THE circuits for this machine will be studied in three sections; namely, punch unit circuits, D. C. power supply circuits, and electronic computing unit circuits. In all circuit explanations, the location of the various circuit components both on the machine and on the wiring diagram will be stressed. Owing to the newness of electronic computing circuits to most Customer Engineers, the electronic circuits will be analyzed in as much detail as possible.

PUNCH UNIT CIRCUITS

WIRING diagram 213639A shows the power supply, punch unit circuits and the electronic circuits. The timing chart for the punch unit is a part of this wiring diagram. An electronic timing chart will be found on the last page of the manual. The diagram is indexed to facilitate location of circuit components. Before proceeding with the discussion of these circuits, the various terminals used on this diagram will be listed together with an indication of their location on the machine. All terminals are counted from left to right, top to bottom, front to rear, facing the machine.

On machines equipped for 115 volt A.C. operation only, there are twenty terminals for the 115 volt A.C. and 40 volt D.C. connections in the punch unit. These terminals are located on top of the main transformer. Post 1 and post 3 are the 40 volt D.C. supply terminals while posts 7 to 20 are 115 volt A.C. and transformer terminals. Post 2 and 4 are not used. The terminals on the tube power supply chassis are designated by a number preceded by CH. There are ten of these terminals located at the rear of the power supply chassis. Post CH3 represents power supply chassis terminal 3.

On machines equipped for 115-230 volt A.C. operation, all transformers have two primary coils and more terminals are necessary. In these machines there are 24 terminals on the main transformer and 15 on the tube power supply chassis.

The terminals designated as CN, for example CN9, represent the connections on the cable connector. CN9 is the 9 connection on the cable connector on the punch unit, counted as indicated on the wiring diagram, Section 22B. The cable is detachable at both ends, hence, a sub-letter is used to indicate which connector is meant. Every other terminal is used to lessen the possibility of a short across terminals.

Relays and cam contacts can be located on the circuit diagram by means of the location chart shown in Section 17-18 of the wiring diagram. In tracing circuits, normally closed points will be abbreviated by N/C, normally open points by N/O, and the operating strap O/P.

All power is furnished by the commercial supply through the attachment cord which is connected across terminals 7 and 8 on top of the main transformer. The main line sentinel switch turns power to the machine ON or OFF. Most machines made require a 115 volt A.C. supply. However, transformers are available which permit either 115 volts or 230 volts A.C. operation. The power supply circuits for 115-230 volts A.C. operation appear in Section 3 of the wiring diagram, while Section 4 shows the circuits for 115 volts A.C. operation only.

HD3 and HD4 relays are A.C. relays wired directly across the A.C. line from post 9 to post 10. When the main line switch is ON, HD4 is picked up and its points complete a circuit to the primary of the main transformer. The main transformer is protected by two 20 ampere fusetrons. The reason for this arrangement is that no sentinel switch was available to handle the total current demand when this circuit was designed. With this arrangement, HD4 relay points act as a switch, and the sentinel switch protects only the punch drive motor and the tube power supply transformers;

the main transformer is protected by fusetrons. HD3 points open the ground connection when the switch is OFF.

The tube power supply transformer primary connections are made across posts 9 and 10. The drive motor is directly across the main line switch and hence operates on the commercial A.C. supply under the control of HD1 relay. It is protected by the 10.9 ampere element in the sentinel switch. A split plug allows the motor to be disconnected from the machine.

Note that the test lamp outlet is "hot" as long as the attachment cord is plugged in, regardless of the setting of the sentinel switch. The test lamp outlet is protected by 3 ampere glass fuses 12 and 13.

As soon as the main line switch is turned ON, 40 volt D.C. supplied by the selenium rectifier is available across posts 1 and 3. Post 1 is the positive side of the line and post 3 is the negative side. For sake of consistency, wherever possible, *all circuits will be traced from negative terminals to positive.*

Time Delay Circuit

Owing to the necessity of heating the cathodes of the rectifier tubes and the vacuum tubes to operating temperature before putting them in operation, it is necessary to allow an interval of time before starting the machine. To insure full operating temperature, approximately 50 seconds is allowed for heating the tube cathodes. The rectifier tubes in the power supply chassis are gas-filled tubes and will be damaged if the load is applied before their filaments have reached operating temperature. If vacuum tubes are placed in operation before they have been fully heated, the tubes will not be damaged, but erratic operations will result.

The time delay is effected by a thermal delay relay (R5 in machine). One contact strap of this relay is a bi-metal strip, i.e., it consists of two strips of different metal placed one on top of the other and bonded together. These two metals expand at a different ratio when heated and hence the strap will bend. A coil of high resistance wire is wound around this strap to serve as the heating element. The lower strip of metal has the greater expansion rate; therefore, the strap will bend upward when heated, and the contact points will touch to close a circuit to the coil and complete circuits for the operation of the machine. The upper contact point is in the form of a screw tipped with contact metal. This screw provides a means of varying the time interval required for the relay points to close by varying the distance between the contact points. The adjusting screw is normally set to provide 50 seconds delay. An air gap of approximately $\frac{3}{32}''$ will provide a good starting point in setting this adjustment. This time is applicable when starting with a cold machine. Naturally, the time delay will vary if the machine is turned ON and OFF several times in a few minutes because the heating unit will not have time to cool.

The time delay relay operates on the regular 40 volt supply of the punch unit furnished by the selenium rectifier. With the main line switch ON, a circuit is complete to the time delay heating element as follows: post 3, terminal CNp5, through ground cable in the electronic unit and back to CNp13, through heater element, N/C points of R5BL, to R2A N/C, P16, P1, post 1. Also, as soon as the main line switch is closed, R2 coil will be energized in parallel with the heating element. The purpose of R2 and the cable jumper will be explained shortly.

When the heating element has sufficiently heated the bimetal contact strap, which is one strap of R5A points, the R5A points will close, and a circuit will be completed to the coil of R5 as follows: post 3, terminal CNp5, through ground cable to CNp13, through R5 coil, R5A contact, and out to post 1.

Relay 5 will then pick up and its BL and BU points will transfer. When R5BL transfers, the circuit to the heating element is opened and a holding circuit for R5 is completed.

When R5BU points close, the HD2 relay will be energized since R2 is already energized and the R2A contacts transferred. The circuit is as follows: post 3, terminal CNp5, through ground cable, power switch in electronic unit (Section 22A), back through cable to post CNp15, through HD2 coil, R5BU, R2A N/O to P16, P1, and post 1. The HD2 contacts are in the primary of the tube power supply transformer and are shown on the power supply circuit diagram. Power for the tubes in the electronic unit becomes available as soon as HD2 is energized.

Start Circuit and Bias Interlock

In order to insure that the tube power supply is functioning properly, the starting of the machine is under the control of start circuit interlock relay R6 and bias interlock relay R4. R4 must pick up to complete the anode power supply circuit and also to pick up R6. The bias interlock is necessary to insure that the grid bias voltage is applied before the anode voltage is applied; otherwise, excessive anode current will flow through the tubes and overload them before the control grid comes into operation. Eventually this will damage the tubes. When R4 is picked up, the R4 contacts complete a circuit to R6, which is connected across the grid and anode voltage supplies; hence R6 cannot pick up unless the anode voltage is applied to the vacuum tubes.

The voltage output terminal CH3 (Section 4A) on the power supply chassis is the ground terminal, or point of reference for all voltages, and is considered the zero point for all voltage references. Note that CH3 is connected to post 3 which means that post 3 may be considered as a zero voltage reference point. Terminal CH4 supplies plus 150 volts, i.e., 150 volts *above ground,* while CH2 supplies minus 100 volts, or 100 volts *below ground,* making the voltage between CH2 and CH4, 250 volts. Terminal CH1 supplies minus 250 volts.

Each of the power lines is protected by a 2 amp glass fuse. Fuse 9 protects the −250 volt line, fuse 10, the −100 volt line, and fuse 11 the +150 volt line.

Note that the coil of R4 is connected directly across the −100 volt supply (bias supply), between fuse 10 and the ground connection at the relay common. The circuit for picking up R4 is as follows: post 3, fuse 6, to R1, R3, R7, through R4 coil, to fuse 10. This relay will then remain energized as long as the bias voltage is applied. Bias voltage is furnished to the electronic unit through the cable connector CNp3.

When the R4A points close, a circuit is completed to supply +150 volts to the electronic unit through 2 amp fuse 11, R4A, and the cable connector CNp7. The R4A contacts also complete the following circuit: fuse 11, R4A, R6 coil, three 25,000 ohm resistors in parallel, to fuse 10. Thus, R6 remains energized as long as R4 is picked up and as long as the +150 volt supply is available.

The purpose of the three 25,000 ohm resistors (net resistance approximately 8000 ohms) is to create a sufficient voltage drop across the 250 volts between fuses 11 and 10 so that the proper voltage is applied to the coil of R6. The purpose of the capacitor across the R4A contacts is to absorb the arc across R4A in case a fuse blows, etc.

Once R6 is picked up and the R6A contacts close, the machine is ready to start. The green pilot light indicates that the punch is ready to start. The circuit to light the pilot light is as follows: post 3, through pilot light, post 5, die contact, post 6, knockoff bar contact, R6A contacts, to center strap of R2A, P16, P1 and post 1. The knockoff bar contact and die contact are both safety contacts. The die contact is closed only if the die is properly in place with its latching bars in position in the grooves in the side frame. The knockoff bar contact is closed only if the knockoff bar in the magnet unit is properly in place.

Start Interlock Circuits (Gang Punching Only)

In case it is desired to use the punch unit for gang punching only, it is desirable to disable the start interlock circuits and open the tube power supply circuit, although it is not necessary. This can be done by disconnecting the cable at either end.

If the cable is to be disconnected at either end, it is recommended that the main line switch first be turned OFF. With the cable disconnected, the circuit to R2 and R5 coils is opened. If R2 and R5 fail to pick up, the HD2 relay cannot pick up, and no power will be furnished by the power supply chassis to pick up R6. Note, however, that the N/C side of the R2A contacts provides a path around R6A to post 1.

Start and Running Circuits (No Cards in Machine)

It is most important to bear in mind, when tracing any circuit or set of circuits, the objective of the circuit. The objective of the start and running circuits is to control the feeding of cards through the punch. This is done by starting the motor, causing the punch clutch to engage, and then keeping the machine running once cards have reached the second set of brushes. The motor is under the control of HD1 relay which in turn is controlled by R10. The punch clutch is also under the control of R10; hence it is obvious that R10 must be energized to cause the motor to run and to cause the punch clutch to engage. Depressing the start key and closing the contact will cause R10 to pick up (assuming R6 is picked up). R10 will remain energized as long as the start key is held depressed through the following circuit: post 3, through fuse 6 to R1P, R1H, HD1, through R10 coil, through start key contact, stop key contact, R57B contact, post 5, die contact, post 6, KO bar contact, R6A contact, to center strap R2A, to P16, P1, post 1.

