PROCEDURES for testing will be given only for the electronic computing unit and the punch circuits which tie the two units together. The use of a multiplying test deck will aid in checking and analyzing the multiplying circuits. The test deck should be punched (wherever possible) with the multiplier and multiplicand factors in the same card columns which the customer uses. The control panel is set up for individual multiplication, using the full capacity of the machine.

Table I shows the multiplier and multiplicand factors together with the individual products and accumulated products appearing in the product counter. If the multiplier, multiplicand, and product are punched in each card and interpreted on the card, all the information will be available on the test deck. Then as the cards are run through the machine, the machine may be stopped at any point and the product in the counter compared with the amount punched in the card. (The products counter is read from bottom to top, since the first counter position is at the top.) The progressive totals appearing in the product counter, if the counter is not cleared, are also shown in the Table I. If desired, the product summary switch may be wired ON, and the individual totals will accumulate in the product counter. The machine may be stopped at any point and the total checked against the amount shown in the table below. The last card of the test deck may be X (or digit) punched to cause automatic clearing of the product counter after all cards have been multiplied. Otherwise, the product counter may be cleared manually by means of the product cancel push button.

If the individual products are punched in the test deck, it is possible to test the machine with all covers on. By wiring the machine for double punch detection and re-punching the product in

Multiplier	Multiplicand	Individual Product	Progressive Total
111111	111111	012345654321	012345654321
111111	222222	024691308642	037036962963
111111	333333	037036962963	074073925926
111111	444444	049382617284	123456543210
111111	555555	061728271605	185184814815
111111	666666	074073925926	259258740741
111111	777777	086419580247	345678320988
111111	888888	098765234568	444443555556
111111	999999	111110888889	555554444445
222222	111111	024691308642	580245753087
222222	222222	049382617284	629628370371
222222	333333	074073925926	703702296297
222222	444444	098765234568	802467530865
222222	555555	123456543210	925924074075
222222	666666	148147851852	074071925927
222222	777777	172839160494	246911086421
222222	888888	197530469136	444441555557
222222	999999	222221777778	666663333335
333333	111111	037036962963	703700296298
333333	222222	074073925926	777774222224
333333	333333	111110888889	888885111113
333333	444444	148147851852	037032962965
333333	555555	185184814815	222217777780
333333	666666	222221777778	444439555558
333333	777777	259258740741	703698296299
333333	888888	296295703704	999994000003
333333	999999	333332666667	333326666670
444444	111111	049382617284	382709283954
444444	222222	098765234568	481474518522
444444	333333	148147851852	629622370374
444444	444444	197530469136	827152839510
444444	555555	246913086420	074065925930
444444	666666	296295703704	370361629634
444444	777777	345678320988	716039950622
444444	888888	395060938272	111100888894
444444	999999	444443555556	555544444450
555555	111111	061728271605	617272716055
555555	222222	123456543210	740729259265
555555	333333	185184814815	925914074080
555555	444444	246913086420	172827160500
555555	555555	308641358025	481468518525
555555	666666	370369629630	851838148155
555555	777777	432097901235	283936049390
555555	888888	493826172840	777762222230
555555	999999	555554444445	333316666675
666666	111111	074073925926	407390592601
666666	222222	148147851852	555538444453
666666	333333	222221777778	777760222231
666666	444444	296295703704	074055925935
666666	555555	370369629630	444425555565
666666	666666	444443555556	888869111121
666666	777777	518517481482	407386592603
666666	888888	592591407408	999978000011
666666	999999	666665333334	666643333345
777777	111111	086419580247	753062913592
777777	222222	172839160494	925902074086
777777	333333	259258740741	105160814827
777777	444444	345678320988	530839135815
777777	555555	432097901235	962937037050
777777	666666	518517481482	481454518532
777777	777777	604937061729	086391580261
777777	888888	691356641976	777748222237
777777	999999	777776222223	555524444460
888888	111111	098765234568	654289679028
888888	222222	197530469136	851820148164
888888	333333	296295703704	148115851868
888888	444444	395060938272	543176790140
888888	555555	493826172840	037002962980
888888	666666	592591407408	629594370388
888888	777777	691356641976	320951012364
888888	888888	790121876544	111072888908
888888	999999	888887111112	999960000020
999999	111111	111110888889	111070888909
999999	222222	222221777778	333292666687
999999	333333	333332666667	666625333354
999999	444444	444443555556	111068888910
999999	555555	555554444445	666623333355
999999	666666	666665333334	333288666689
999999	777777	777776222223	111064888912
999999	888888	888887111112	999952000024
999999	999999	999998000001	999950000025
123456	123456	015241383936	015191383961
234567	234567	055021677489	070213061450
345678	345678	119493279684	189706341134
456789	456789	208656190521	398362531655
567891	567891	322500187881	720862719536
678912	678912	460921503744	181784223280
789123	789123	622715109129	804499332409
891234	891234	794298042756	598797375165
912345	912345	832373399025	431170774190
010101	010101	000102030201	431272804391
020202	020202	000408120804	431680925195
030303	030303	000918271809	432599197004
040404	040404	001632483216	434231680220
050505	050505	002550755025	436782435245
060606	060606	003673087236	440455522481
070707	070707	004999479849	445455002330
080808	080808	006529932864	451984935194
090909	090909	008264446281	460249381475
101010	101010	010203020100	470452401575
202020	202020	040812080400	511264481975
303030	303030	091827180900	603091662875
404040	404040	163248321600	766339984475
505050	505050	255075502500	021415486975
606060	606060	367308723600	388724210575
707070	707070	499947984900	888672195475
808080	808080	652993286400	541665481875
909090	909090	826444628100	368110109975

