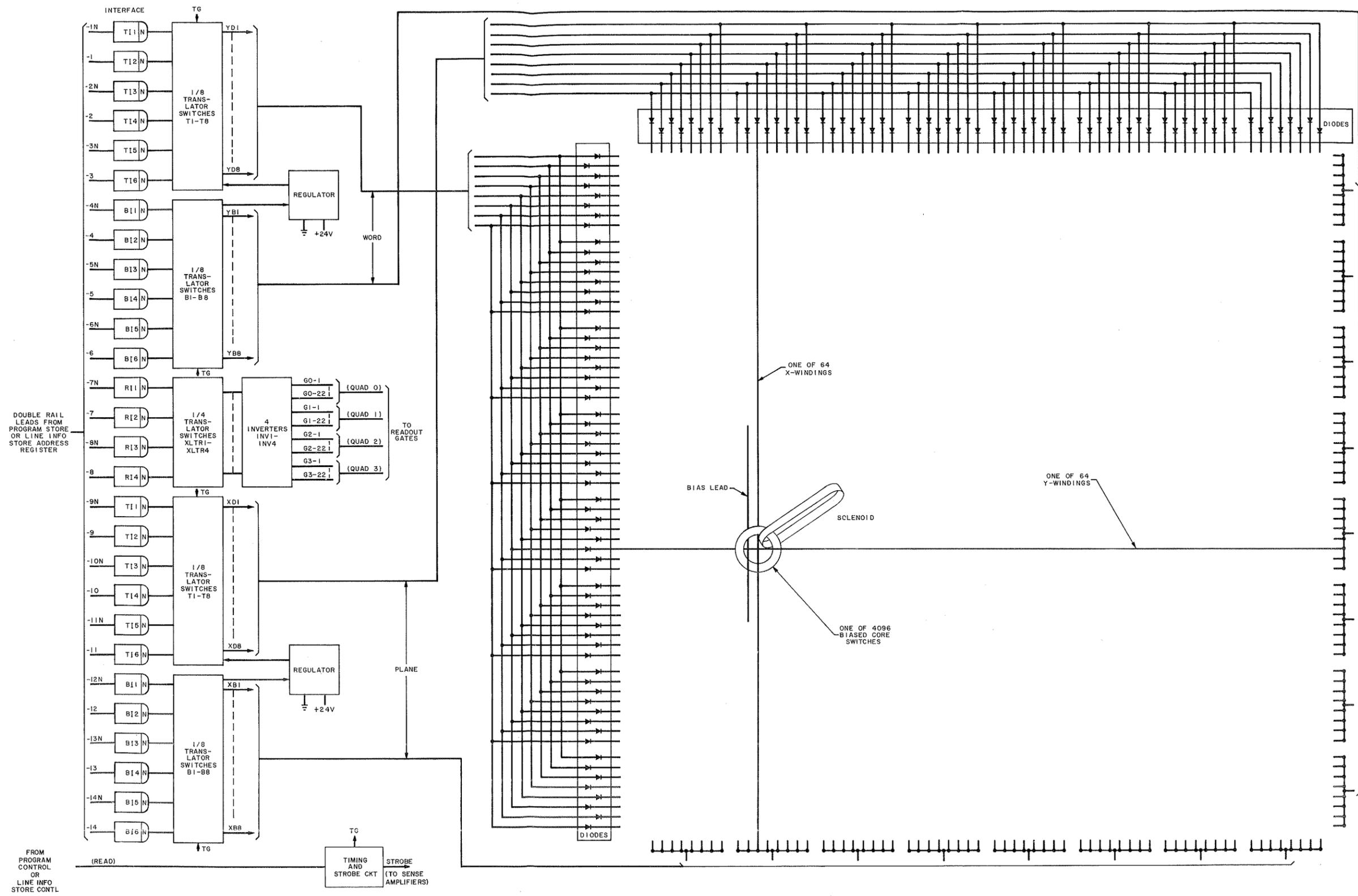
