

ROYAL PRECISION  
HIGH SPEED READER & PAPER TAPE PUNCH  
MAINTENANCE MANUAL

INTRODUCTION

The purpose of this Instruction Manual is to supplement the basic Royal Precision Electronic Computer LGP-30 Maintenance Manual as an aid to the service personnel when the subject equipment is used as auxiliary input-output means.

The prime use of the High Speed Reader and Punch is to decrease the time necessary for entering instructions and/or data into and extracting information from the LGP-30 Computer.

The Ferranti Reader is dependent for operation on the voltages and circuits provided in the LGP-30 Computer and may not be used separately. It may be used with or without the punch but only in conjunction with the control cabinet provided. The Ferranti is capable of reading up to 200 characters per second. However, this speed may not be obtained in operation with the computer because of programming limitations. The punch unit will operate at a maximum rate of 20 characters per second.

Provision is made in the auxiliary unit to interconnect the reader, punch, and electric typewriter in four different combinations of input-output modes, allowing considerable flexibility in the use of the equipment as well as increasing the operational speed.

PHYSICAL DESCRIPTION

The complete system consists of the Control Cabinet, the Ferranti Reader Unit, and the Paper Tape Punch Unit. The cabinet is supplied with a recess

in the top cover for the reader to rest in. Adjacent to the recess for the reader is a similar recess provided for the punch unit. If the punch unit is not used, this space is covered by a removable panel. Interconnection between the reader, the punch and the control cabinet is by pluggable cable.

The reader unit contains the high speed tape transport system, cooling fan, light sensitive reading elements, signal amplifying circuits, light source, and a filament transformer for the vacuum tube used. The direct current voltages necessary for the operation of this unit are supplied from the computer through the control circuits in the cabinet. The reader feed system is capable of handling either 5 or 7 hole tape at speeds of up to 200 characters per second and of stopping between characters. These characteristics are achieved by using a friction drive to feed the tape instead of the more conventional sprocket drive. The friction drive consists of a combined tape drive and brake drum connected to one output shaft of a differential gear. The second output shaft is controlled by the clutch. The optical projection system operates on the "pin hole" principle in that the image of the light source is passed through the holes in the tape and focused on the plate of individual photocells. A single prefocused lamp located in a housing directly over the tape feed mechanism is mounted such that the light from the lamp through the holes in the tape and the corresponding holes in the masking plate beneath the tape is directed in equal intensity to each of the six digit photocells and the tape feed hole photocell.

The punch unit contains a mechanical paper tape perforator and feed mechanism identical to those used in the electric typewriter supplied as standard equipment with the LGP-30 Computer. The punching unit is mounted to one side of a small metal housing which contains the drive motor and electrical cams and connections.

The control cabinet contains the components and circuitry for the control of the reader and tape punch: two tape storage bins, each capable of holding up to 600 feet of tape from the reader or punch; a removable electronic chassis which utilizes plug-in cards similar to those used in the computer; control switches and indicator lamps; and cable connections for the interconnection of the computer, punch, reader, and electric typewriter. Access to the tape bins and the electronic chassis is achieved through the hinged front panel which swings open as a door. The components located on the electronic chassis are made accessible by the slide mounting of the unit which allows it to be pulled forward when the door is open. Under the chassis is space for a fiberglass air filter through which air is drawn from the bottom of the cabinet for the purpose of cooling the heat producing elements. The filter space has been designed to allow the use of a standard filter as supplied for the LGP-30. The filter and the air inlet are of such size that when one section of the filter becomes unusable because of dust, it may be turned around 180 degrees and the other half of the filter used. The plug-in card complement consists of two standard Triple Inverter Cards, One Logic Card (same size as a 22 pin card), and one Control Card having one thyatron each, cathode follower, and inverter circuit. The necessary tube filament transformer and the isolation transformer for the punch unit are located to the top rear of the chassis. A mercury relay for a common start signal circuit is provided for the reader, punch, and typewriter. The small cooling fan is mounted directly to the rear of the plug-ins. Signal Test Jacks are provided in the form of an unused connector installed for this purpose directly above the plug-ins.

The auxiliary controls consist of two rotary and four push button type switches mounted on the sloping front panel of the cabinet. The two position

rotary switches select the reading and start compute circuits of the Ferranti or of the typewriter as input to the computer and as output media either the print circuits of the typewriter or the punching circuits of the higher speed punch unit. To the left of the rotary function switches are located the Reader Power Switch and the Stop Reader Switch. Depressing the power switch causes all A.C. and D.C. voltages supplied by the computer to be connected to the reader circuits. A second depression of the switch causes the voltages to be disconnected. Depressing the momentary contact stop reader switch causes the electromagnetic brake in the Ferranti to be activated and the clutch to be dropped out. To the left of the Stop Reader Switch is the Punch Power Switch. Depressing the Punch Power Switch causes the punch drive motor circuits to be activated. Depressing the switch a second time disconnects the circuit. To the left of the Punch Power Switch is the Tape Feed Switch. Depressing this momentary contact switch will cause the punch unit to feed blank tape if the punch power is on. The punch may be operated without the Reader Power switch on.

#### INSTALLATION

The Ferranti Reader and Punch Unit are packed for shipping separate from the control cabinet. After unpacking, it is necessary to place them in their respective depressions in the top of the control cabinet. Two polarized cable connections are provided for the reader and one for the punch unit to connect them to the electronic chassis.

All normal precautions should be taken on installation of the equipment to observe that no physical damage occurred in shipment and that all components are in place.

The Ferranti Reader 20 Character Punch and Control Cabinet unit is designed to be directly usable with all LGP-30s manufactured subsequent to LGP-30 No. 14. To use the auxiliary unit on computers manufactured prior to this will require slight modification to the thyatron output circuits. Installation consists of removing the short cable connection from the electric typewriter to the computer. A 12 foot cable supplied with the control cabinet connects the cabinet to the computer in place of the short cable at J631. A second 12 foot cable connects the control cabinet to the electric typewriter in place of the short cable at P632.

#### OPERATION

To operate the Ferranti Reader, depress the Reader Power Switch. Do not turn on the reader power before the computer has been turned on and cycled through the normal warm up phases. To do so will cause the reader clutch to be energized during the "stand-by to operate" period. In the advent that this should happen depression of the Reader Stop Switch will drop out the clutch and pick the brake. Place the tape to be read in the receptacle to the rear of the reader unit in such manner as to permit the feeding of the tape into the reader upside down. Note- The tape is fed from the leading end of the tape as with the typewriter reader, the only difference being that the tape must be inverted. This is because the physical position of the individual hole photocells are reversed, i.e., 6 and 5 interchanged, 1 and 4, and 2 and 3 reversed. Lift the tape release lever located on the rear of the projection lamp housing. Set the tape guide pin adjustment to the seven unit tape position which is to the rear. See Fig. 1. Insert the tape under the tape guide plate which was lifted by the raising of the tape release lever, and between the tape feed rolls. Sufficient tape leader should be provided (minimum of 6") to assure that the tape may be properly

gripped by the feed rolls without placing the first character holes past the position marked by a scribed line on the masking plate. Once the tape is inserted, depress the tape release lever. The spring loaded guide plate will hold the tape in position. The tape may be positioned to a desired location to begin reading by sliding the tape to the front or rear manually. If it is desired to start reading between words, simply place the holes designating the first character to be read over the optical projection holes.

With the rotary "Typewriter-Reader" switch in the typewriter position, enter the necessary coding to transfer to the programmed routine which will control the operation of the Ferranti. If the programmed input routine is stored beginning at track zero, sector zero, it is only necessary to clear the control counter. Switch the rotary selector switch to the Reader position and depress the start compute switch on the computer or the typewriter. The start compute switch on the typewriter is operative when the selector switch is in the Reader position but all input circuits to the computer are switched to the reader. The execution of P0000 order will have no effect on the reader. However, the execution of a IXXXX order will cause the reader clutch to be energized and the tape to be fed. All characters which are read into the computer by the typewriter will be entered by the reader. All characters not entered into the computer by the typewriter will also be ignored by the reader. The reading of a stop code will generate a start compute signal to the computer and stop the tape feed before the next hole to be read.

To manually fill into the computer after the reader has been used, it is necessary to turn the selector switch to the typewriter position.

To use the Paper Tape Punch, depress the Punch Power Switch. Depressing the Tape Feed Switch will cause blank tape to be fed for a leader. Turn the rotary selector switch marked "Punch-Typewriter" to the Punch position. The output thyratrons in the computer are now connected to the punch magnets and the typewriter translator unit is disconnected. The execution of any (PXXXX) instruction other than "Start Read P0000" will cause that character to be punched. At the end of each punching cycle a start compute signal is generated similar to operation of the typewriter when printing.

Do not turn the Punch Power Switch on until after the Computer has cycled through the normal warm up stages. To do so will cause all of the punch magnets to be energized when the computer reaches the Stand-By to Operate phase.

#### THEORY OF OPERATION

Ferranti Reader- When punched paper tape is fed past the tape reading position, the light from the projection lamp above the tape is directed on the photo emissive surface of the individual photocells for each of six digit holes and to the photocell corresponding to the tape feed hole. The current passed by each photocell is proportional to the light directed on it and therefore, dependent upon the position of the holes in the tape relative to the reading position. Each photocell is connected in the grid biasing circuit of individual triode amplifiers. See fig. 7. These amplifiers are biased to operate in the conducting state with no hole present in the tape. With an increase in light on the photocell the negative bias on the amplifier increases, causing the output of the amplifier circuit to increase positively. The output from the plate of each digit amplifier,  $H_1$  through  $H_6$ , is cabled to the input connection of six standard inverters.