Table I

the same field as it is already punched, any errors will be indicated by the machine's stopping and showing an error light.

Progressive punching may be checked in the same manner described above if the product summary is wired ON and the R19B points are shorted. Progressive punching may also be obtained by leaving the product summary unwired and shorting either R19A points or P11 cam contact.

If wrong results are being obtained, an effort should be made to determine the type of trouble before removing any covers. In any event, all voltages should be checked before any analyzing is done. In this way, blown fuses, wrong voltage adjustments, or any trouble in the power supply can be detected before any time is spent attempting to find troubles in the electronic unit.

To eliminate carry and also to provide a product easily calculated manually, a 111111 x 111111 card should be used to check computing. By working out the problem in detail manually it is often possible to determine the type of trouble.

When covers are removed from the electronic unit, it is possible to check the values read into the multiplier and multiplicand counters and computed product in the product counter before punching. To avoid any possible change in the multiplier and multiplicand counters during computing, read-in should always be checked before computing. This can be easily done by setting the manual control dial switch OFF. If read-in is correct and it is desired to start computing, it is only necessary to turn the switch to MANUAL for an instant and back to OFF.

Before looking very far for trouble in the electronic unit, a visual check should be made for an open filament circuit. The individual tube in an open string may be found by substitution or by means of an ohmmeter.

If the multiplier or multiplicand is reading in wrong, the factor reversal switch may be set ON, and the factors again read in. If the trouble shifts to the other counter, it is obvious that the trouble is in the punch unit. Then by crossing control panel wires or using different brushes, the trouble can be readily localized.

If a counter position fails to receive a reading and it is known to be in the electronic unit, first check the counter read-in trigger indicator lights. If the read-in triggers turn ON, but the counter fails to receive a reading, the read-in switch tube should be exchanged with a good one.

If the trouble is in the counter, it may be localized to one position by crossing the input wires on the counter chassis terminals. Once it is localized to a counter chassis, the tubes may be checked by exchanging all the tubes in one position with all the tubes in another position that is working properly. Then the trouble may be localized to an individual tube by exchanging tubes one at a time.

If a read-in trouble is localized to one counter position and the tubes are good, the trouble should be in the components wired to the tube sockets. A visual check should locate such troubles as broken wires, shorts between components, loose solder connections, "burned" resistors, etc. The values of resistors may be checked with an ohmmeter if no trouble is located visually. It must be kept in mind that exact readings cannot be obtained in many cases because of back circuits. However, sufficiently accurate readings can be obtained to indicate whether or not a resistor is within operating range. In checking capacitors, shorted capacitors can be detected with an ohmmeter. Open capacitors can be easily detected by substituting a good capacitor across the suspected one. For a quick check there is no need to solder the substitute capacitor in place; it may be held across the suspected capacitor while the circuit operation is checked. If trouble is located in a trigger circuit, it must be kept in mind that the trigger circuit must be symmetrical; therefore, resistors or capacitors should be replaced in correspondingly matched pairs. A tube socket may be ordered with all trigger components mounted on the socket. In many cases of trouble in the trigger circuit, it may be wise to replace the tube socket with all trigger circuit components mounted on it.