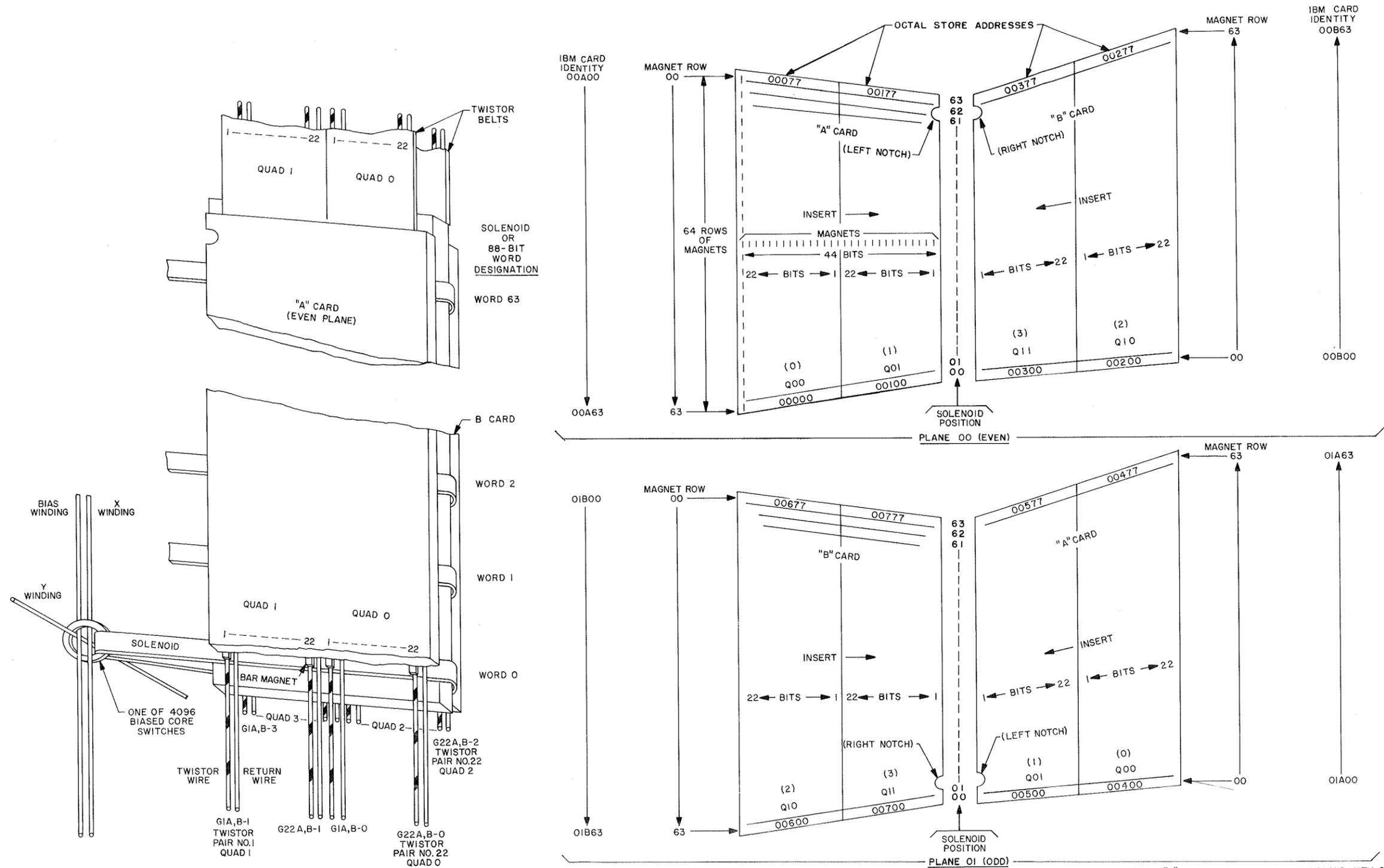