The action of the inverters is to form the input signal into the proper shape and voltage as required by the computer logic and to provide the necessary inverse function. The outputs of each inverter labeled K1-K1 through K6-K6 are connected to the logic card where when P\* is true the respective P<sub>1</sub>\*-P<sub>1</sub>\* through P<sub>6</sub>\*-P<sub>6</sub>\* are formed. The action of the diode gates on the reader logic board duplicates the functions of the selector contact switches in the electric typewriter. The complete circuit for digit hole one is shown in Fig 2. The P\* signal that is necessary for the formation of the digit P\*s is formed in a similar manner with the exception that the photocell activated by the light from the tape feed hole controls the grid of a pentode amplifier which drives a Schmidt trigger. The pentode amplifier is biased such as to be cut-off with the absence of light on the feed hole photocell. An increase in light on the photocell as the feed hole passes over the reading position causes a decrease in voltage at the input grid of the Schmidt trigger. The Schmidt trigger acts as a squaring circuit and is so designed that as the light increases past a predetermined level the output of the circuit suddenly changes to the opposite of one of two states similar to the action of a flip-flop. As the light on the photocell decreases, the voltage at the input grid of the trigger increases until at a predetermined point the output voltage at the output of the circuit suddenly reverts to the first state. The output from the Schmidt trigger drives a cathode follower output tube. This signal Fh, is high or true with no feed hole and low or false when a hole is read. This is opposite to the output of the digit hole amplifiers. The Fh signal is cabled to the logic card in the control cabinet where it is used to control generation of the P\* and the b<sub>s</sub> signals. Because the feed hole is smaller in diameter than the digit holes, and because of the squaring action of the Schmidt trigger,

the Fh signal will be false only after the other digit holes have set their respective inverters and will go true before the digit holes have passed the reading position. The feed hole then generates a sampling pulse for the digit holes.

The logic for the formation of P\* is as follows:

$$P^* = (\underline{K1} + \underline{K2} + \underline{K3} + \underline{K4} + \underline{K5} + \underline{K6}) (\underline{Fh}) (\underline{C}) (\underline{K5} + \underline{K6} + \underline{K3K2})$$

The term will be true then for all characters and symbols that normally enter the computer from the typewriter but will be false for all control characters except tabular. To facilitate construction of the logic the above term is inverted and the equation as used on the logic board is:

$$\underline{P}^* = (\underline{K1} \underline{K2} \underline{K3} \underline{K4} \underline{K5} \underline{K6}) + (\underline{K5} \underline{K6}) (\underline{K3} + \underline{K2}) + \underline{Fh} + \underline{C}$$

C is derived from a resistor dividing network on the control card. When the clutch is energized the term is false or at -20 volts. See Fig. 4.

The P\* from the logic board is used as the input to the inverter circuit on the control card from which is taken P\* and P\* for the other logical gates.

The P\* equations for setting the input flip-flop in the computer are:

$$P_{1*} = P^* \underline{K1}$$

$$\underline{P}_{1*} = P^* \underline{K1}$$

$$P_{2*} = P^* \underline{K2}$$

$$\underline{P}_{2*} = P^* \underline{K2}$$

$$P_{3*} = P^* \underline{K3}$$

$$\underline{P}_{3*} = P^* \underline{K3}$$

$$P_{4*} = P^* \underline{K4}$$

$$\underline{P}_{4*} = P^* \underline{K4}$$

$$P_{5*} = P^* \underline{K5}$$

$$\underline{P}_{5*} = P^* \underline{K5}$$

$$P_{6*} = P^* \underline{K6}$$

$$\underline{P}_{6*} = P^* \underline{K6}$$

To generate a start signal,  $b_s$ , when a stop code is read, the logical sum gate:

$\underline{b}_s = \underline{K1} + K5 + K6 + \underline{C} + \underline{Fh}$  is formed. This is the inversion of:

$b_s = K1 Fh C \underline{K5} \underline{K6}$  which says that when reading tape and a stop code is read,  $b_s$  is true, or conversely that  $\underline{b}_s$  is true for each digit time except when a stop code is read. The  $\underline{b}_s$  term is connected to the grid of the cathode follower on the control card. The output of the cathode follower is used to generate the start signal for the computer. At the same time the  $\underline{b}_s$  term is coupled to the grid of the brake thyatron causing it to conduct, picking the brake and dropping out the clutch.

The tape clutch is energized during the execution of an input order by means of the thyatron THiG in the computer. This thyatron is ionized by the gate formed by the I order set up in the Q flip-flops and phase 4. When the clutch is picked the brake is automatically released causing the tape to be fed. The time interval between the execution of the I order and entering phase 1 is sufficiently short to permit the reading of the first character even though it may be located over the reading holes at the time the clutch is energized.

#### THEORY OF OPERATION: Paper Tape Punch

The operation of the tape punch is identical to the operation of the translator in the electric typewriter used as standard equipment on the LGP-30. The circuits of one or the other are interchanged by the rotary selector switch on the control cabinet front. The punch magnets are picked by their respective thyatrons in the computer on the execution of a Print order. At the completion of the punch cycle a start signal is generated and the plate circuit of the thyatrons is opened.

## CIRCUIT DESCRIPTION - Ferranti

All control signals to the reader and input signals from the reader to the computer are switched in or out by means of the rotary switch S3. This switch consists of 5 ganged decks of 4-pole, 2-position switches. These decks are labeled from front to rear A through E. The terminal connections on each deck are numbered 1 through 12. Each of the fourteen P\* signal input leads to the computer are connected to the center tap of one of the switches. To each of the corresponding switched contacts which are connected to the center tap when S3 is rotated to the Reader position are connected to the P\* leads from the reader logic card. The opposite terminals are connected to the P\* contacts in the typewriter. The terminal connections are shown on Print 314974, Schematic-Control Circuits. Fig. 3 identifies the physical location of the numbered terminals. In addition to switching the P\* signals the start compute circuit of the reader is switched in or out depending on the position of S3. Note that as long as either the reader-typewriter or the punch typewriter switch is in the typewriter position the start signal circuit of the typewriter is effective either by itself or in parallel with that of the reader or punch. When the switch S3 is in the reader position the thyatron THiG is connected to the reader clutch magnet and the thyatron THst, rd. is disconnected from the typewriter start read relay.

The common connection of the brake and clutch magnets of the reader are connected to the +150 volts supplied from the computer via the Reader Power Switch S1, a 120 ohm 2 watt resistor and 20 microfarad filter located on TB1. The opposite end of the clutch magnet winding is connected through shielded cable to a 2K, 10 watt resistor, through switch S3 terminals E10 and 11 and through shielded cables to the iG thyatron in the computer. A capacitor

is connected from the end of the 2K resistor common to the plate of the iG thyatron, to the plate of the brake thyatron. When the iG thyatron is allowed to conduct, the sharp decrease in the plate voltage is coupled to the plate of the brake thyatron which is already conducting. This negative going pulse is of sufficient magnitude to force the plate of the brake thyatron below the point at which the thyatron will maintain conduction and deionization takes place dropping out the brake magnet. Because the grid of the brake thyatron is held cut off until a stop code is read from tape or the Reader Stop Switch is depressed, the clutch magnet will remain energized.

#### Brake Circuit-

The common of the brake magnet is connected to the same source of +150 volts as the clutch magnet. The opposite end of the brake magnet winding is connected through a shielded cable to a 2K ohms 2 watt resistor on TBl which is in series with the brake magnet and the plate of the brake thyatron located on the control card. The control grid of the brake thyatron is normally held negative by a voltage divider network between ground and the -162 volts. When the  $b_s$  signal from the logic card goes negative and returns to ground as a stop code is read from tape, a coupling capacitor between the  $b_s$  circuit and the grid of the thyatron differentiates the signal and develops a positive going pulse sufficient in magnitude to drive the brake thyatron into conduction. The negative going signal from the plate of the brake thyatron is coupled through the plate coupling capacitor to the plate of the iG thyatron causing it to deionize, dropping out the clutch at the same time that the brake is energized.

An alternate method of stopping the tape drive is to depress the Reader Stop

Switch S6. The -162 volts used to bias the grid of the brake thyatron negatively is obtained through this normally closed switch. When the switch is depressed the -162 voltage is removed from the dividing network and the grid is allowed to return to ground, causing the brake thyatron to conduct, stopping the tape. The clutch and brake circuits are shown in Fig. 4.

#### Start Signal Circuit

The method by which the start signal is generated in the computer made it necessary to develop a start signal circuit in the equipment which would allow the various units to be operated in combination with each other. This was done by using a quick acting, reliable mercury relay. The combined start signal circuit is shown in Fig. 5. Referring to the drawing, if switch S3 is in the reader position, the computer start signal circuit is connected through relay RY1 contacts 1 and 3, (normally open), switch S3 terminals D 7 and 9, to the cathode follower V1. The relay RY1 will be picked from the +150 volts to ground through either the punch unit normally closed cam B, or the standard typewriter start signal circuit depending on which way selector switch S4 is set. Until a stop read signal is read from tape the cathode of V1 will remain at zero volts as the input to the cathode follower  $b_s$  will be true. When a stop read code is read from tape the cathode of V1 will drop to -20 volts allowing the start signal capacitor on the computer logic board to charge. When the cathode of V1 returns to ground the charge developed across the capacitor is sufficient to raise the  $Q_2$ ' gate to the true state. Note that any start signal generated in the typewriter if the Punch-Typewriter switch S4 is in the typewriter position will cause the relay RY1 to drop out momentarily causing a start compute signal to develop. The same holds true if the switch S4 is in the Punch position and the punch is activated. Switches S3 and S4 are the make before break type so that the

start signal circuit is not broken during switching.

#### Reader Power Circuit-

All voltage supplied by the computer to the reader are switched through the Reader Power Switch S1. This switch is of the latching type and has sliding and micro switch contacts. The circuits to and from this switch are self explanatory and shown in Fig. 6. The depression of the switch S1 causes the lamps under the switches S1 and S6 to be energized and voltage made available to the lamp circuits for the punch control switches.