If after a reasonable length of time, the trouble cannot be found in a counter, it may be necessary to replace the counter chassis and return the old chassis to Endicott or repair the old chassis in the local office.

Read-in trouble affecting both multiplier and multiplicand counters can be in either the punch or the electronic unit. By observing the indicator light for the read-in pulse trigger, it can be determined whether this trigger is operating. If the trigger is operating properly and no pulses are getting to the counters, the power tube may be at fault. If the trigger fails, either the cam contacts in the punch unit are at fault, or the trigger tube or circuit is at fault.

If read-in is found to be correct, but the wrong product is obtained, the computation should be repeated at 5 cycle per second frequency. Visual observation of the indicator lights will show up any obvious troubles, such as failure of the primary or secondary timers, failure of any or all positions of the multiplier counter to advance, failure of any positions of the multiplicand counter to roll, failure of multiplicand read-out triggers, failure to column shift, etc. Once the trouble is localized to a certain function, visual observation of the indicator lights will show whether or not certain timing triggers are functioning, such as B3, A35, B16, B17, etc. Once a trouble is localized to a certain area, defective tubes may be easily found by exchanging suspected tubes with good tubes. Any trouble behind the chassis can be found by methods already discussed.

In some cases it may be desirable to resort to handpulsing so the computation may be stopped at any point desired. A microswitch mounted in a convenient holder is provided for manual pulsing. The switch is arranged so it may be jack-plugged in the chassis and placed in operation by setting the dial switch on the A chassis to KEY. When the microswitch is depressed, the manual pulse trigger goes ON and the indicator light on the A chassis glows. This produces a negative B pulse (or a positive A pulse) throughout the machine, provided the start trigger is ON. When the switch button is released, the manual pulse trigger again goes OFF, and a positive B pulse (or negative A pulse) is produced. Thus, the depressed position of the microswitch corresponds to index line pulses (0, 1, 2, 3, etc. on electronic cycle), while the normal position of the microswitch corresponds to mid-index line points (0.5, 1.5, etc.).

Often it may be helpful in analyzing a trouble, to stop computing after 1, 2, 3, 4, 5, or 6 column shifts either at 5-cycle speed or 35kc speed. Computation may be easily stopped after any column shift by removing the wire to post A45 (compute stop wire) from post C23. Then by means of a clip lead, attach the compute stop wire to post C38 to stop after the 1st column shift; to post C37 to stop after the 2nd column shift; to post C31 to stop after the 3rd column shift; to post C30 to stop after the 4th column shift; to post C24 to stop after the 5th column shift. No half-entry position should be wired when this is done.

Once computing stops after a given number of column shifts, trigger A32 is ON; therefore, a problem cannot be continued by merely turning the manual control dial switch to MANUAL. In order to carry a problem through one column shift at the time, proceed as follows:

1. Set manual control dial switch OFF.
2. Clip compute stop lead to post C38.
3. Read multiplier and multiplicand factors in by feeding card through entry brushes.
4. Turn manual switch to MANUAL for a moment and back to OFF; this will cause computation to go through 1st column shift leaving A32 triggers ON.