The closing of the R10 contacts simultaneously completes a circuit to the P-clutch and HD1 motor relay. Circuit for the P-clutch is as follows: post 3, fuse 5, punch clutch coils, R10BU, P16 cam contact, to P1 and post 1. This circuit energizes the P-clutch magnets, which in turn unlatch the clutch pawl so that it may engage the ratchet at D on the index.

The circuit to the motor relay is as follows: post 3, through fuse 6, 40 volt HD1 coil, R10BL contacts, and on to post 1 as in the start key circuit. The HD1 contacts complete a circuit to the drive motor and keep the drive motor in operation as long as R10 remains energized. The 2mfd capacitor across the HD1 contacts suppresses arcs which might cause trouble in the electronic circuits. This capacitor is not shown on the wiring diagram, 213639A.

The motor drives the continuously running mechanisms; at D, the P-clutch engages, and all units go into operation. Shortly after the P-clutch engages, the circuit to the P-clutch magnet is broken by P16 at 14 on the index. Remember, from the mechanical operation of the clutch, that once the clutch engages it must make a complete revolution before relatching. If the start key is held closed for more than one cycle, P16 makes again at 12.3 on the index to energize the P-clutch magnet and prevent relatching of the pawl.

In order to prevent the machine stopping part way through a cycle when the start key is released, a P-cam provides a hold circuit for R10 to insure the completion of any cycle during which the start key may be released (or when the machine stops owing to any other reason). The start relay hold circuit is completed through P19 as follows: post 3, through fuse 6, R10 coil, R10AL, P19, die contact, and on to post 1 as in the start key circuit.

Start and Running Circuits (Cards in Machine)

The running circuits are designed to keep the machine running automatically once cards have reached the second set of brushes and to stop the machine for any of the following reasons (1) when the last card runs out of the magazine, (2) when the stacker is filled to capacity, (3) when an error is made in checking, or (4) when any card fails to advance to the die or to the punch brushes 2 (read for gang punching and checking).

Card lever contacts are provided to signal the presence of cards in the magazine or at any of the stations through the machine. A stacker stop switch signals a full hopper, while a relay is provided to signal an error when checking.

As soon as cards are placed in the hopper, R3 will pick up as follows: post 3, through fuse 6, through R3 coil, hopper card lever contact, to post 1. The R3A contacts are in the R10 running hold circuit.

The other card lever contact relays R1, R7, and R8 are energized through their corresponding card lever contacts when the contacts are closed by the cards.

After the cards are placed in the hopper, it is necessary to hold the start key depressed through three complete cycles before the machine runs continuously.

After the third cycle, the machine runs automatically. The card levers are designed so that their contacts do not open between cards; therefore all card lever contacts remain closed once cards start through the machine. As a safety precaution, R1 is held by P33 between cards, and R8 is held by P16 between cards. This insures the card lever relays remaining energized even if the card lever contacts open for an instant when corner cut cards are used.

All that is necessary to keep the machine running continuously is to keep R10 energized. This is done through the following circuits once cards reach the second set of punch brushes: post 3, through R10 coil, R10AU, R7BL, R3A, R1AL, stacker stop switch, stop key contact, R57B, die contact, KO bar contact, R6A, to R2A o/p and post 1. This circuit is complete until any one of the contacts is opened.

Reading Brush Circuits

R8B contact is used in the read for entry and control brush reading circuit, while R7A contacts are similarly used in read for gang punching and checking brush reading circuit. The purpose of these contacts is to prevent readings from the brushes when no cards are in position at the brushes.

P1 through P4 (Section 7A) serve as circuit breakers for both sets of brushes. P1 and P2 control the making time at the line of index while P3 and P4 control the breaking time at three teeth past the line and provide CB pulses of 3-tooth duration.

The purpose of the first set of brushes is to read the card for entering the factors in the various counters and for X control, group multiplier control, sign control, while the purpose of the second set of brushes is to read the card for checking or for gang punching operations. The complete circuit for reading into a counter will be deferred until the electronic circuits are discussed but the portion shown on the punch unit diagram will be traced. To simplify the tracing of this circuit it will be necessary to depart from the rule established and start at the positive terminal. The circuit for reading into any one position of the multiplier counter is as follows: post 1, through P1, P2, P3, P4, R8B, common brush, contact roll, through hole in card, individual brush, brush hub, entry hub for multiplier counter (Section 15A), through factor reversal relays, cable connector and cable to electronic counter.

In gang punching, the punch hubs are connected to the second set of brushes, and a punch magnet is energized when a hole is read in the column to which the punch magnet is wired. The circuit is as follows: post 3, through R12B (Section 15B), punch magnet common connection, punch magnet coil, punch hub, wire to hub, read for gang punching brushes (Section 7A), individual brush, through hole in card, contact roll, common brush, R7A contacts, P3, P4, P1, P2, to post 1.

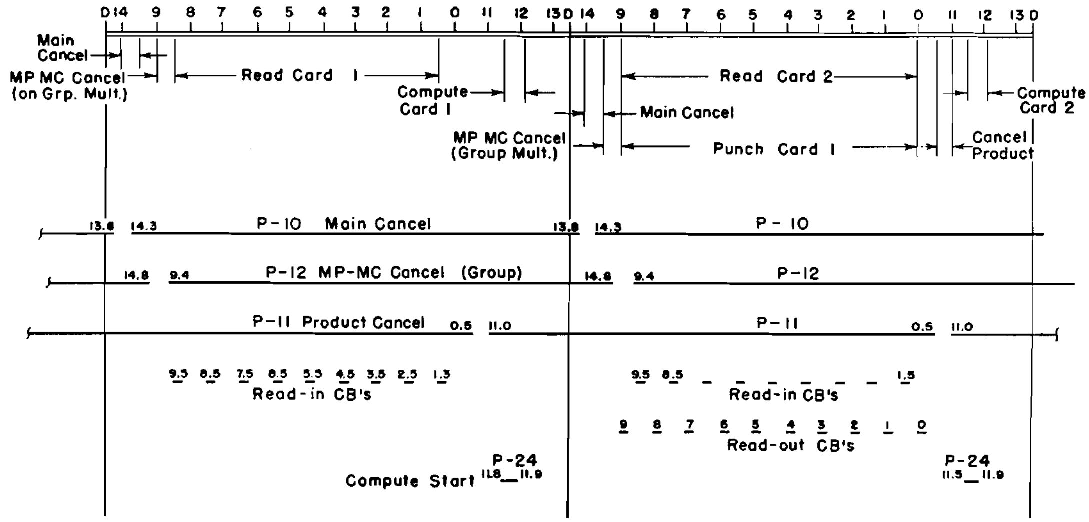

Figure 48. Timing Chart for Computing Operations

Electronic Computing Control Circuits

The circuits in the punch unit for controlling the electronic computing unit are primarily timing circuits to time the computing operations to the movement of the cards through the punch unit. No attempt will be made to trace complete circuits for these controls; only the general function of each timing cam will be given. Figure 48 is a timing chart showing the relationship between the computing functions and the card movement through the punch unit.

Electronic counters are restored to zero by opening the −100 volt grid bias circuit by means of a P-cam contact. Other circuits are similarly restored to normal by opening a contact. P10 (Section 5A) is the main cancel contact and controls the restoration of all circuits except the product counter to normal. This restoration occurs at the very beginning of a cycle before any figures are read from a card. When group multiplying, R26 is picked up, R26A points transfer, and either the multiplier or the multiplicand counter, depending upon the setting of the factor reversal switch, is cleared by P12 under further control of R27-3 points. P12, which opens slightly after P10 closes, is effective only during cycles that R27 is picked up.

The product counter cannot be cleared until after punching is complete, consequently the clearing is separately controlled by the product cancel cam contact P11, which is under further control of R19A. P11 opens at 0.5, and the product counter is cancelled or cleared, provided R19, the product summary relay, is not picked. When it is desired to store and accumulate products, R19 is picked up and P11 is no longer effective.

The reading of factors into the electronic counters occurs at mid-index points under control of P5 through P8 (Section 8A); P5 and P6 provide read-in pulses of three-teeth duration at mid-index points. P17 permits only 9 of these pulses to be used. P7 and P8 provide pulses of three-teeth duration at index points to control the electronic read-out circuits. P18 allows 10 of these pulses to be used. The reason for the two sets of CB's will be apparent in the discussion of the electronic read-in and read-out circuits.

Once factors are read into the counters from a card, it is necessary to start the computing section. This is timed by P24 cam contact which provides a pulse to start computing at 5 teeth past 11 on the index if R1BU points are closed. R1BU prevents computing operations in case the punch is running without cards.

Read-out is also under the control of P5 through P8 except that read-out pulses are index line pulses. Also, read-out is under further control if R1BL (die card lever relay), R19B (product summary relay), and R29AL(group multiplier relay). If any of these three relay points are open, the product cannot be read from the electronic unit to the punch.

Read-out is further controlled by the P14 cam contact (Section 4B), which applies anode potential to the read-out power tubes only during the 9 through 0 punching time of the cycle. The electronic portion of the read-out circuit is reserved for the section on the electronic computing circuits; only the portion on the punch unit will be covered. Read-out pulses from the electronic unit come to the punch under the control of P7 and P8 through the cable and to the hubs labelled PRODUCT (Section 15B). Normal wiring for punching the result is from the PRODUCT hubs to the PUNCH hubs. The circuit for energizing a punch magnet from the product counter is as follows: post 3 (Section 5B), through R12B (Section 15B), punch magnet common, through punch magnet, hub, wire, to hub marked PRODUCT, to cable connector, through cable to electronic unit, back through cable to CNp28 (Section 4A), P14, to +140 volt terminal.

Punch Suppression

If it is desired to suppress punching in a card, the card is either X-punched or punched with a control digit in a specified column. The control punching then causes the pickup of R12 to suppress punching on the cycle following.

R15 (Section 9B) is the X relay which picks up from 0.3 through 11.3 of each cycle under control of P37. Points of R15 are used in the X pickup circuits of various relays. For example, R15AU is in the X pickup circuit of R11 (Section 8B), so that R11 can pickup only on X's if the X pickup is wired from the first set of brushes (read for entry and control). If it is desired to pick R11 on other digits, the D pickup hub is wired from the first set of brushes.