#### Photocell and Amplifier Circuits-

The complete reading circuits of the Ferranti are shown in Fig. 7. The operation of these circuits has been described in the theory of operation section.

#### Maintenance

Periodic preventive maintenance inspections are required on the electronic and mechanical components of the auxiliary equipment as with the computer. As the electronic circuits are of the same type and characteristics as those in the computer, the same methods of servicing will apply to both. Three adjustment potentiometers are provided to obtain the proper operating voltages in the reader. On the top of the electronic chassis is located potentiometer R1.

This potentiometer acts as a voltage divider between ground and the -162 volts and must be adjusted to -82 volts at the center tape. This voltage is used as the biasing voltage for the reader amplifier and photocell circuits. Under the bottom of the reader unit are the feed or locating hole bias potentiometer and the digit hole bias potentiometer. These may be reached by opening the front of the control cabinet and inserting a screw

driver through the access holes in the top cover, or the reader unit may be lifted from its recess and turned on its side. The location hole bias potentiometer controls the voltage level at which the Schmidt trigger changes state. The correct adjustment of this control must be made with an oscilloscope. The signal H1 through H6 from each of the photocell amplifiers and the output of the feed hole circuit FH are connected to socket J812 located on top of the electronic chassis to the right of the potentiometer R1. This receptacle is provided as a test point facility. The Fh signal may be observed here with the oscilloscope set to trigger on the incoming signal. The signal will appear rectangular and of 30 to 35 volts amplitude. The location hole potentiometer will control the relative width of the on and off periods of the signal. These should be adjusted to be of equal periods.

The digit hole potentiometer controls the conducting level of the digit amplifiers when no holes are being read. This adjustment is necessary as the density of the paper tape used will vary. Although a considerable latitude is allowable in the adjustment of this potentiometer it should be adjusted so that with blank holes being read the voltage read at the test points H1 through H6 is -25 to -30 volts. When holes are being read the voltage at the respective test points H1 through H6 should read approximately +20 volts.

A standard 22 pin card extender may be used to extend the two inverter cards and the control card for servicing. The logic card is of special design and has 44 separate terminal connections. **DO NOT INSERT ANY CARD EXTENDER IN THIS POSITION.** Refer to Fig. 8 for the card layout. Because this card may not be extended, a cut out is provided in the left side of the card chassis to permit servicing of the logical gates.

WARNING - The mercury relay used in the start signal circuit must be operated in the vertical position. Do not at any time operate the system with this chassis in any position but vertical as to do so will cause the shorting of the relay contacts.

#### Mechanical Adjustment-

The chief requirement of the feed mechanism is that it should be possible to stop the tape within a limit of .003" from the point at which the stop code is read. To achieve this it is necessary that the brake magnets be adjusted to provide the smallest possible air gap between the armatures and the cores. A gap of .002" is required for this purpose. In adjusting for this stopping characteristic, it is sometimes necessary to compromise between rapid acceleration and stopping. To adjust the air gaps of the brake magnets, remove the lamp housing and disconnect the lamp plug. Remove the top plate of the reader unit. Fastened to this plate is the drive assembly. Referring to Fig. 9, loosen screws marked A, B and C, turn the armature stop screw until it is well clear of the armature. Hold the armature firmly against the core of the magnet and slide both brake and armature assemblies until the brake shoe is against the brake drum. Retaining firm pressure of the shoe against the drum, tighten screws A. Apply a pressure of approximately one pound on the brake shoe against the drum to assure that it is correctly seated and tighten screws B. While maintaining the force of one pound on the armature toward the pole piece of the magnet (brake shoe in firm contact with the drum), slide the magnet toward the armature until the gap between the armature and the pole face is .002". Tighten screws C. When the tension is released from the armature the gap may increase. If this gap exceeds .0035" the adjustment should be corrected. Adjust the armature stop screw until the gap is .005" with the magnet denergized. The clutch magnet and

shoe is adjusted in a like manner. After adjusting the clutch and brake units the system must be run and the start and stop times tested to assure that the tape will stop in the prescribed distance and that the first hole will be read correctly.

If it is necessary to replace the projection lamp the adjustment of the optical system must be checked. To replace the lamp, the lamp contact arm at the base of the light is moved to the side to release the old lamp. Insert the new lamp so that the filament of the lamp is toward the bottom. Move the lamp contact arm back to retain the new lamp in place. Adjust the optical system by placing a tape with only the digit hole "1" punched, in position over the reading position. With a voltmeter monitor the voltage output of the photocell amplifier for this digit hole at the test point J812-A. Loosen the lamp socket retaining screws and adjust the lamp until the most positive voltage is obtained. Tighten the lamp retaining screws. The output of each of the other photocells must be checked at this time. The lamp is of a special straight cylindrical filament type selected so that the filament image will cover the entire area of the photocell surface. No substitution of lamp types should be made.

Because of the nature of the optical operation the unit is effected by excessive dust. It is essential that the system be periodically cleaned.

After 500 hours of operation it is recommended by the manufacturers that a light grease be used to lubricate the points indicated in Fig. 11. Access to these points is by means of removing the lamp housing. Extreme care must be taken that no excess lubricant gets on the clutch and brake drums. A light oil should be used on the tape pressure rollers.

## Spare Parts

With each optical reader shipped is an Instruction Manual produced by the manufacturers of the reader and two spare part packages. The circuits shown in the manual are not those used and should be ignored. Spare parts package 65/13714 contains misc. screws, nuts, washers, and two special spanner wrenches for the reader that are not readily available in the United States. The second package, 65/12439, contains a spare projection lamp. These spares must remain with the unit at all times and when one item is used a replacement must be ordered immediately.

The tube complement in the standard reader consists of 8 Mullard 90AV photocells, 1 Mullard EF 90 pentode, and six 12AT7 dual triodes. The photocells and the pentode are not directly replaceable with American made tubes and must be specially ordered. The 12AT7 tube may be replaced by a 5965 type. The recommended spares for each installation are:

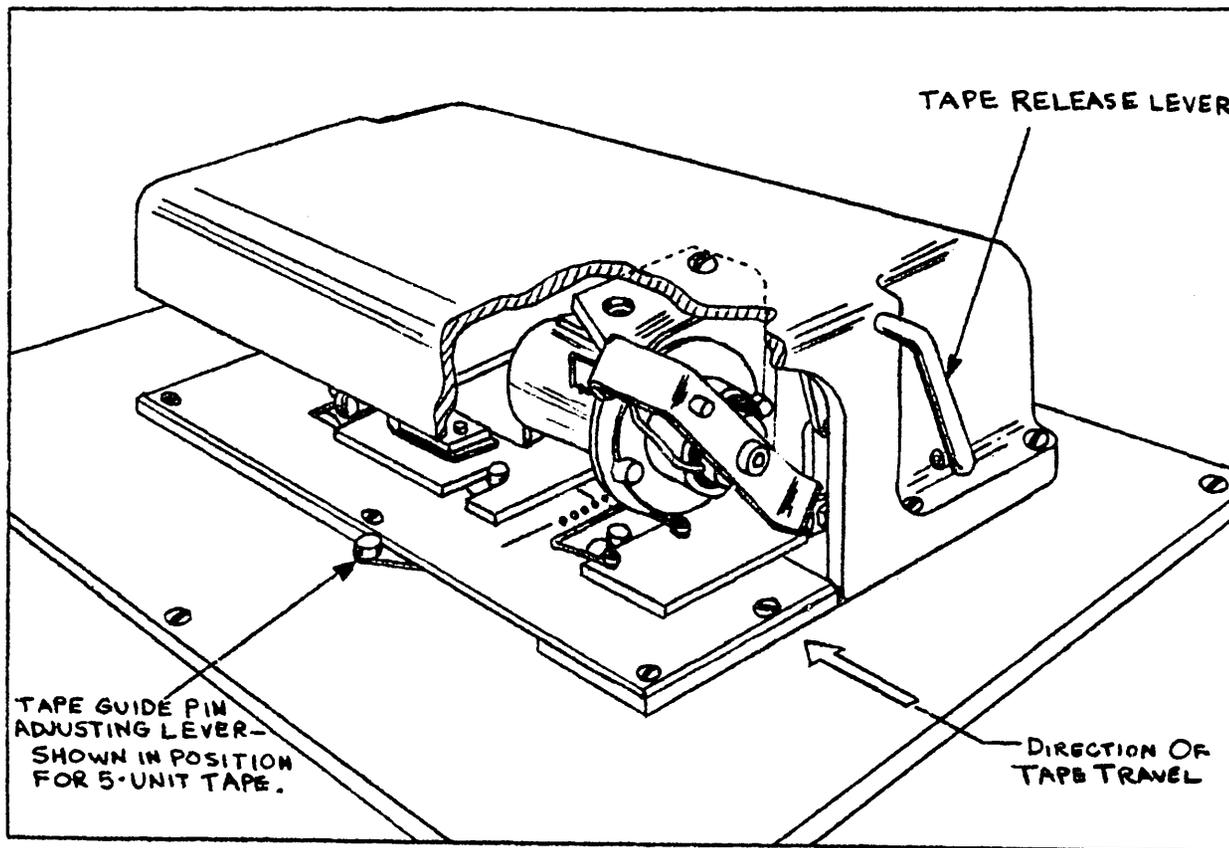
- 4 - prefocused 12v lamp (Lucas No. 162)
- 2 - Photocells (Mullard type 90AV)
- 1 - Pentode (Mullard type EF 91)

The other necessary components for the maintenance of the reader may be obtained from those used for the maintenance of the LGP-30.

The following prints are required for servicing the equipment.