Fig. 8 - Access Circuits for Twistor Store



NOTE: "A" CARD MAGNET ROWS CORRESPOND WITH SOLENOID POSITION IN ODD PLANES ONLY. "B" CARD ROWS CORRESPOND WITH SOLENOID POSITION IN EVEN PLANES ONLY.

THE IBM CARDS USED IN THE MAGNETIZATION PROGRAM ARE NUMBERED ACCORDING TO PLANE, TYPE CARD AND MAGNET ROW (XXAXX) (XXBXX).

Fig. 9 - The Word-Bit Layout in the First Two "Planes" in the Twistor Store

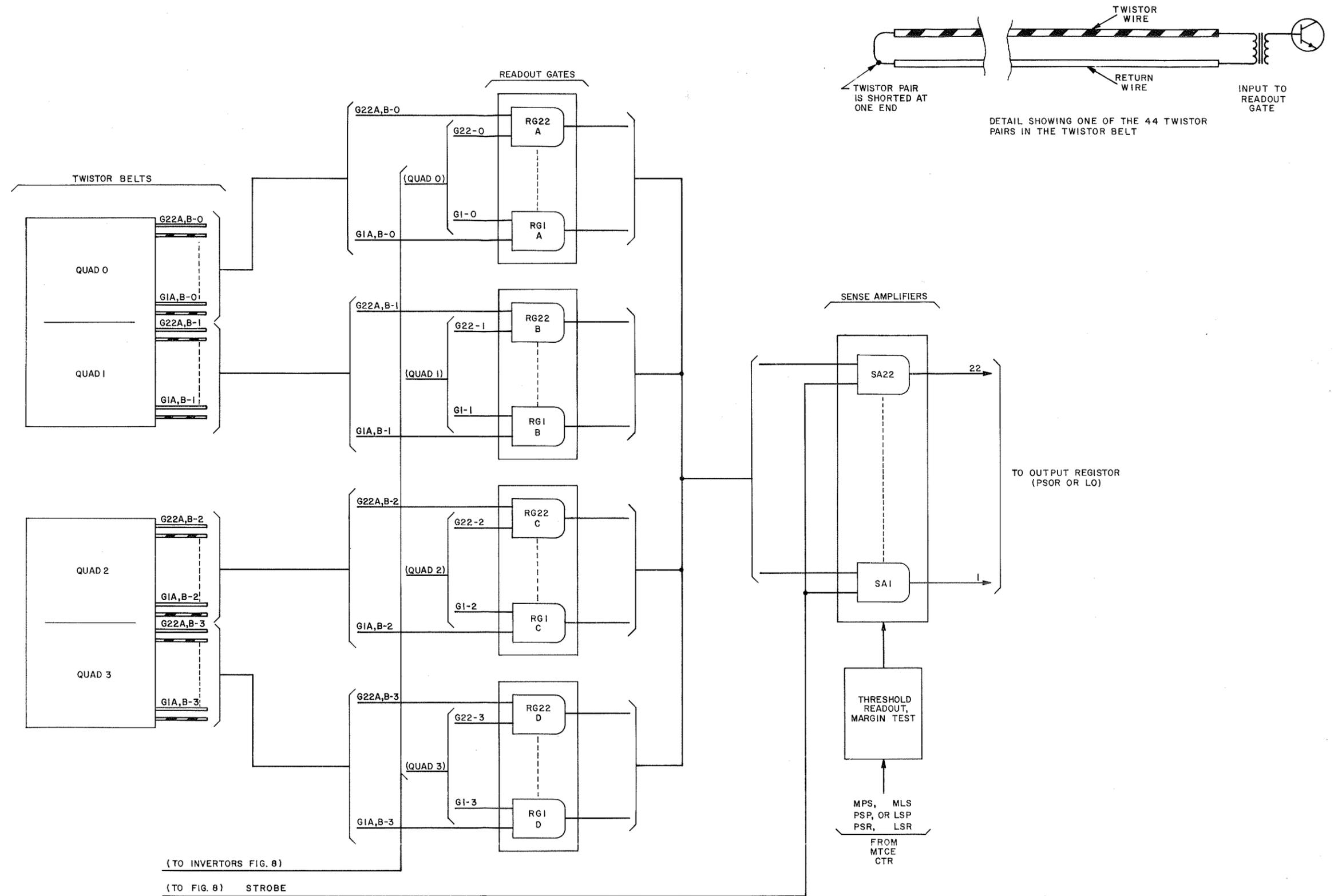


Fig. 10 - Twistor Readout and Sensing