The sequence of operations for punch suppression is shown in Figure 49. When R11 picks, the R11A points close to hold R11 energized through P21 until 14.5 of the next cycle. The R11B points establish a circuit to pick R12 under control of P22. If the punch suppression device is wired to suppress on X's, R12 will pick up at 13.6, provided R11 is already energized. R12A points close to hold R12 through the R12H coil until P23 breaks at 13.4 of the same cycle. R12B is in the punch magnet common circuit so that no punching can occur as long as R12 is energized.

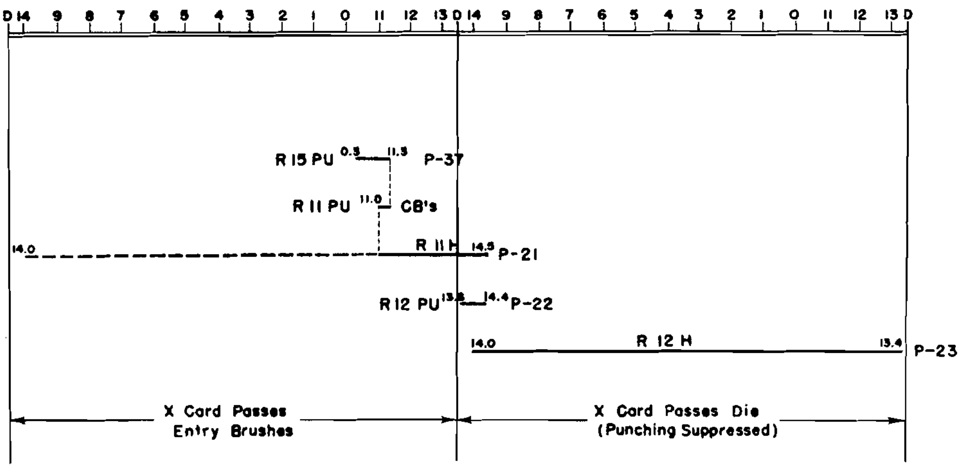

Figure 49. Sequence of Operations on Punch Suppression

It is obvious from the circuit that if the punch suppression feature is wired for N suppression, R12 will pick up every cycle that R11 is *not* picked up. Therefore, punching will be suppressed when there is no X (or digit) punched in a card.

The punch suppression feature can be used to perform group gang punching operations, that is, information in interspersed master cards can be punched into the detail cards following the master. Either the master cards or the detail cards can be X (or digit) punched.

Product Summary

Often it is desired to accumulate several products before punching. This permits special operations, such as crossfooting on two cards, punching the sum of several products, etc. To accomplish this, it is necessary to prevent reading out and clearing of the product counter. The product summary feature has the same type of controls as punch suppression, i.e., X or digit pickup and X or N control. To place the product summary in operation, a jack must be placed in the ON position of this switch. This causes R19 to be picked up as long as R18B points are closed. R18 picks under the control of R17, which in turn picks under control of an X or digit punching. The X or D hubs of the product summary device are wired to the first set of brushes (read for entry and control). The X hub is under control of R15BL points so that only X's can energize R17.

Once R17 is picked, it is held by the R17H coil through R17A and P21 until 14.5 of the next cycle. Then with R17B transferred, R18 picks when P22 makes, provided X control is being used. R18 holds through R18H coil, R18A, and P23 until 13.4 of the cycle following the reading of the X (or digit). During the cycle that R18 is energized and R18B points are open, R19 cannot be energized. When R19 is in a normal position, R19B points (Section 8A) are closed to permit read-out from the product counter, and R19A points (Section 5A) are open to permit cancelling the product counter when P11 opens. Thus, an X or digit punching will cause normal operation when set for X control.

If the product summary is set for N control, R18 picks every cycle that no X or digit punching appears and normal operation continues until an X or digit punching appears. An X or digit will cause progressive addition of products and suppression of punching when set for N control.

A blank card with the proper control punching must precede a product summary run if the machine has just been turned ON. Otherwise, the first group may be over because of the random figures which might set up in the product counter when the switch is turned ON. Remember that on normal multiplication the product counter is cleared before the first computation, whereas on a product summary run, it is not.

Product Overflow

Often the number of columns set aside on a card for punching the product of a multiplication is not large enough to permit punching the largest products. However, if only a very small percentage of the total number of cards exceeds the capacity of the field, it may not be worth increasing the size of the card field and thereby limiting the number of columns available for other punching. To take care of such cases the product overflow feature is furnished on this machine.

To place the product overflow feature in operation, the product counter position *next to* the highest order wired to punch is wired to the product overflow entry hub. Observe that P38 cam contact (Section 9B) is in this circuit and that P38 will permit any impulse from *9* through *1* to pass and pick up R16. As long as the product counter position wired to product overflow contains *0*'s, nothing happens. Any digit from *1* through *9* in this position causes R16 to pick. R16 then holds through its R16H coil, R16AL, and P21 cam contact. R16AU points complete a circuit to the error light and error relay R57 (Section 11B), so that the machine will stop and indicate with a red light that the product just computed and punched exceeds the capacity of the card field.

Since the error light is used for other error signals, it is desirable to distinguish between errors and overflow products. This is accomplished by punching a 12 in a card in which the product exceeded the card field capacity. To punch the 12 the product overflow 12 hub is wired to any punch magnet, and a 12 hole will punch under control of P36 (Section 9A) provided R16B points are closed. With this arrangement, a card is examined after an error light and if a 12 hole is punched, it is apparent that the error was due to an overflow product. This card can then be handled manually.

Factor Reversal and Check Circuits

Multiplication is checked by re-multiplying with the multiplier and multiplicand factors reversed, then checking for double punchings or blank columns by means of the double punch and blank column detection circuit. This checks the multiplication, because if a different answer is obtained on a check run than was obtained on a multiplying run, the card will be double punched in some column. The check circuit also checks for failure to punch during the first multiplication run and again checks for blank columns during the check run. An error will cause the machine to stop and the error light to glow. Before restarting the machine, the double punch reset push button must be depressed to extinguish the error light.

Factor reversal is accomplished by switch control to permit rapid change-over from one setup to another. When the factor reversal switch is ON, relays R21 through R25 are picked up and remain energized as long as the switch is ON. R21, R22, and R23 are used to reverse the entry to multiplier and multiplicand counters so that the factors normally entering the multiplier enter the multiplicand and vice versa. R24 reverses the multiplier and multiplicand read-in control and cancel circuits on a group multiplying setup, while R25 is used in connection with sign control.

One control panel switch is provided for each position of blank column checking. Double punch checking may be used alone or in combination with blank column checking. Blank column checking cannot be done alone, but must be used in combination with double punch checking. The product field in the card is wired from the second set of brushes (read for gang punching and checking) to the double punch entry hubs for double punch detection. If blank column checking is also desired, the corresponding blank column switches are set ON. When checking multiplication, it is necessary to use both double punch and blank column checking.

As the card passes the first set of brushes, the factors are read in to re-multiply. The result is again punched, and the card is checked as it passes the second set of brushes. As the card passes the second set of brushes, a circuit will be completed through the hole in the corresponding column of the card to pick up R37. Only the first position will be considered in tracing circuits. The R37B points indicate the presence of a hole in the column being checked. R38 then picks up and sets up a circuit through its R38A points to the error relay, R57. If another hole is present in the same column after R38 is picked up, the error relay will be energized and the machine will be stopped.

The circuit for energizing R37 is as follows: post 3, through fuse 7, relay common, through R37 coil, R38A N/C, DPBC entry hub, wire, read for gang punch and check brushes, hole in card, contact roll, common brush, R7A, P3, P4, P2, P1 to post 1.

This circuit picks up R37, closes the R37A points, and opens the R37B points. The opening of the R37B points prevents the energization of R57H coil when P35 makes.

R37 is held through R37A and P34 until 13.3 of the same cycle. R38 will not pick up as soon as R37A points close, because there is a shunt circuit around the R38 coil through the hole in the card and the CB's. When the CB's open, R38 will be energized through the R37 hold circuit.

R38A points then transfer and open the pickup circuit to R37 and set up a circuit to the R57P coil. If no other hole is punched in the same column, nothing further happens and no error is indicated. However, if another hole is sensed in the same column, after the foregoing circuits have been established, R57P will be energized as follows: post 3, fuse 7, R57P coil, R31BL, R38A N/O, hub, wire to read for gang punching and checking brushes, and out through hole in card to post 1.

R57 will then be held by its holding coil and R57A points until the reset push button is depressed. As the error light is in parallel with the R57H coil, it will light when the hold circuit is completed and remain lighted until the push button is depressed.

When R57 picks up, its R57B points open, and as soon as P19 opens, R10 will drop. This will open the circuit to the P-clutch magnets and to the HD1 motor relay, thus stopping the machine. The error light will also glow, indicating an error.

In case of a blank column in the units position, R37 will not pick up and the following circuit will be completed to pick up R57 when P35 makes at 12.2: post 3, through fuse 7, R57H coil (and error light in parallel), R37B, hub, jackplug, R31AL, R7BU, P35, to post 1.

R57 and the error light then remain energized through the R57A points until the reset push button is depressed.

The circuits are the same for any position other than the first. The circuits are designed so that an error in any one column will stop the machine.

As an optional feature, ten additional positions of double punch and blank column checking are available. When the additional ten positions are installed, relays 58 through 77 are used.

Group Multiplying

Group multiplying signifies multiplication of a group of cards by the same multiplier. The multiplier factor is punched in the first card of each group and is known as the *rate card* or *master card*. The rate card is identified by a 9 punching in any column. As the rate cards are interspersed in front of each group, the machine senses the approach of a new rate card by the 9 punching and clears the multiplier counter to allow a new rate to enter. Also the machine suppresses punching of the rate card during the cycle the rate card is passing the die. When checking, the machine must also suppress the checking operations when the rate card passes through the machine.

Relays 26 through 31 are the group multiplying relays. Relay 27 is a wire contact relay. This relay is used in this circuit because of its fast pickup. This relay must pick up between 9 time, when a hole is read, and 5 teeth past 9. To allow a sufficient safety factor the wire contact relay is used. The contacts on the wire contact relays are in line, and therefore the identification of the contacts is by contact number. Thus R27-3 indicates the number 3 contact on wire contact relay 27.

When it is desired to group multiply, the control panel switch labelled GRP MP is wired ON. This causes R26 to pick up and remain energized as long as the GRP MP switch is wired ON (Section 10B).