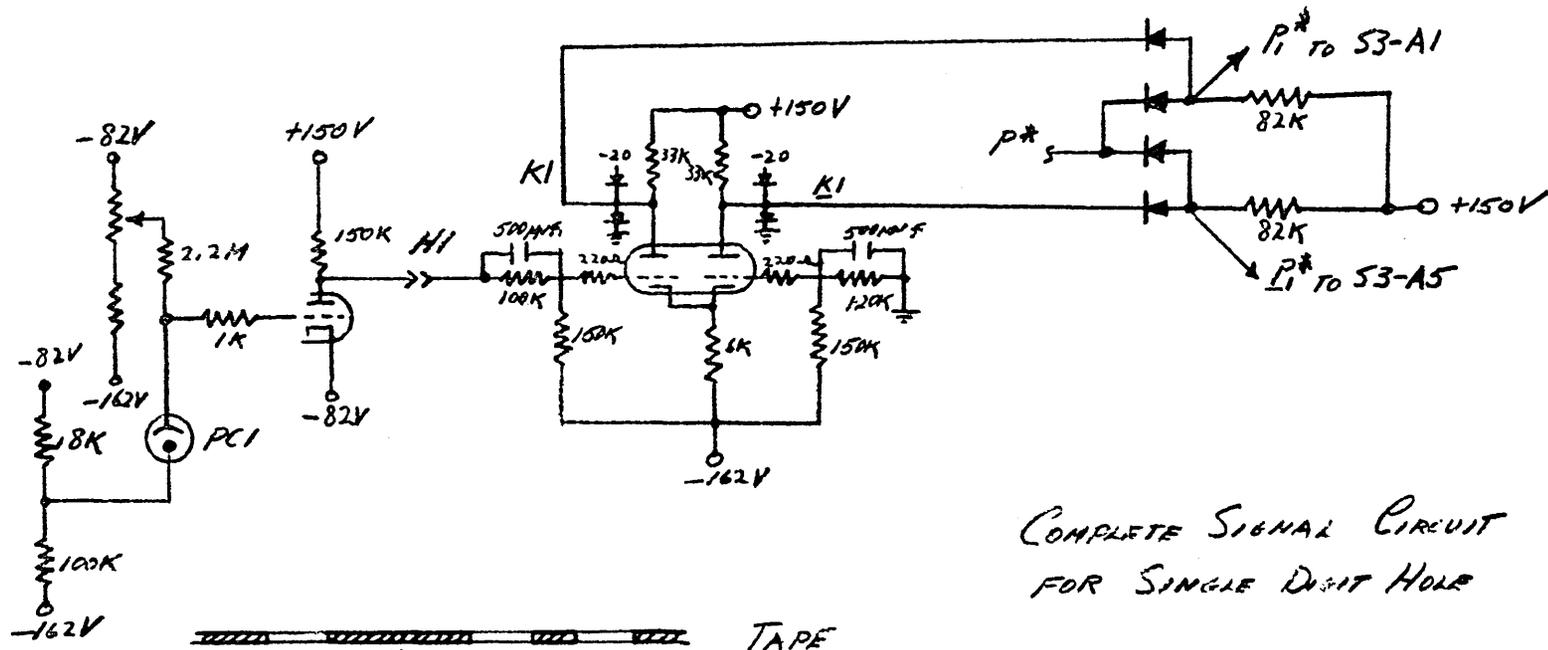
Drawing No.	Title
314974	Schematic - Control Circuits
315023	" - Switch Module Circuits
314919	" - Card - Diode Logic
314925	" - " - Control Circuits
312150	" - " - Inverter

315037	Schematic - Power Isolation
	" - Punch Circuits
315117	Jumper Cable - Reader to Control
315119	" " - Typewriter to Control
315122	" " - LGP-30 to Control
None	Ferranti Mk II Manual

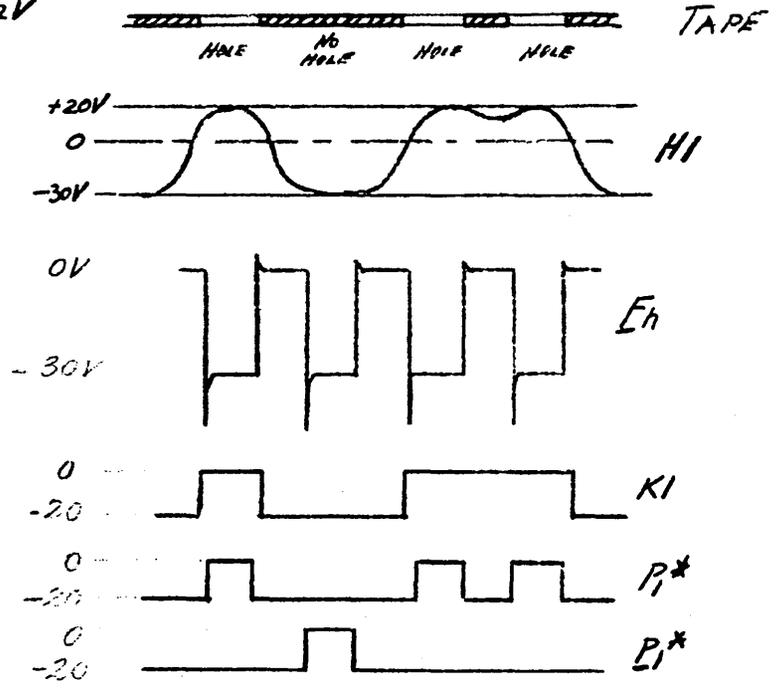


TAPE GUIDE MECHANISM  
AND LAMP HOUSING

Fig. 1

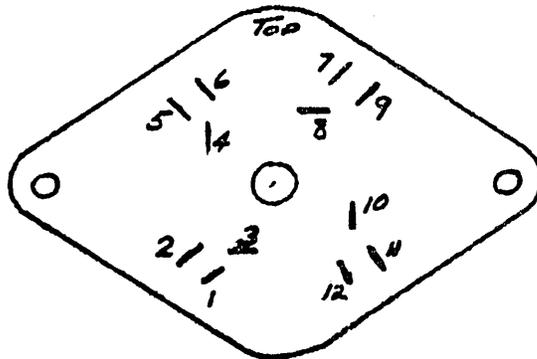


COMPLETE SIGNAL CIRCUIT FOR SINGLE DIGIT HOLE



TYPICAL SIGNALS FROM ABOVE CIRCUIT

FIG. 2



TERMINAL CONNECTIONS OF SWITCHES S3 AND S4  
AS VIEWED FROM THE REAR

TB-1

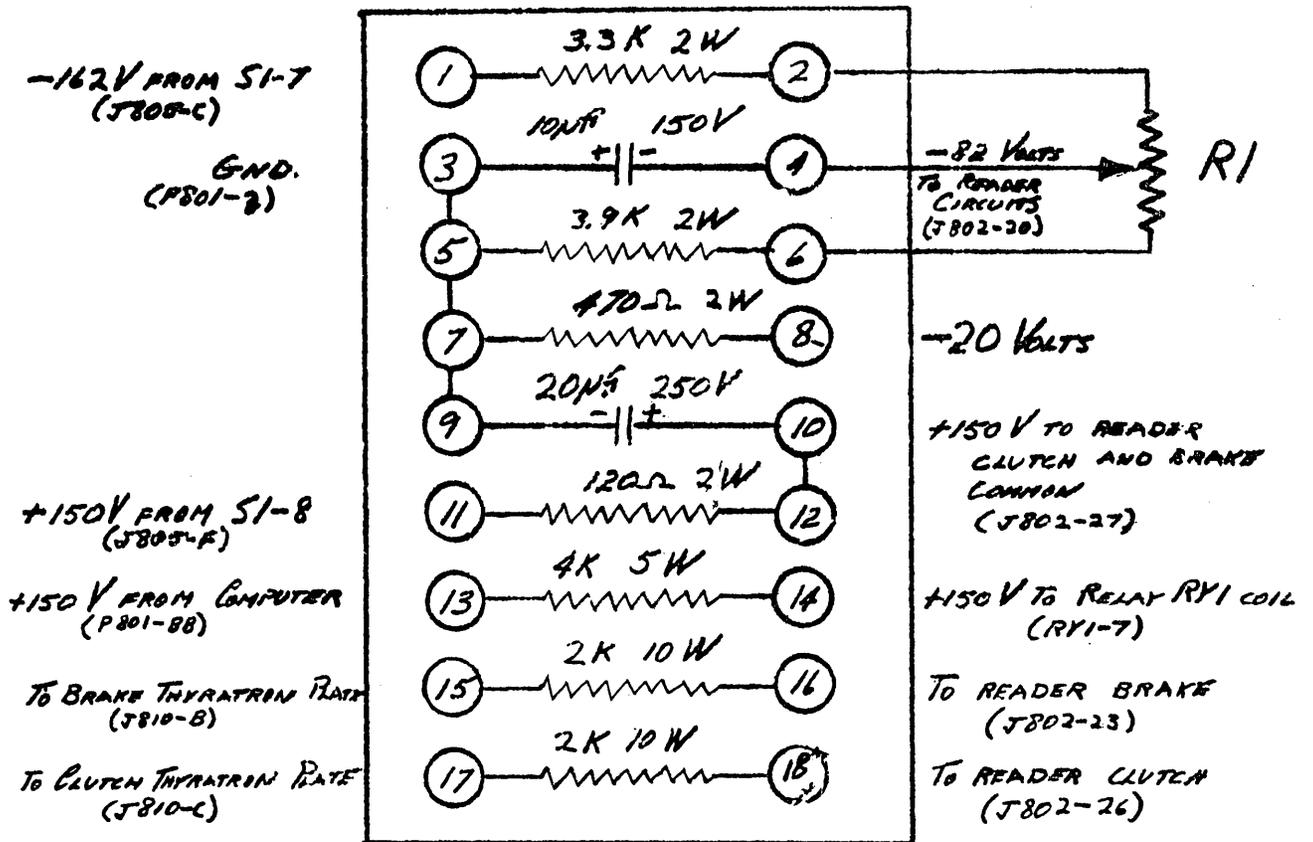
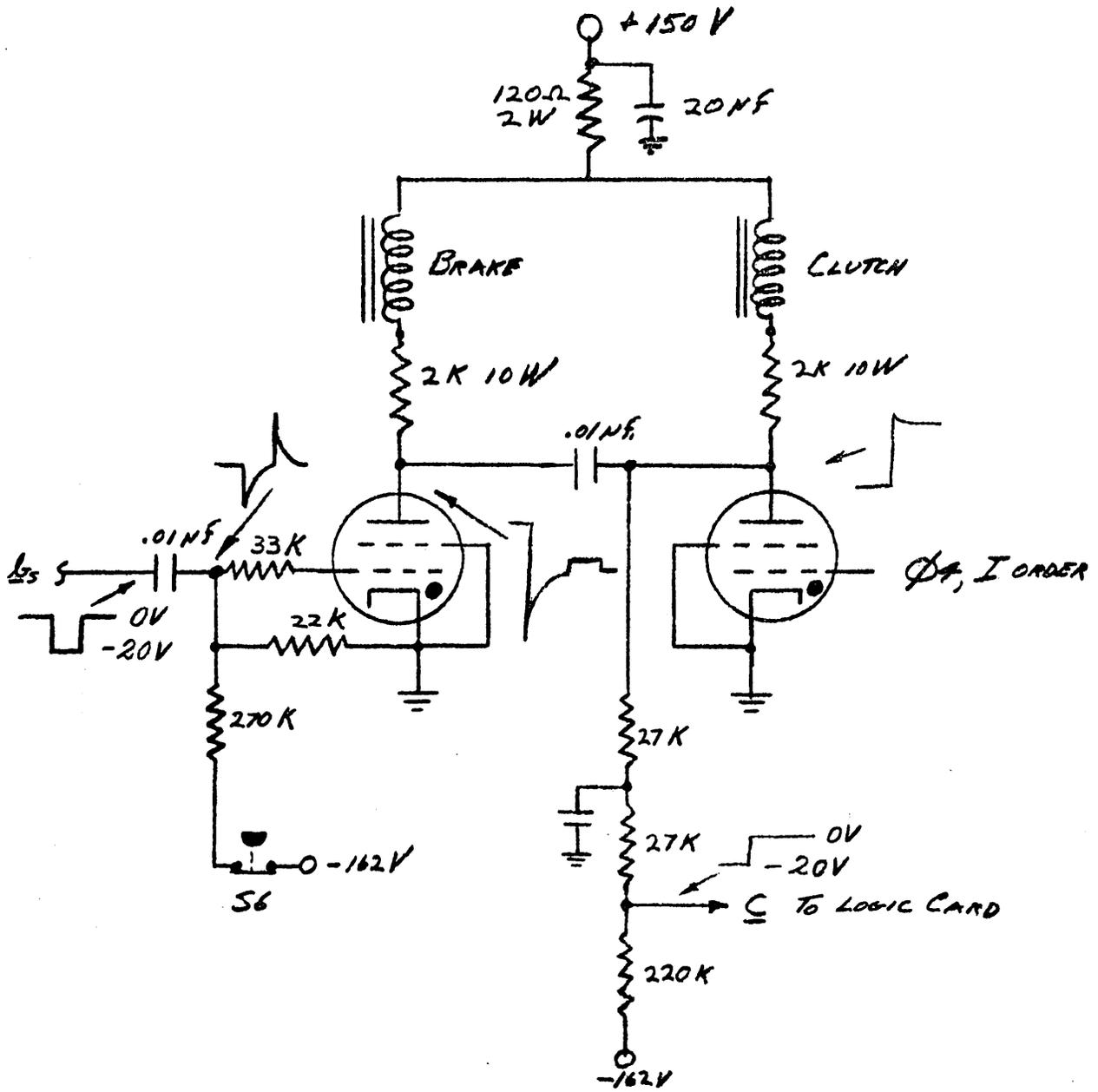