The R26BU points set up the circuit to the 9 pickup hub to control the pickup of R27. R26BL points transfer to place the screens of the multiplier or multiplicand read-in switch tubes (depending on the setting of the factor reversal switch) under the control of R27-2 points. R26A points transfer the control of the multiplier or multiplicand cancelling circuit (depending on setting of factor reversal switch) from P10 to P12 and the R27-3 points. A pentode can be blocked by opening the screen potential circuit. Use is made of this fact in controlling read-in to the counter containing the rate. When it is desired to block all entries to a counter, the screen potential circuit for the read-in switch tubes of that counter is opened.

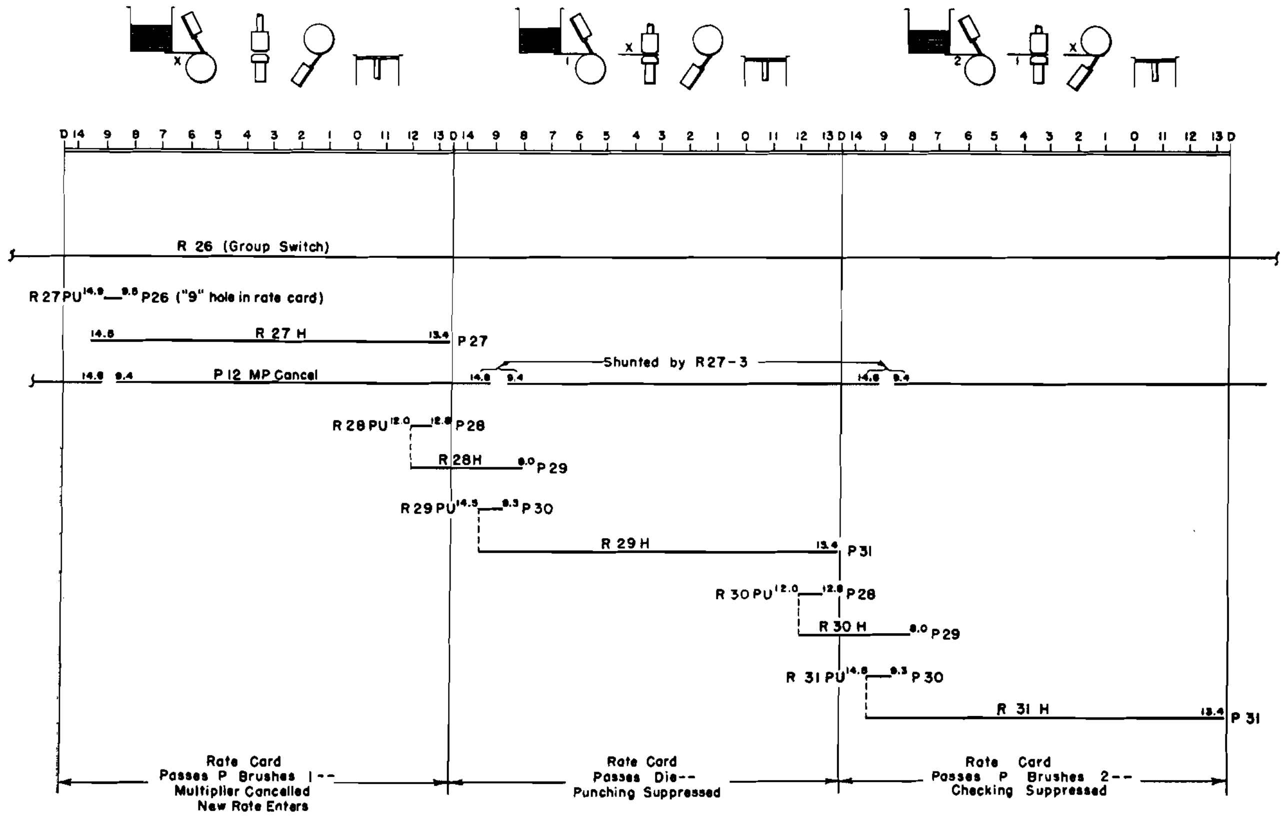

Figure 50. Sequence of Operation for Group Multiplication

To signal a rate card, a 9 is punched in a predetermined column and this card column is wired to the 9 pickup hub. Then when a 9 is read as the rate card enters the first set of brushes, a circuit is completed to pick R27 as follows: post 3, through fuse 7, relay common, R27P coil, R26BU, P26, 9 hub, control wire, brush hub, individual brush in first set of brushes, 9 hole in card, contact roll, common brush, R8B, CB's, to post 1. P26 allows only 9 holes to be recognized. R27 is then held through its R27H coil, R27-1 points, and P27 until 13.4 of the same cycle. The sequence of operations of the above and succeeding circuits for group multiplying is shown in Figure 50. This sequence chart should be studied carefully in connection with the group multiplying circuits.

In the following circuits it is assumed that the factor reversal switch is OFF and that the multiplier counter contains the rate (or group multiplier).

When R27 picks up, R27-3 points open and permit P12 to cancel the previous multiplier as P12 is open at this time. P12 is required in addition to P10 because the cancelling of the multiplier counter must be delayed until it has been determined whether or not the card entering the first punch brushes contains a 9. R27-2 points close to complete a circuit which provides screen potential to the tubes controlling multiplier read-in, and thus permit reading of a new factor into the multiplier counter. R27-4 sets up the circuit to R28P coil so that when P28 makes at 12, R28 is picked, and it holds through its R28H coil, R28A, and P29 until 8 of the next cycle. The R28B points set up a circuit to cause R29P coil to be energized when P30 makes at 14.5 of the cycle following the pickup of R28. R29 is held through its R29H coil, R29AU points, and P31 until 13.4 of the same cycle.

While R29 is energized, the R29AL points (Section 8B) are open to suppress the product read-out circuits so that no punching of the rate card from the product counter can take place.

R29BU points set up a circuit to pick R30 when P28 makes at 12. R30 then holds through its R30H coil, R30A points, and P29 until 8 of the following cycle. R30B points set up a circuit to R31 so that R31P is energized when P30 makes at 14.5 at the beginning of the cycle during which the rate card passes the second set of brushes. R31 then remains energized through this entire cycle through its R31H coil, R31AU points, and P31.

R31AL points open to suppress the blank column check circuits as the rate card passes the second set of punch brushes. R31B points open the circuit to R57P coil, thereby suppressing the double punch detection circuit.

As previously stated, the sequence of operations from the reading of the 9 hole in the rate card through the holding of R31 is shown in Figure 50. A careful study of this chart should provide a complete picture of the group multiplying operations.

Column Split, 0 and X, Hot 1

Two positions of column split are available as standard on this machine. R33 picks up each cycle when P33 makes from 0.2 through 12.2. Thus the 0-9 hubs of the column split are connected with the C hubs from 9 through 0, and the 11-12 hubs are connected with the C hubs for 11 and 12. This device permits an X or 12 punching over a 0-9 digit to be recognized independently or to be ignored.

The 0 and X hub provides a source for impulses at 11 and 0 time to punch *X's* or *0's* under the control of P32 cam contact (Section 7A). If only an *X* or *0* is desired, the 0 and X impulse is wired through a column split to separate the 0 from the X.

The Hot 1 hub provides a source for a 1 impulse under control of P20 cam contact (Section 7A). This may be used to punch 1's or to enter a 1 into the electronic counters for unit multiplication.

The hub labelled CB is a source for impulses at all index points. It is used primarily in connection with the distributor which is an optional feature.

Sign Control (Optional Feature)

As an optional feature, this machine is designed to handle either positive or negative factors. Negative factors are identified by an X punch. The X may be punched in any column to identify a negative factor. If *either* factor is negative, the result is negative. If *neither* factor, or *both* factors are negative, then the result is positive. Hence, it is obvious that an X must be punched in the card if either the multiplier or the multiplicand is negative.

The MCX and MPX hubs are wired to the first set of brushes. The MCX hub is wired to the brush in the column containing the X to identify a negative multiplicand, while the MPX hub is wired to the brush in the column containing the X to identify a negative multiplier. The PR X PCH hub is wired to the punch magnet corresponding to the card column in which the product X is to be punched. To make the sign control wiring effective the SIGN CTRL switch must be wired ON (Section 13B).

The objective of the sign control circuit is to sense a negative result and punch an X over the proper column to identify a negative product.

The general sequence of events for punching an X to identify a negative product is as follows:

1. R100 picks up at X time.
2. An X is sensed in either the MC or the MP field, and the corresponding sign control relay picks up.
3. The sign control relay is held until after X time and the sign delay relay picks up and is held through the next cycle when the card is in punching position.
4. At X time of the second cycle an X is punched to identify a negative product.

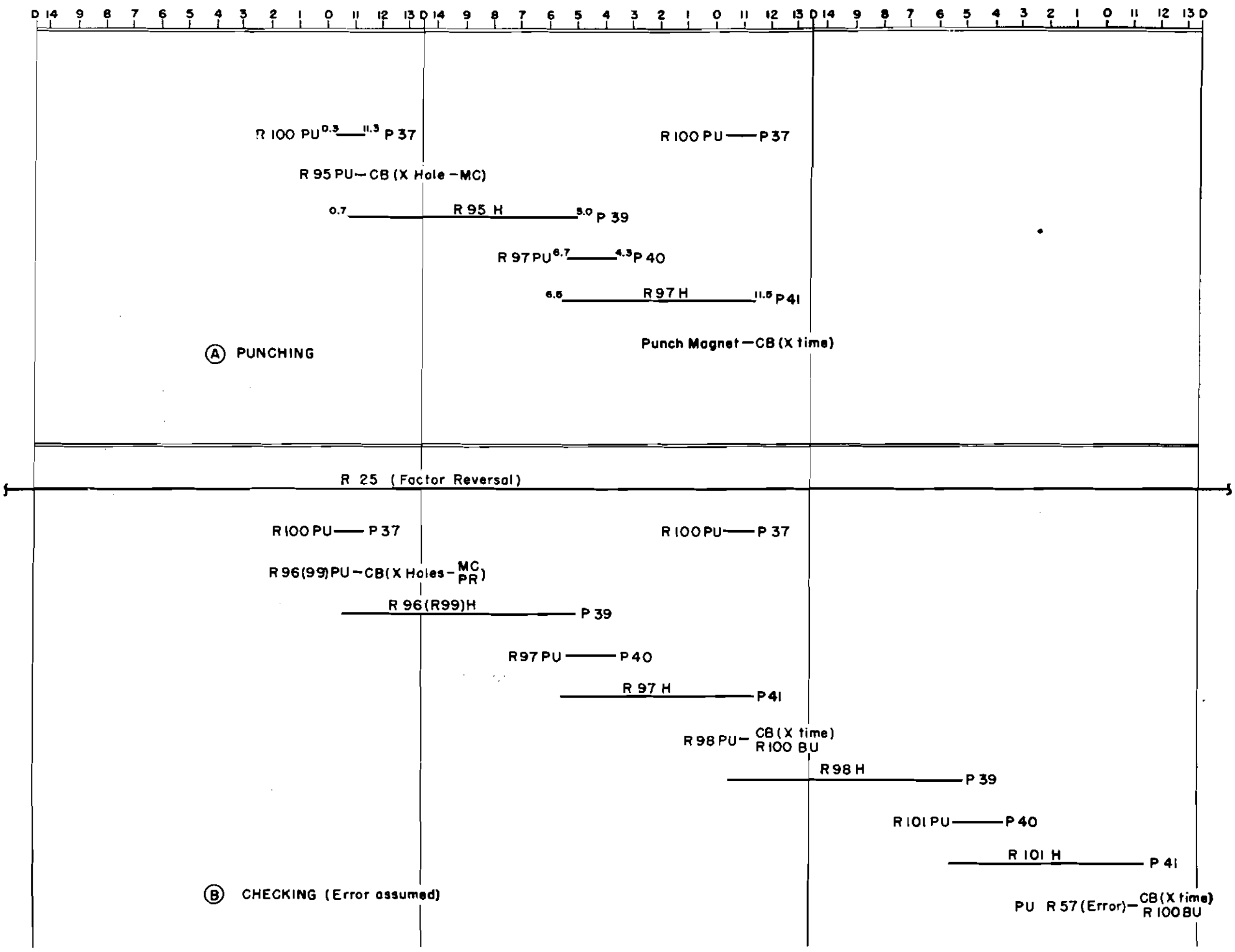

Figure 51. Sequence of Operations for Sign Control

The actual contacts and relays involved in this operation together with the timings are shown in sequence chart in Figure 51A.

The circuits traced in the order in which they operate are given below. R100 picks up at X time every cycle when P37 makes provided the SIGN CTRL switch is wired ON. The points of R100 control the pickup of all other sign control circuits.

Assuming an X in the multiplicand field, R95 will then pick up when the card passes the first set of brushes and the X hole is read. R96 would be energized if there were an X identifying a negative multiplier. R95 holds through its holding coil R95AU, and P39 until 5 of the following cycle, and R95B points set up a circuit to pick R97 when P40 makes.

The sign delay relay R97 is energized when P40 makes at 6.7 of the cycle following the reading of the X. Note that if *neither* or *both* R95 and R96 are energized, R97 cannot pick up. R97 is then held through its R97H coil, R97A points, and P41 until 11.5 of the same cycle. At X time of this cycle the punch magnet wired to PR X PCH is energized as follows: post 3, through R12B, punch magnet common, punch magnet coil, PUNCH hub, control panel wire, PR X PCH hub, R25AL N/C, R97B, R100BU, through CB's, to post 1.

For standardization it is recommended that the X identifying negative amounts always be punched in the units column of the field. In this manner a negative amount can always be spotted at a glance.

Sign control checking is accomplished by comparing X-punchings in the multiplier and multiplicand fields against X's in the product field. If the factors indicate a negative product and the product is not so identified (or vice versa), the machine will stop and indicate an error.

The only additional control panel wiring necessary for a checking operation is the wiring of the card column containing the product X to the PR X CHK hub from the first set of brushes. The X's for the multiplier or multiplicand are sensed through the MPX or MCX hubs. However, when checking, the factor reversal switch is ON and R25 is picked up; consequently the MPX and MCX hubs are reversed so that a multiplier X picks R95 and a multiplicand X picks R96.

In order to set up a given problem, assume an X punch in the multiplicand field only. The single X means that the product is negative and that an X should be punched. If for some reason the product X is not punched, the machine must detect this as an error.

The sequence of events involved in a sign check are shown on the chart in Figure 51B. Note that when an error is sensed, the machine is not stopped until the end of the cycle during which the card in error passes the second set of brushes.

The circuits are completed in the sequence in which they are traced below. Remember that R25 is energized during a check run and that R100 picks up at X time of each cycle under control of P37.

When the card passes the first set of brushes, the multiplicand X is read and R96 picks as follows: post 3, through fuse 8, R96P coil, R100AL, R25BL N/O MCX hub, control wire to hub of read for entry and control brushes, individual brush, X hole, contact roll, common brush, R8B, CB's, to post 1. R99 would be energized if the product X were punched. Since the assumption is that no product X is punched, R99 is not picked up. R96 holds through its R96H coil, R96AU points, and P39 until 5 of the next cycle. R96B points set up the circuit to R97P, which picks as follows when P40 makes: post 3, through fuse 8, R97P coil, R96B N/O, R95B N/C, R99B N/C, P40, to post 1. R97 holds through its R97H coil, R97A, and P41 until 11.5 of the same cycle. R97B sets up a circuit to R98P, so that at X time of this cycle, R98 is energized as follows: post 3, through fuse 8, R98P coil, R25AL N/O, R97B, R100BU, through CB's, to post 1. R98 holds through its R98H coil, R98AL, and P39; R98AU points set up a circuit to R101P so that R101 picks when P40 makes. R101 then holds until 11.5 through its R101H coil, R101A, and P41. R101B points set up a circuit to energize the error relay at X time as follows: post 3, through fuse 7, R57P coil, R31B, to R38A N/O, through R101B (Section 14B), R-100BU, CB's to post 1.

When R57 picks, its R57B points open, causing the machine to stop as previously explained. Also, the error light will glow to indicate an error.

Observe that if the X to identify a negative product had been punched, R99 would have picked and held through its R99H coil, R99A, and P39; then when P40 made, R99B would be transferred along with R96AL, and R97 could not pick up. If R97 does not pick up, nothing further happens in the checking operation. The R99B points in combination with the R95 and R96 points provide a means of completing a circuit to R97 for proper X punch and X-check control.

Since it is recommended that X's be punched over the units column of a field, it is necessary to suppress the X check when using the double punch check. This may be done by wiring the units column through the column split, so that only the 0-9 positions of the card column are checked for double punch.

Class Selectors (Optional)

Class selectors are optional features on this machine. If one class selector is installed, relays 80 through 86 are used. The second class selector

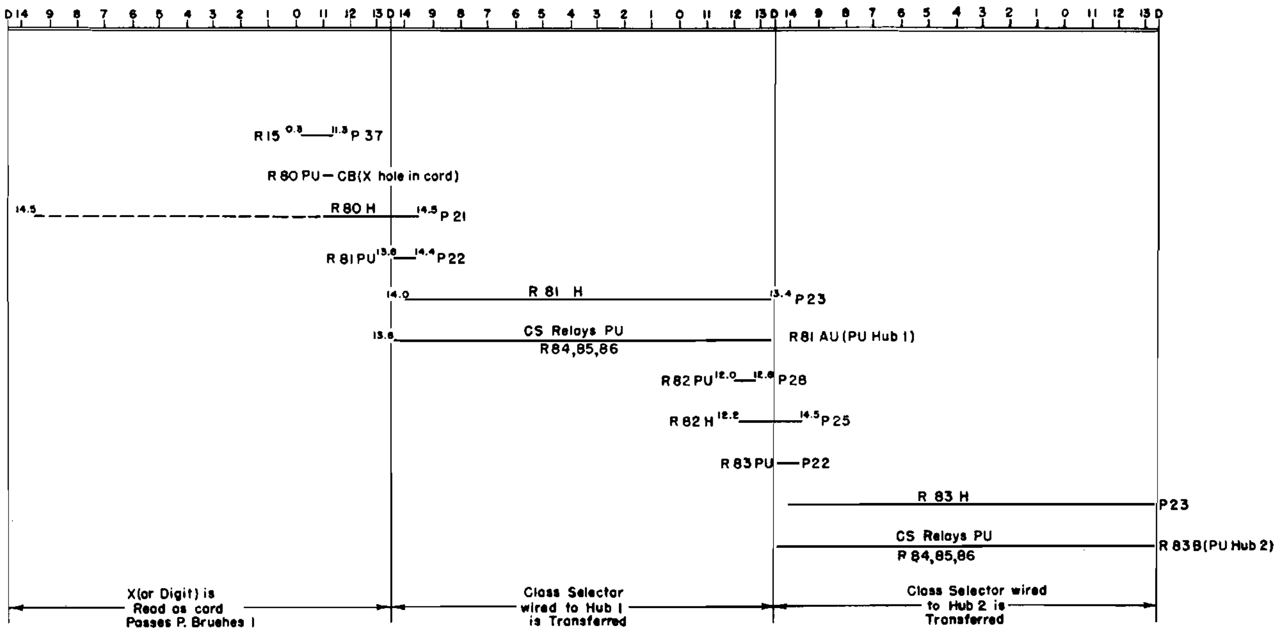

Figure 52. Sequence of Operation of Class Selectors

uses relays 87 through 93. The circuits will be traced for number 1 class selector.

The sequence of operation of the selector circuits is shown in Figure 52. This sequence should be carefully studied in connection with the circuits to enable a clear understanding of the circuits.

The selectors are arranged for either X or D pickup and for normal or delayed operation. If it is desired to transfer the selector during the cycle following the reading of the X, the C PLG hub is wired to the 1 hub. Wiring the C PLG hub to the 2 hub causes the selector to transfer during the second cycle following the reading of the X hole.

When an X is sensed at the first set of brushes, a circuit is completed to R80P through the X pickup hub and R15AL. R15AL allows only X's to be recognized by the X hub. If digit control is desired, the D hub is used to pick R80. R80 holds through its R80H coil, R80A, and P21 until 14 of the cycle following its pickup. At 13.6 of this same cycle, R81P is energized through R80B and P22. R81 holds through its R81H coil, R81AL, and P23 until near the end of the cycle. Then if the selector is wired to operate on this cycle, R84, R85, and R86 are energized through the R81AU points during this entire cycle. The points of R84 through R86 are the actual selector points, as indicated by the chart on the wiring diagram.

If the selector is wired to operate during the second cycle following the X, R83 must be energized before R84, R85 and R86 can pick up. At 12.2 of the first cycle following the X, R82 is energized through R81B and P28, and a holding circuit is completed through R82H coil, R82A, and P25 until 14.5 of the second cycle. At 13.6 of the second cycle, R83 is energized through R82B and P22. R83 holds through the entire second cycle through its R83H coil, R83A points, and P23. R83B points complete a circuit during this cycle to energize the class selector relays R84 through R86.

Distributor (Optional)

A conventional 12-segment distributor can be installed as an optional feature on this machine. The distributor can be used as a digit emitter by wiring the CB hub to the C hub of the distributor.