FIG. 3



CLUTCH AND BRAKE CIRCUIT  
FIG. 4

# START SIGNAL CIRCUIT

NOTE: S3D SHOWN IN READER POSITION  
S4C SHOWN IN PUNCH POSITION

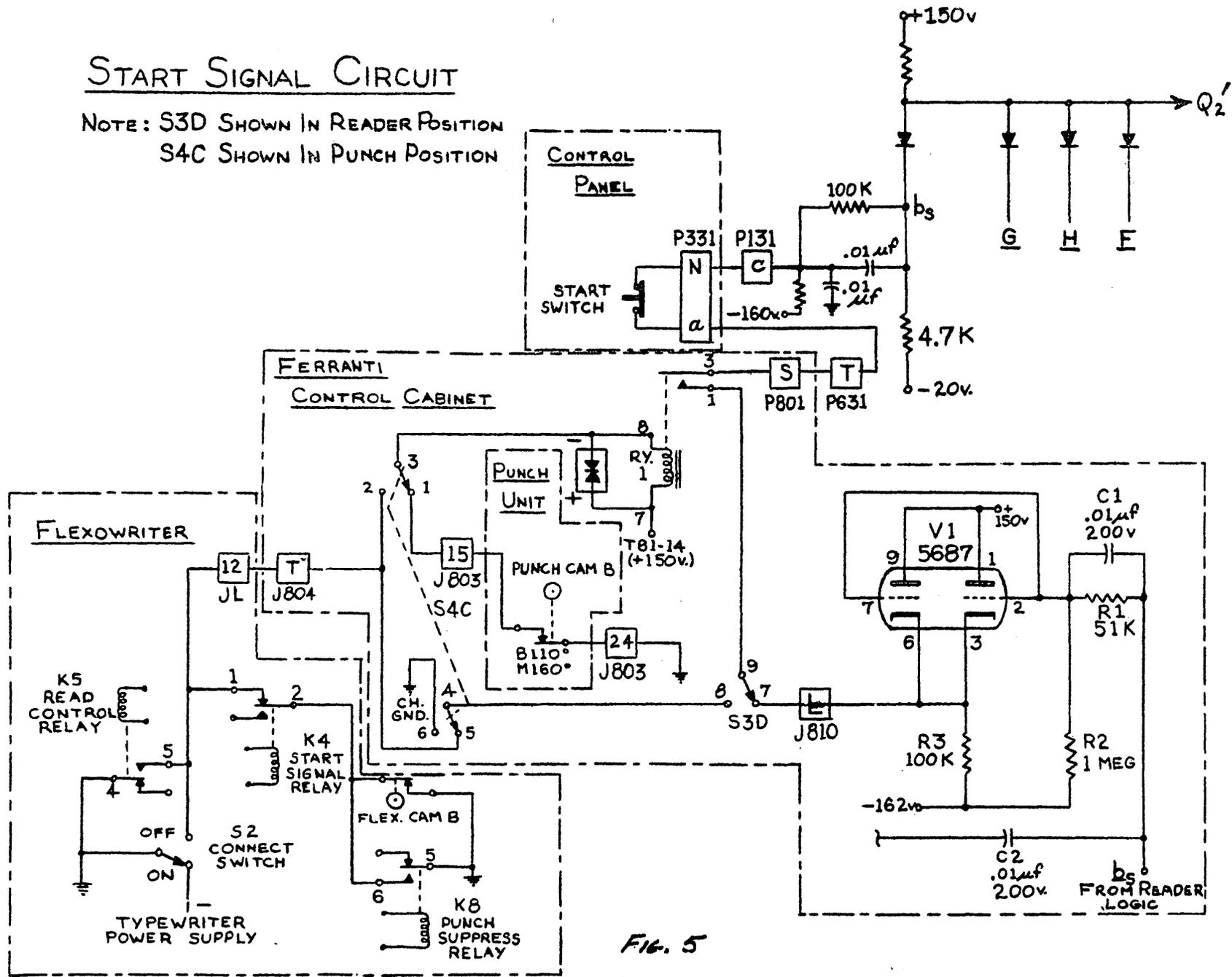


FIG. 5

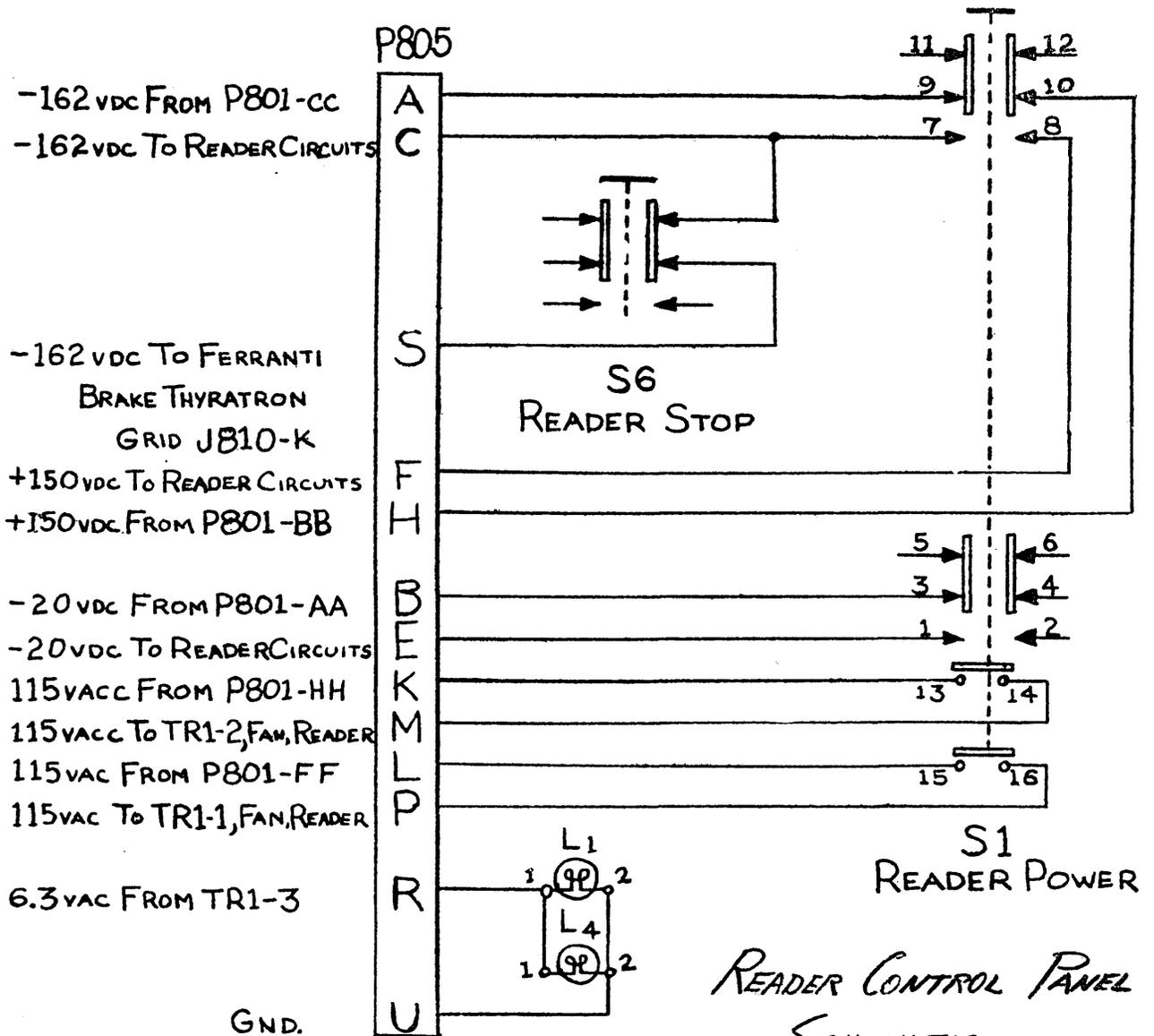
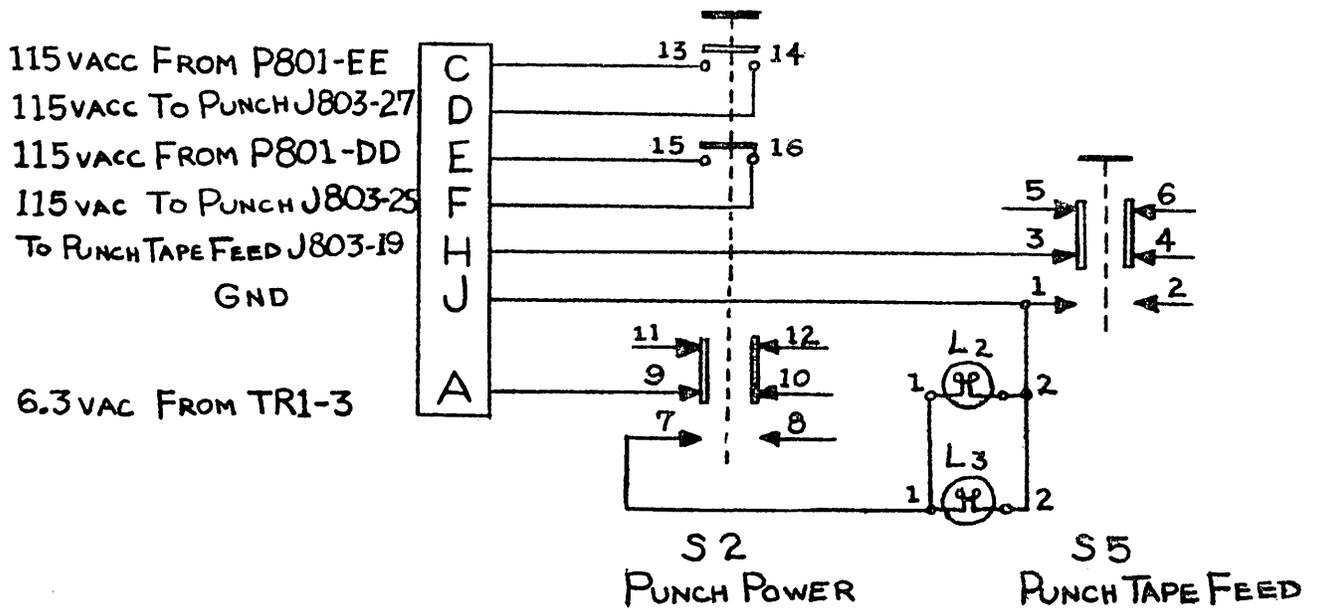
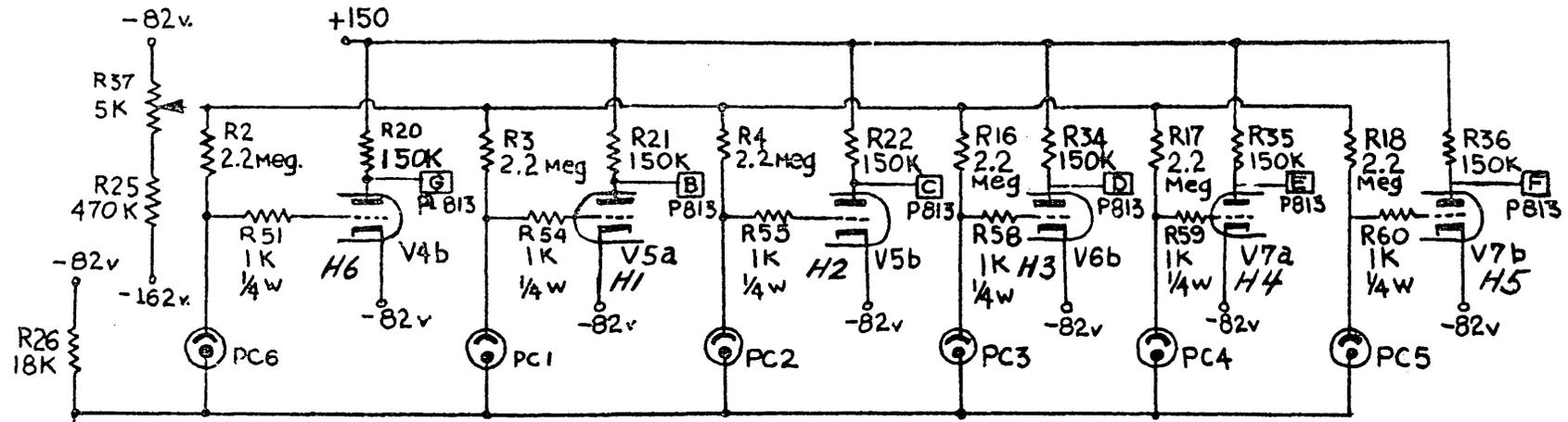
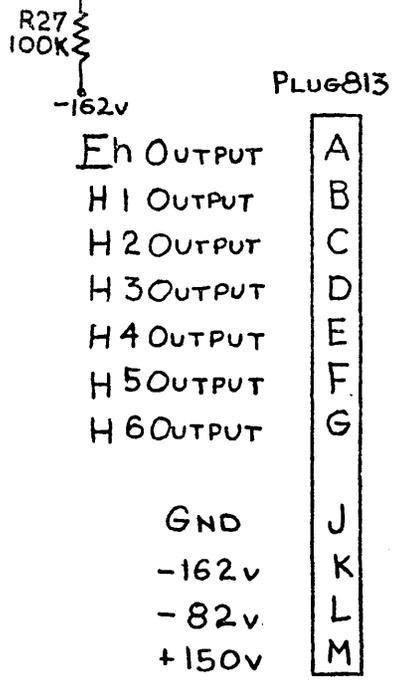


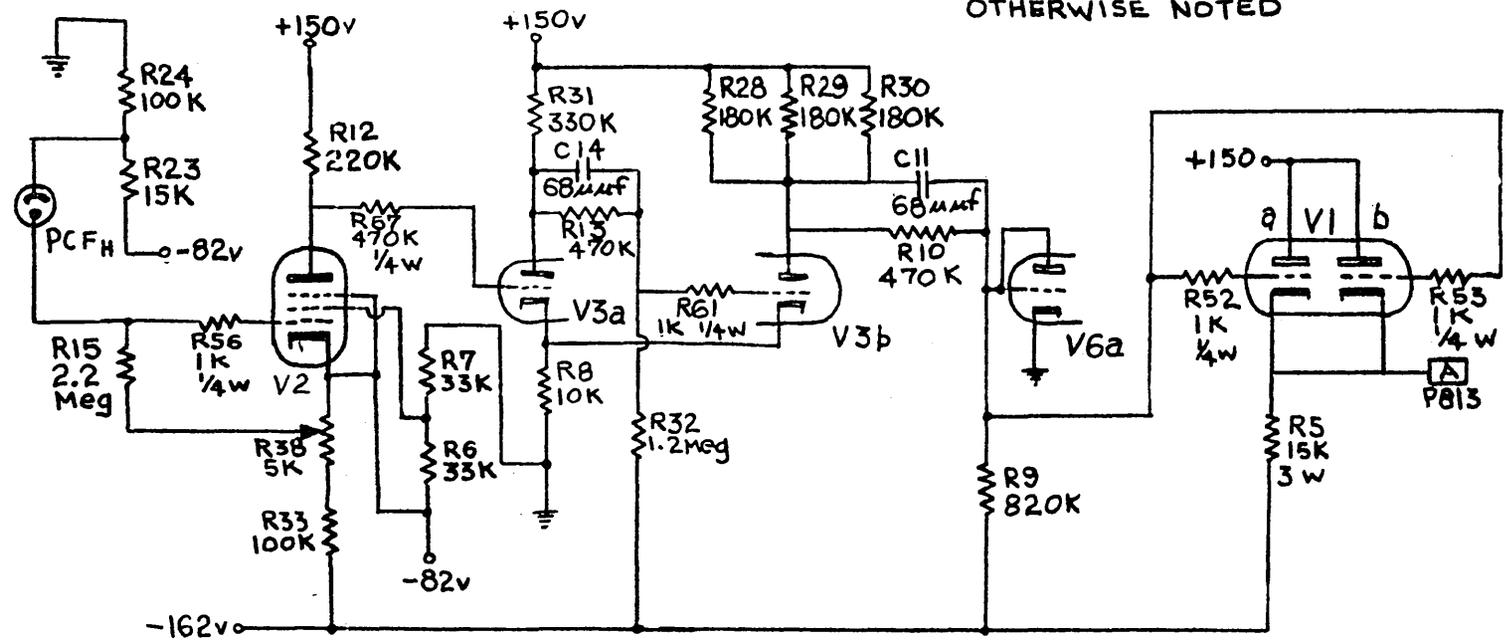
FIG. 6.