Any timed impulse from 9 through 12 is available at the distributor hubs labelled accordingly. The distributor can also be used as a digit selector by wiring from the brushes to the C hub of the distributor. Only the desired digit in any card column can be recognized by proper wiring of the 9-12 hubs of the distributor.

POWER SUPPLY CIRCUITS

Main Transformer and Selenium Rectifiers

Power is supplied to this machine by two transformers, the main transformer and the tube power supply transformer, which can be seen in the power supply circuit diagram (Section 3 for 115-230 volt A.C. operation and Section 4 for 115 volt A.C. operation). The main transformer is mounted directly behind the control panel. The only difference between the 115 volt A.C. transformer and the 115-230 volt A.C. transformer is that the latter has two primary coils. All following discussion will assume a 115 volt A.C. transformer. Three taps are provided in the primary to permit constant secondary output voltages at 105, 115, or 125 volt primary voltages. The secondary is provided with six taps to supply 115 volts A.C. for the tube filaments and to supply the selenium rectifiers which provide D.C. outputs of 40 volts and 140 volts. The 140 volt supply is the anode voltage supply for the 25L6 read-out power tubes in the electronic computing unit. The 40 volt supply furnishes the power for all relays and magnets in the punch unit which are usually supplied by a generator.

From the punch running circuits it will be remembered that when the main line switch is ON, the A.C. from the main line appears across posts 9 and 10 to pick up HD3 and HD4. The HD4 points in turn complete a circuit to the main transformer primary across the two 20 amp fusetrons. The circuit through the primary of the main line transformer is from post 8, through 20 amp fusetron 3, HD4 points, primary terminal 17, primary coil, terminal 19 (for 115 volt supply), fusetron 4, to post 7. The RMS or effective voltage produced at *full load* by transformer action between each of the secondary taps is shown in Figure 53. (RMS is the abbreviation for the root mean square value of alternating current or voltage, also called "effective value." It is the square root of the mean values of the squares of the instantaneous values taken over a complete cycle.) All tube filaments in the electronic computing unit are heated by the 115 volt A.C. between terminals 13 and 14. The filament supply uses cable connectors CNp18 through CNp20 and CNp38 through CNp40. Three connectors are used on each side to distribute the load. It is advisable to adjust the primary tap so that the filament supply is approximately 110-115 volts. Although the tubes will require slightly longer to heat, their life will be considerably longer. A 15% increase in voltage will reduce the life of the tubes 30%.

40 volt D.C. is supplied by the full-wave selenium rectifier across terminals 11 and 12. This rectifier is mounted on the right end gate. The center connection of the selenium rectifier is the positive connection while the transformer center tap between terminals 11 and 12 (terminal 15) is the negative connection. Terminal 15 serves as the reference point for *all* voltages, i.e., it is the point of zero reference and is the ground connection. Four 2000 mfd, 40 volt electrolytic capacitors connected in parallel act as the filter for the 40 volt supply. These capacitors are mounted on the lower section of the left end gate. Post 1 and post 3, which are the 40 volt terminals, are connected across the 2000 mfd capacitors.

The actual D.C. voltage produced at the output terminals is greater than the A.C. voltage at the transformer secondary because the capacitors charge to peak voltages. The actual D.C. voltage is equal to the peak voltage of the A.C. ($\sqrt{2}$ times the RMS voltage) minus the voltage drop across the selenium rectifier stack, which is approximately 6-10 volts at full load.

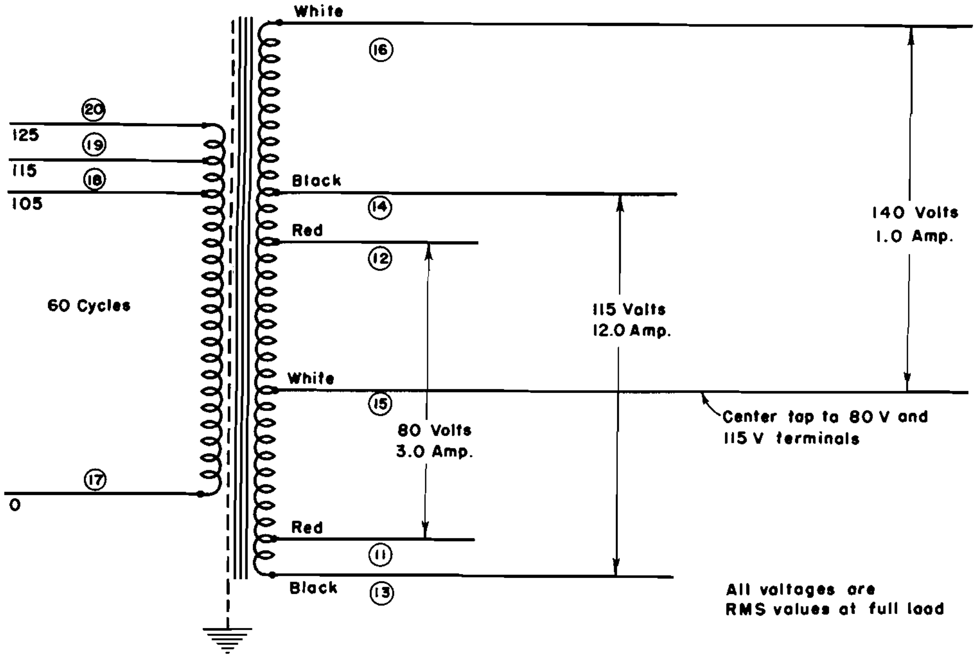

Figure 53. Main Transformer

140 volt D.C. is supplied by the half-wave selenium rectifier connected to transformer terminal 16 through R4B contacts. The purpose of R4 was discussed in connection with the start and bias interlock circuits. A half-wave rectifier is sufficient for this supply because of the very light load. The two 200 mfd 200 volt electrolytic filter capacitors in parallel are able to maintain a fairly constant supply with the light load on this line. A 5000 ohm bleeder resistor is connected across the capacitors to maintain a minimum current flow and thus prevent the high peak voltages which would exist at very light or no load. With this bleeder resistor, better voltage regulation results. All the components for the plus 140 volt supply are mounted on the left end gate.

Tube Power Supply Chassis

The tube power supply chassis contains all components enclosed in the dash-dotted section in Section 4 of the main wiring diagram. The tube power supply transformer for 115 volt A.C. operation is provided with taps on the primary in 5-volt steps to permit constant secondary output voltages at primary voltages of from 100 volts to 125 volts. The taps are connected through a tap switch to post CH10 and to post 10. The extreme right-hand setting is the 100 volt tap. When the tap switch is set to the extreme left-hand setting, the transformer primary is disconnected. The tap switch is mounted on the power supply chassis and is accessible from the front of the machine by lowering the left front cover.

Note that the circuit to the transformer primary passes through the HD2 contacts. The operation and purpose of this relay was discussed in connection with the time delay circuits. The circuit through the primary is from post 9, through HD2 contacts, post CH7, primary coil, tap switch, post CH10, to post 10. The secondary of the transformer is in two equal sections, one delivering 388 volts RMS approximately, and the other approximately 364 volts RMS. These values vary with the setting of the tap switch. Each section is centered-tapped to allow full-wave rectification. The upper section shown on the circuit supplies

+150 volts for the anode voltage and −250 volts for bias voltage, while the lower section supplies −100 volts for bias voltage. A voltage regulating circuit is provided between the +150 volt and the −100 volt lines to maintain a constant ratio between anode and grid voltages. This circuit will be discussed shortly.

The tube power supply transformers along with the rectifiers and chokes are shown in Figure 54. Note that all transformers are supplied with grounded electrostatic shields, indicated as dotted lines between the primary and secondary windings in Figure 54. The purpose of these electrostatic shields is to prevent any high frequency transients in the A.C. line from being passed to the secondary through the capacity coupling between windings. With these shields any transients are by-passed to ground.

Full-wave rectification to obtain +150 volts and −100 volts is accomplished by directly heated, gas filled, twin diodes. Heater current is supplied to both rectifier tubes by a separate filament transformer as shown in Figure 54. The chokes are connected to the center taps of the corresponding filament transformer secondaries to provide a more nearly constant output.

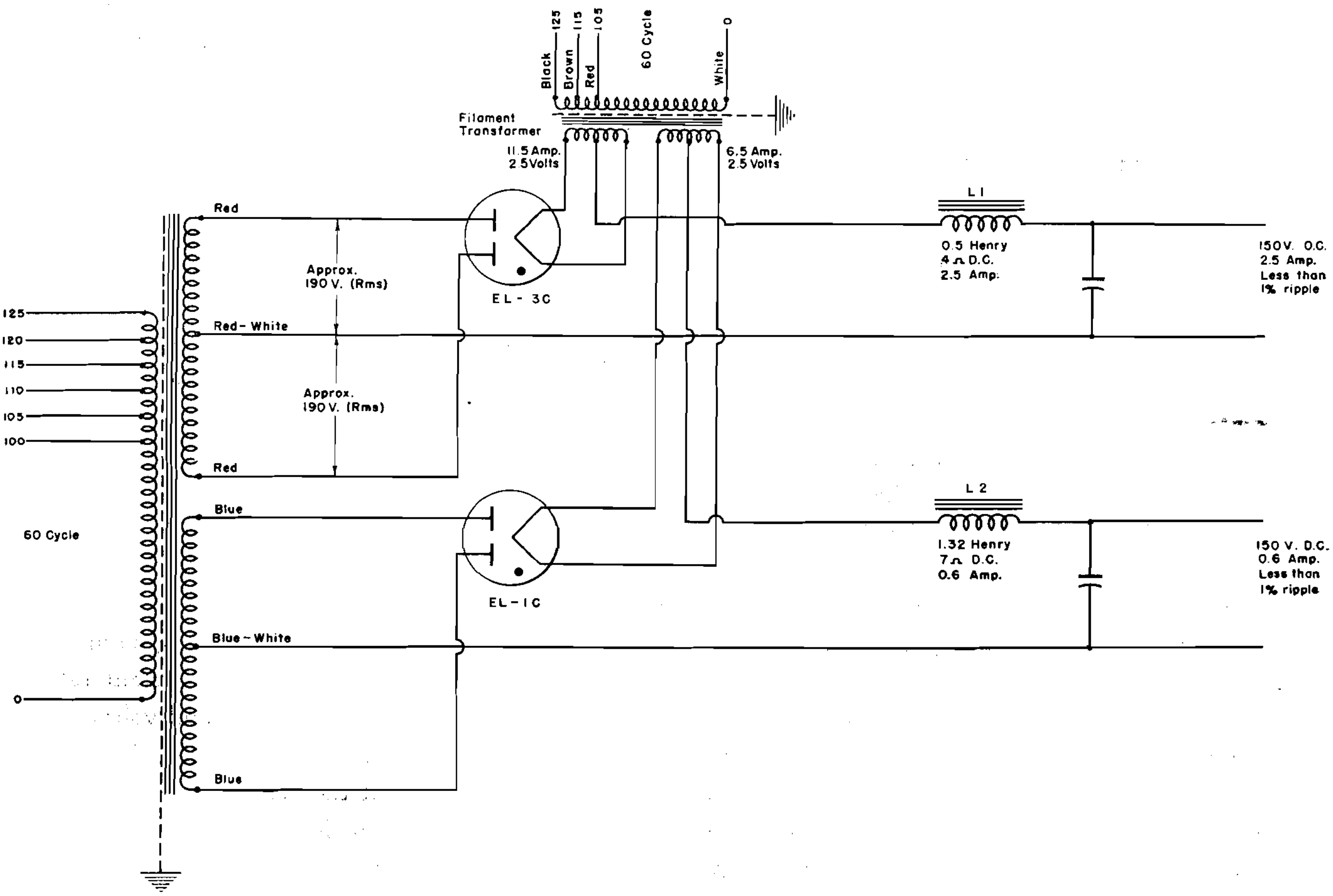

Figure 54. Tube Power Supply Transformers, Rectifiers, and Chokes

The anode supply rectifier is a type EL-3C directly heated twin diode manufactured by Electrons, Inc., of Newark, N. J. The −100 volts bias supply rectifier is a type EL-1C. Both are xenon filled and have an internal drop of approximately 12 volts when conducting. Characteristics of these tubes are shown below:

	Type EL-1C	Type EL-3C
DC Current (Maximum Rated Output)		
Continuous	1.0 ampere	2.5 amperes
Surges (3 seconds or less)	1.5 amperes	3.7 amperes
Oscillograph peaks (continually recurring)	4.0 amperes	10.0 amperes
Peak Inverse Voltage (maximum instantaneous)	725 volts	725 volts
A.C. Volts per Anode	12-250 volts	12-250 volts
Tube Drop	12 volts	12 volts
Filament Voltage	2.5 volts	2.5 volts
Filament Current	6.5 ±0.5 amperes	11.5 ±1.0 amperes

To provide the best voltage regulation, choke input filters are used in the +150 volt and −100 volt lines. The ratings of the chokes and capacitors are shown on the circuit diagram and on Figure 54. The chokes L1 and L2 are mounted beside the power supply transformer. Choke L3 and all capacitors are mounted under the chassis and are accessible only when the chassis is removed.

The purpose of the 0.1 mfd capacitor across the electrolytic capacitors is to protect the electrolytics by by-passing high frequency transients. Electrolytic capacitors by their nature do not readily pass high frequencies.

Note that the output across the filter capacitors of both the +150 volt line and the −100 volt line is 150 volts D.C. This is arrived at by subtracting the voltage drop across the rectifier tube and across the choke from the RMS voltage across one-half the secondary and converting the resulting RMS voltage to *average* voltage, since the filter capacitors charge to the *average* voltage when a choke input filter is used. (RMS voltage = 0.707 peak voltage, and average voltage = 0.636 peak voltage.) To obtain 100 volts for the −100 volt line, the voltage ratio regulator circuit provides a regulated 50 volt drop.

Before discussing the voltage regulator, the rectifier circuit for the −250 volt bias supply will be discussed. The load on this line is very light and consequently a vacuum tube is used. The tube used is a type 25Z6 twin diode. Note in Figure 55 that the cathodes of the 25Z6 are connected across the upper section of the transformer secondary. It is necessary to reverse the connections in this case because the output from this rectifier must be negative with respect to ground, and the same common ground as the +150 line is used. Since the load is very light on this line (approximately 10 ma), satisfactory voltage regulation can be obtained with a capacitor input filter. In this manner a higher output voltage can be obtained since the capacitors charge to peak voltage. This is necessary in this case because only about 190 volts RMS are available at the transformer yet 250 volts D.C. are needed at the output. The 50,000 ohm resistor across the 16 mfd electrolytic capacitors serves the usual function of a bleeder resistor, i.e., to maintain a minimum current and thus prevent excessively high peak voltages across the capacitors. All the components for this rectifier are mounted under the chassis and are accessible only by removing the chassis.

In order to provide an adjustment of the −250 volt supply, a rheostat is mounted between the anodes of the 25Z6 and the choke L3. By adjusting the amount of voltage drop across the rheostat, the output can be maintained at −250 volts. The rheostat adjusting knob is accessible through a hole at the rear of the power supply chassis.

Constant Ratio Voltage Regulator

The purpose of the voltage regulating circuit in the −100 volt line is to maintain a constant ratio between the anode voltage and the grid voltage. It is very important in the operation of the electronic computing section that the same relation be maintained between the anode voltage and the grid voltage. If the anode voltage drops sharply owing to a suddenly applied load, the bias voltage must

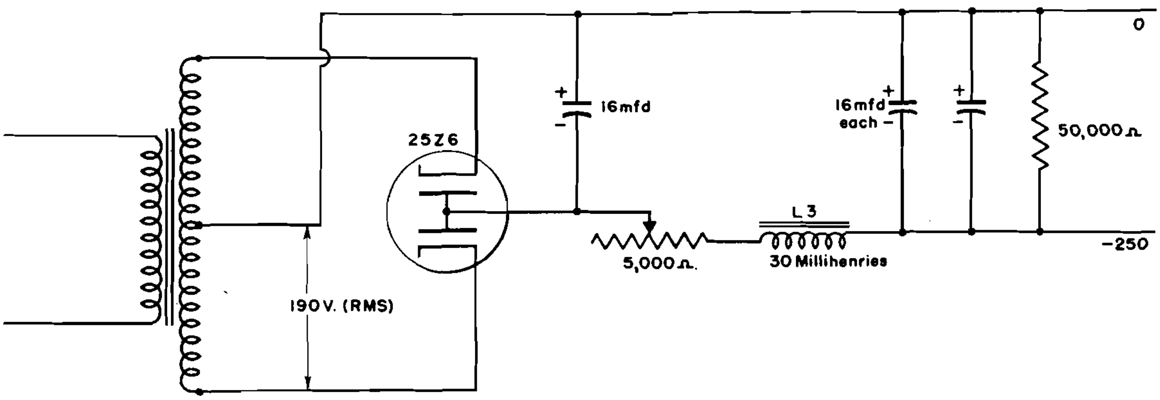

Figure 55. Schematic of -250 Volt Rectifier Circuit

be made less negative to compensate for this. Any increase in anode voltage requires a more negative bias voltage. If the A.C. supply voltage changes, both anode and grid bias voltages change, and the regulation circuit merely adjusts for the proper ratio between the two.

Note that a resistor network consisting of a 36,000 ohm resistor, a 10,000 ohm potentiometer, and a 20,000 ohm resistor is connected between the +150 volt and the -100 volt line. Also note that a 10,000 ohm resistor by-passed by a 0.1 mfd capacitor is connected across the -100 volt terminals. The 10,000 ohm resistor serves as a bleeder for the -100 volt line, and the 0.1 mfd capacitor serves as a by-pass across the -100 volt line for high frequency transients. The regulator tubes consist of three type 25L6 beam power tubes connected in parallel between the filter output and the ground line.

The bias voltage is originally adjusted at -100 volts by the potentiometer. The adjusting knob of the potentiometer is accessible from the rear of the machine through a hole in the rear of the chassis. The 3,300 ohm screen grid resistors and the 10,000 ohm control grid resistors are both current limiting resistors and do not enter into the operation of the regular circuit other than to stabilize the tube operation. Observe that the screen grid resistors are tied to the +150 volt line. This arrangement provides increased current through the 25L6's. Note that the heater filaments of all 25L6's along with the heater for the 25Z6 rectifier are connected in series across post 12 and post 13. 100 volts A.C. is available across these terminals of the main transformer. All components of this regulator circuit except the tubes are mounted under the chassis and are accessible only if the chassis is removed.

In order to simplify the explanation of the regulator circuit, a schematic drawing showing only the essential elements is illustrated in Figure 56. The output from the filters is represented by batteries of the corresponding polarity, and the three 25L6's have been replaced by a single triode. In this circuit the tube acts as a variable resistance controlled by the grid voltage. The value of tube resistance is varied so as to maintain the proper voltage across the -100 volt line at all times. The voltages existing, together with polarities, are shown in Figure 56 when all conditions are normal. The voltage drops across R_1, P, and R_2 can be computed by determining the current flow through the resistors, then calculating the IR drop across each. Or the voltage drops may be computed by the ratio of resistors as follows:

$$E_{R1} = 250 \times \frac{R_1}{R_1 + P + R_2}, \text{ etc.}$$

For sake of illustration, it is assumed that the tap on the potentiometer is set so that there is a 95 volt drop from the -100 volt line to the grid.

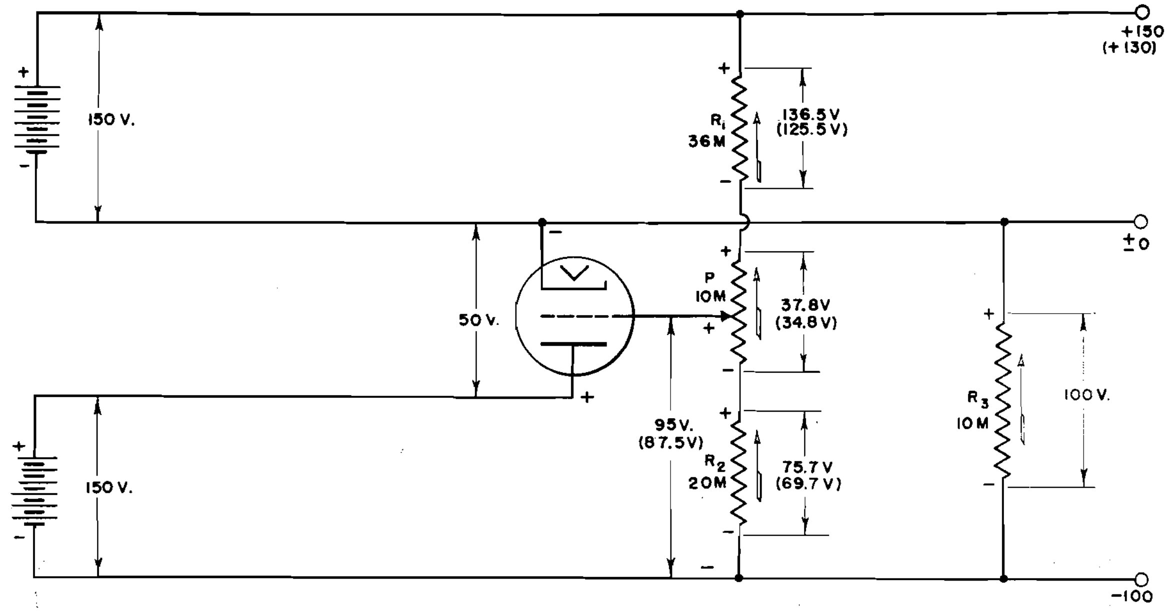

Figure 56. Schematic of Voltage Ratio Regulator Circuit

Because of the polarity of the IR drop across the resistors, this 95 volts can be subtracted from −100 volts to obtain the grid potential (cathode is at ground potential, or at zero potential). This means that the grid is at −5 volts, and sufficient current flows through the tube to provide a 50 volt drop in the line. This 50 volts subtracts from the battery voltage of 150 volts and leaves 100 volts across the −100 volt line. As long as conditions remain normal, nothing further happens.