ALL RESISTORS 1/2 WATT UNLESS  
OTHERWISE NOTED



PC = PHOTOCELL



READER PHOTOCELL AND AMPLIFIER CIRCUITS  
FIG. 7

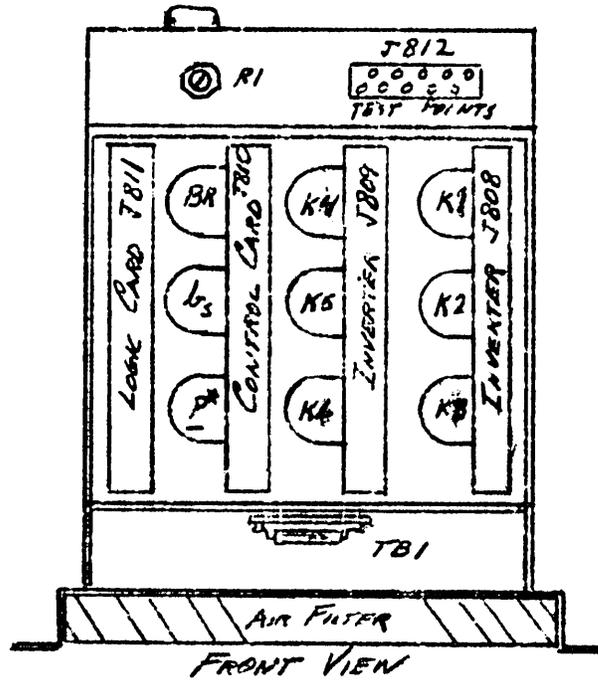
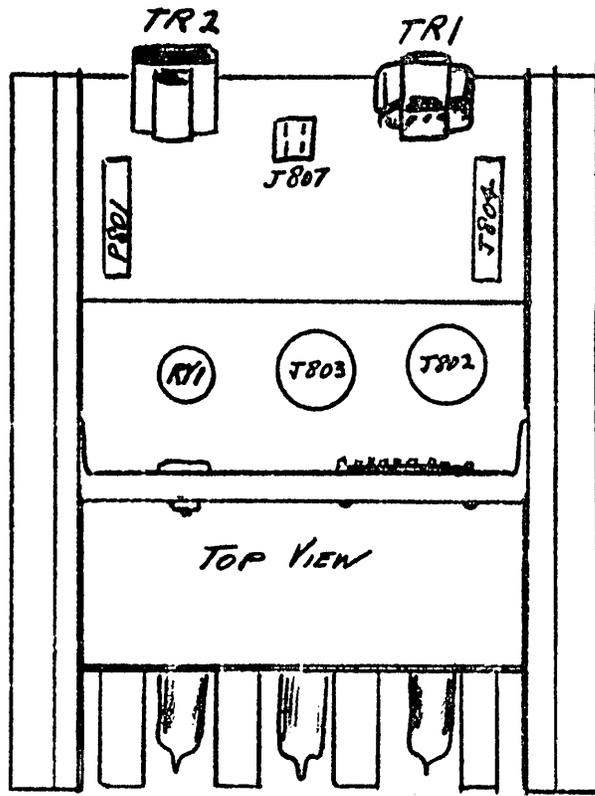


FIG. 8

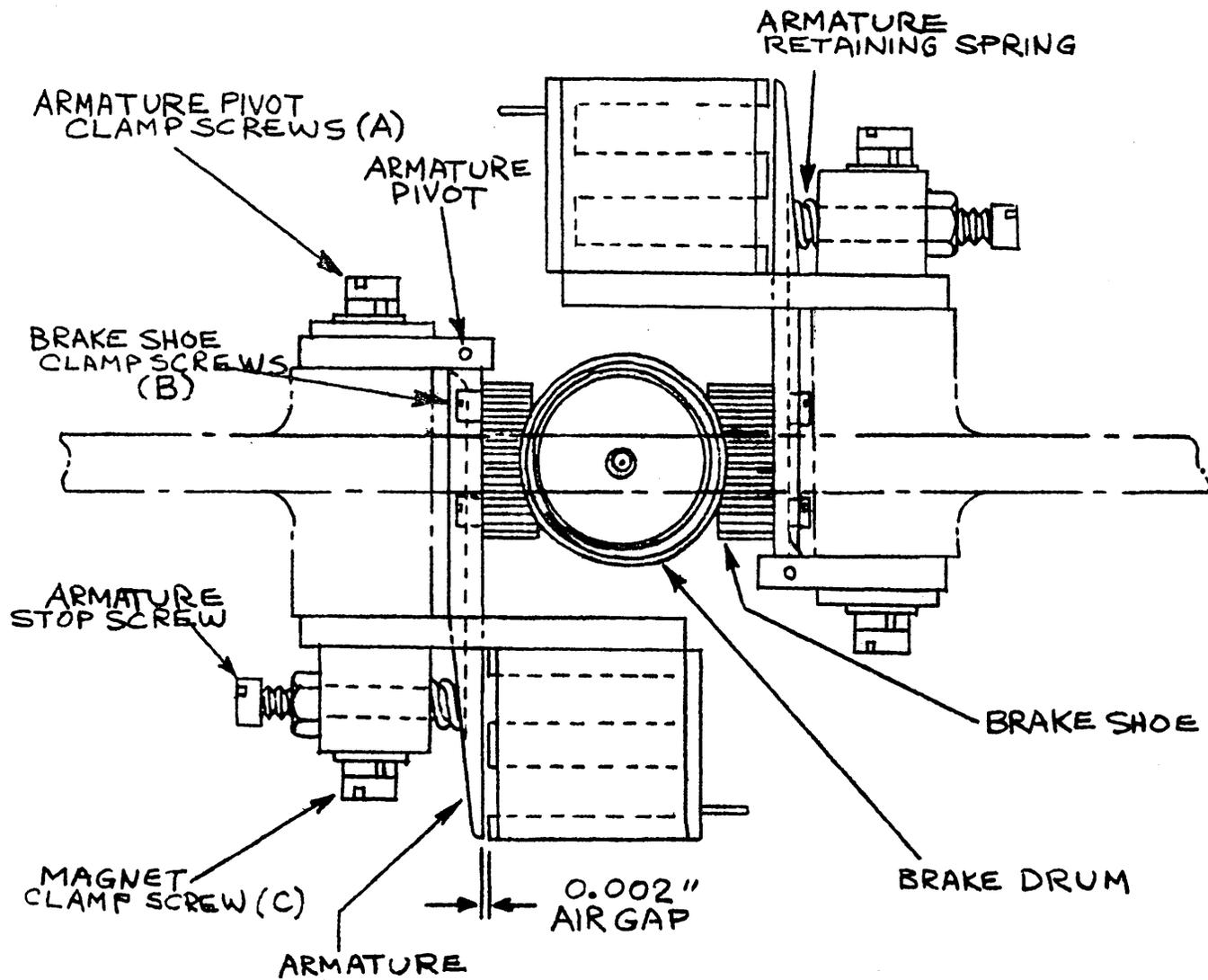
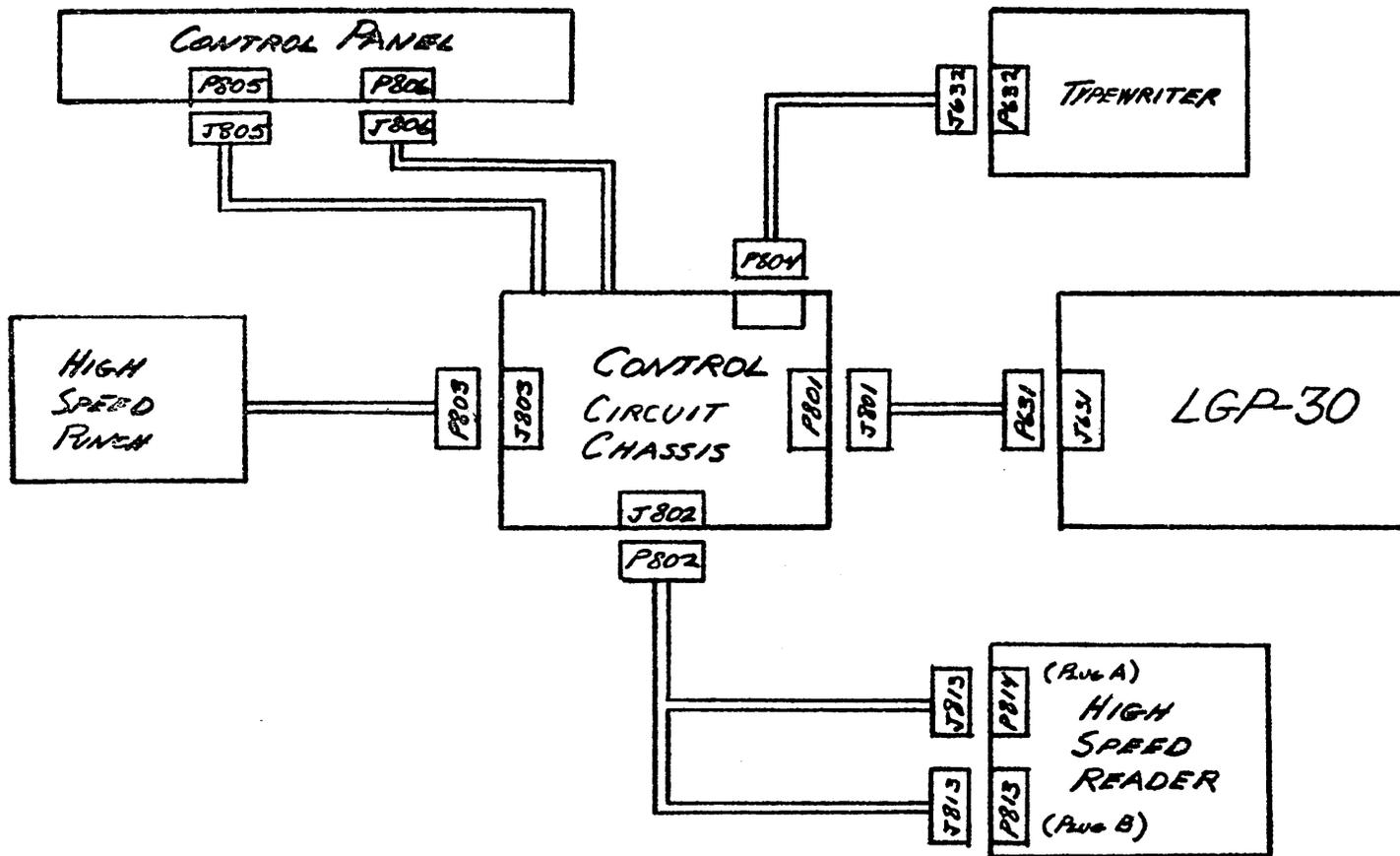


FIG 9. - BRAKE MECHANISM -



CABLE LAYOUT - HIGH SPEED READER

Fig. 10

Ⓛ - LUBRICATION POINTS

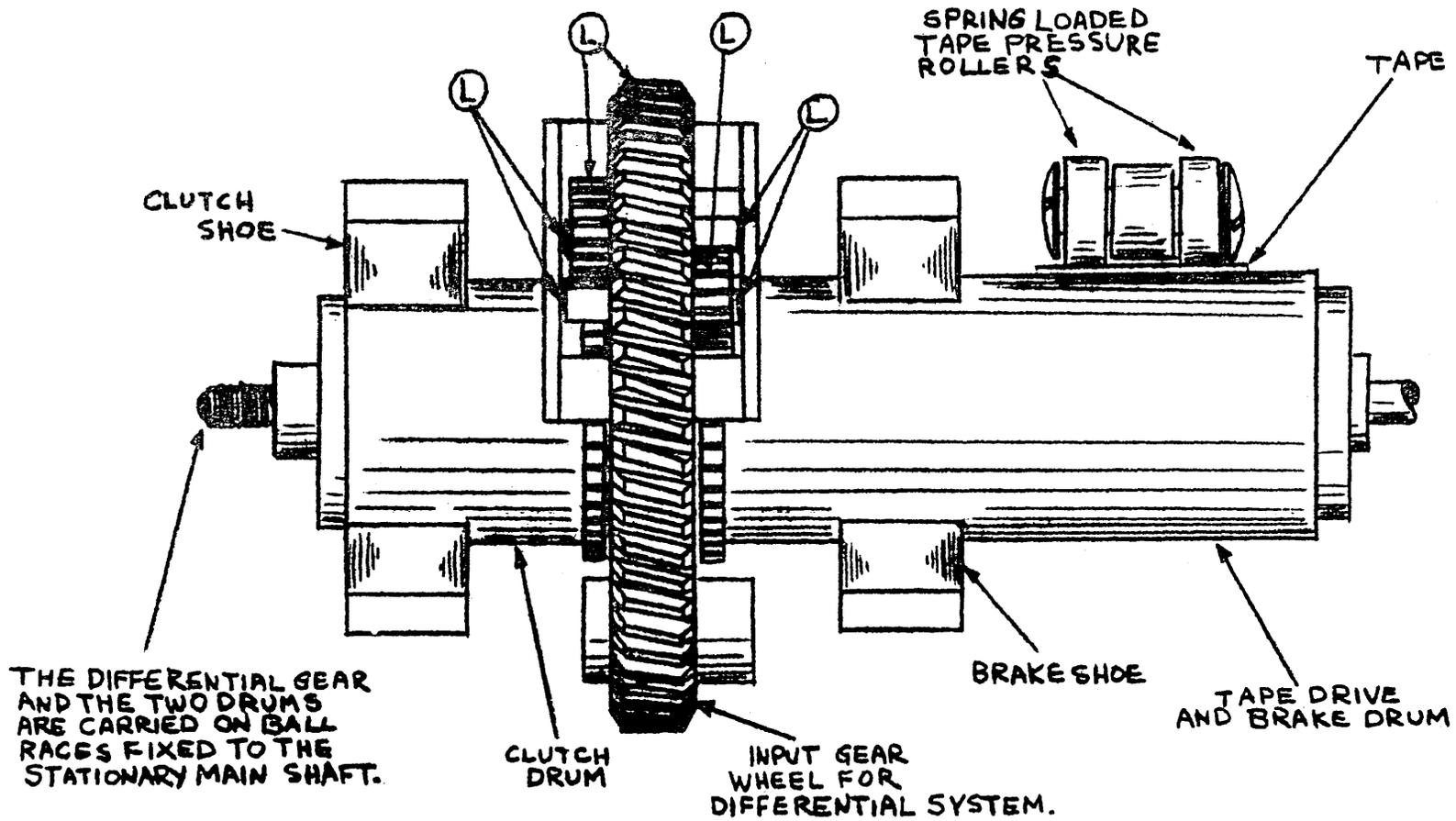


FIG. II - TAPE FEED MECHANISM

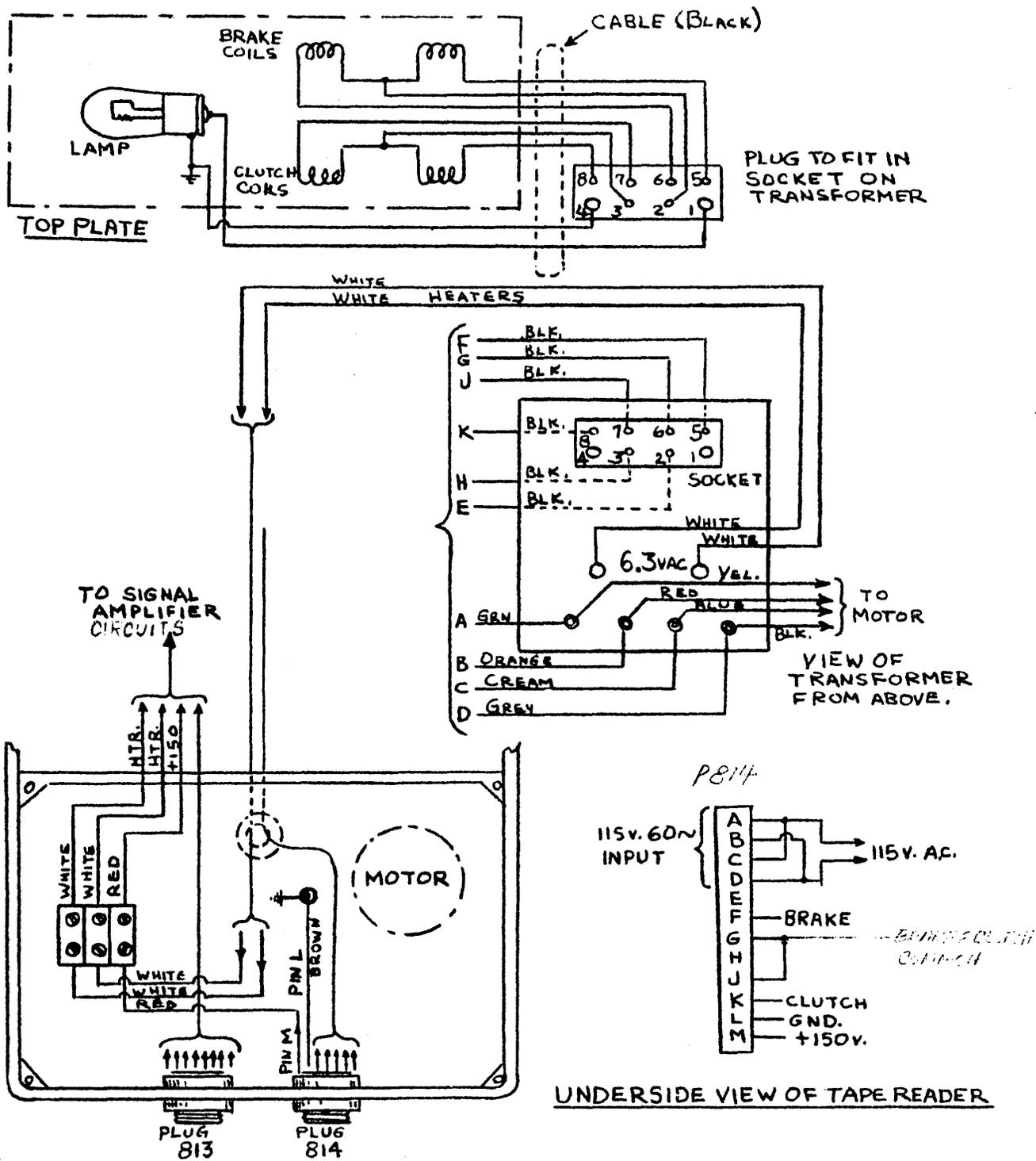


FIG. 12 - READER POWER CIRCUITS