Assume now that a heavy load is suddenly applied across the +150 volt line. The tendency will be to drop the voltage across this line. The job of the regulator is then to make the −100 volt line less negative to compensate for the drop in anode voltage. For sake of analysis assume the anode voltage drops to +130 volts as indicated in parenthesis. Then the new voltage drops across the resistors on the basis of 230 volts across the network are shown in parenthesis. This change will produce a voltage of −12.5 volts at the grid (100 − 87.5), and the current through the tube will be considerably decreased. The decrease in current means an increased voltage drop across the tube. An increased tube drop leaves less voltage across the −100 volt line, thus producing the desired result. Another way of looking at this is that the decreased tube current results in a decreased IR drop across R_3 which is across the −100 volt line.

Of course the operation will be reversed if the anode voltage increases. If both anode and grid voltages change owing to variations in the A.C. supply, the regulator again adjusts for the proper ratio between the two. An analysis in this case is more difficult, but the end result is the same.

The circuits shown outside the chassis on the main wiring diagram have already been discussed in connection with the punch unit circuits.

Screen Grid Supply

Although it is not included in the power supply chassis and not shown in the punch circuit diagram, there is a separate +65 volt supply for the screen grids of all tetrodes and pentodes in the electronic computing unit. This power supply is located on the B chassis (Section 30B), and the circuit is shown in Figure 57. It was necessary to place this power supply on the B chassis because the original design did not call for a +65 volt supply. When it was decided that this supply was

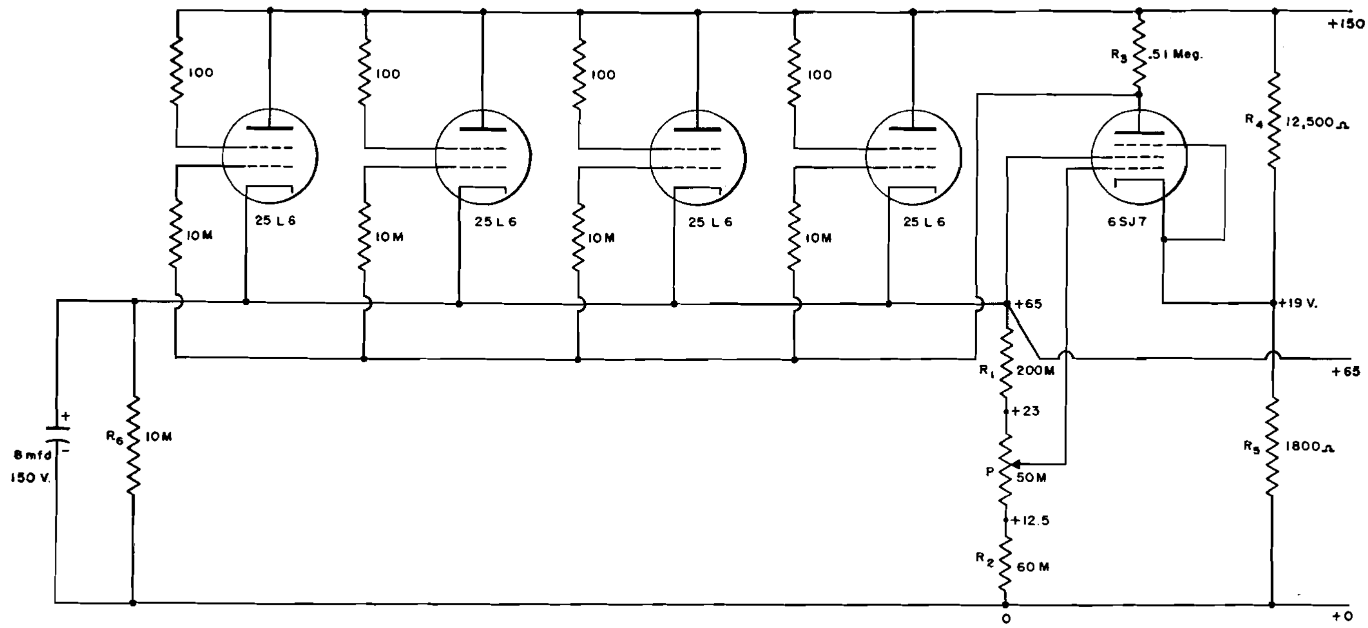

Figure 57. +65 Volt Supply

necessary, there was no room on the power supply chassis for the additional tubes and components.

The +65 volt supply is in reality a voltage regulator circuit. Since +150 volts were already available in the machine when this supply was added, the easiest method of obtaining +65 volts was by means of a voltage regulator circuit which provided an 85 volt drop across the 150 volt line. This provided a 65 volt supply between the ground line and the cathodes of the regulator tubes. In order to provide a constant voltage, a voltage regulating circuit under the control of a 6SJ7 pentode is provided. The operation of this circuit follows:

A study of the circuit in Figure 57 will reveal that four type 25L6 beam power tubes are connected in parallel between the +150 volt line and the +65 volt line. Four tubes are necessary to handle the current requirements of this supply. Obviously, there must be an 85 volt drop across these tubes. Since the D.C. voltage drop across a vacuum tube varies with the amount of current passing through it, it is necessary to regulate the amount of current so that the proper anode current flows at all times to maintain this 85 volt drop. This is done by adjusting the grid potential of the 25L6's. Note that all the grids are connected together to the anode of the 6SJ7 pentode. Any change in anode current through the 6SJ7 will produce a change in potential at its anode owing to the change in IR drop through the anode resistor. Any change in potential at the anode of the 6SJ7 will be felt at the grids of the 25L6's. Consequently, by adjusting the current flow through the 6SJ7, the current flow through the 25L6's can be adjusted. This provides a means of obtaining very close control, since the 6SJ7 has an extremely high amplification factor. A very slight change in grid potential on the 6SJ7 will produce an appreciable change in grid potential at the 25L6's.

The grid of the 6SJ7 is normally biased at approximately −1 volt by means of the potentiometer. This setting provides the proper potential on the 25L6 grids to provide +65 volts between ground and the 25L6 cathodes. This 65 volt potential is maintained at a constant value as follows:

The voltage divider R_4 and R_5 provides a voltage drop of 19 volts across R_5, thus placing the cathode of the 6SJ7 at +19 volts. Between the ground line and the +65 line there is a resistor network consisting of resistors R_1 and R_2 and potentiometer P. The voltage at the top of each component is shown in Figure 57. As previously shown, these values are easily computed by the ratio of resistances. The voltage at the top of R_2 is +12.5 volts and at the top of P is +23 volts; hence by adjusting the potentiometer tap, the grid can be set anywhere from +12.5 volts (–6.5 volts with respect to cathode which is at +19 volts) to +23 volts (+4 volts with respect to cathode). This adjustment is made only once when the 65 volt supply is being adjusted to the line voltage. Thereafter adjustment is automatic. Assume, for example, that the +150 volt line tends to drop in voltage. This will in turn reduce the voltage across the 65 volt supply, meaning a lower voltage drop between ground and the tap on potentiometer P. Less voltage at this tap means a more negative grid on the 6SJ7, since the cathode remains at essentially +19 volts at all times. The more negative grid means a decreased anode current with a consequent reduction in IR drop across R_3, the anode resistor of the 6SJ7. A lower IR drop across R_3 means a less negative voltage at the anode of the 6SJ7. This is the voltage of the 25L6 grids; hence the 25L6 grids will be less negative than before and more anode current will flow with the consequent reduction in drop across the 25L6's and increase the 65 volt line. In this manner the 65 volt supply is restored to its proper value.

Any change in the opposite direction will make the 6SJ7 grid more positive which, in turn, will make the 25L6 grid more negative. This will increase the drop across the 25L6's and again 65 volts will be maintained across this supply.

The 100 ohm screen grid resistors in the 25L6 circuits are current limiting resistors. Low values were selected to allow maximum current without damage to the screen grids. The 10,000 ohm control grid resistors are also current limiting resistors. These resistors also provide more stable tube operation. The 8 mfd capacitor across the 65 volt line serves as a filter with the 10,000 ohm resistor R_6 as its bleeder. R_6 serves the purpose of a dummy load in case the operating load is removed. An extremely high resistance is used at R_3 in the anode circuit of the 6SJ7 to provide very close control. A very slight change in anode current produces a large change in voltage drop across R_3. For example, a *1 micro-ampere* increase in anode current increases the IR drop across R_3 by 5 volts.

NOTE: The 6SJ7 may be replaced by a 6SK7 in an emergency. A slight readjustment of the potentiometer may be necessary.

On some early models the 12,500 ohm resistor, which is part of the voltage divider which establishes the cathode potential of the 6SJ7 tube B-26 (Section 30B on wiring diagram) is a 0.5 watt carbon resistor. The load across this resistor is considerably more than 0.5 watt, consequently this resistor overheats and changes in value, thereby causing fluctuations in the +65 volt supply. This carbon resistor should be replaced by a 12,500 ohm, 5 watt, wire-wound resistor as indicated on the wiring diagram.

Voltage Adjustments

When it is desired to adjust the voltage supplies, a definite procedure should be used to insure that one change does not affect the other. First, the filament voltage should be checked for 110-115 volts. If a change is necessary, the voltage tap on the main transformer primary can be moved to either post 18, 19, or 20. The series filament strings are designed for approximately 113 volts, but a slightly lower voltage will considerably increase the life of the tubes. However, a slightly longer time must be allowed for the tubes to heat. Changing the primary tap on the main transformer will change the voltage output from the selenium rectifiers slightly, but these voltages are not critical and are usually higher than necessary.

The first adjustment in the tube power supplies is the +150 volt supply. This output is adjusted by varying the position of the tap switch in the primary of the power supply transformer. By