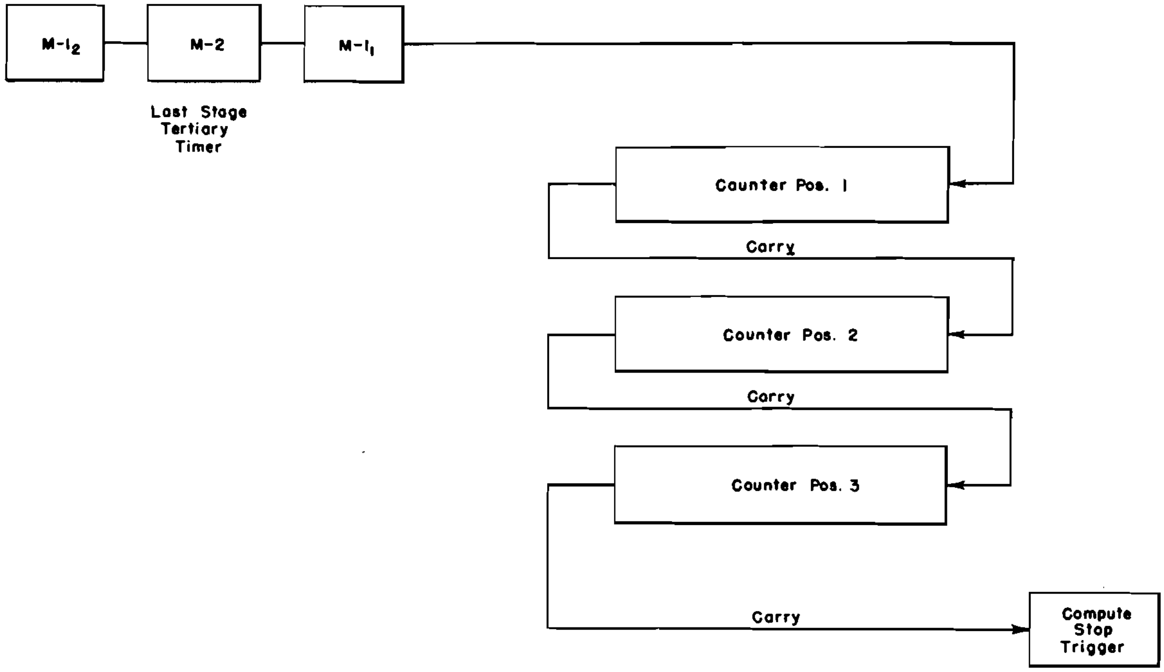


Figure 130. Connections for Manual Checking of Multivibrator Frequency

5. Turn trigger A32 OFF manually by touching the grid pin on the OFF side of A32 (pin 4) with a test lead clipped to +65 volts. (A test lead is provided with the machine for this purpose. A 0.2 megohm resistor is wired in the prod to limit grid current and to prevent a short in case the test lead is connected across "hot" terminals.)
6. Move compute stop lead to post C37.
7. Turn manual switch to MANUAL for a moment and back to OFF; this will cause computation through the 2nd column shift.
8. Repeat above process on through 6th column shift.

Of course it is not necessary to go through all these steps if a new card is fed through the punch after each computation. For example, clip the compute stop wire to post C38 and set dial switch to NORMAL. Then when a card is fed, the machine will compute the problem through the 1st column shift. Now move the compute stop wire to post C37 and feed a new card. This time the problem will be computed through the 2nd column shift. This may be repeated through the six column shifts.

If it is found that the computation is correct at 5-cycle speed, but fails at high speed, it may be that capacitance effect, weak triggers, etc., are at fault. In this case it may be necessary to resort to an oscilloscope. The use of an oscilloscope will be discussed in a later section. One of the first things that should be checked, when failure occurs at high speed only, is the frequency of the multivibrator. In case trouble develops in the multivibrator, resulting in a considerable increase in speed, trouble may be caused by exceeding the frequency rating of the triggers. Also, it is conceivable that the frequency may drop to such an extent that the computation is not finished before cancelling. Of course, this will show up only on automatic operation. In any event, the frequency of the multivibrator can easily be checked without instruments provided the machine is going through a problem properly as far as compute start, column shift, and compute stop are concerned. This is done by performing a problem 1000 times and timing the operation. Then, knowing the total number of cycles taken, it is only a matter of dividing the time into the total number of cycles taken during that time to obtain the frequency. The connections necessary to perform this test are indicated in Figure 130. To make the necessary connections, proceed as follows:

1. The compute stop wire is removed from post A45.
2. The input and output jumpers are removed from the first 3 positions of the multiplier (or multiplicand) counter.
3. Then clip a test lead from the output of counter position 1 (−50 volt output) to the input of counter position 2, and from the output of position 2 to the input of position 3. This will provide three counter positions in tandem, and starting from 0, 1000 pulses applied to the input of the 1st counter position will result in a carry pulse from the 3rd position.
4. The output of the 3rd counter position is clipped by a test lead to the input capacitor at the ON side of compute stop trigger A31. A convenient place to clip this lead is at the midpoint of the two .015 megohm resistors shown under A31 on the circuit diagram. When the 3rd position carries, computation will stop.
5. The input of the first counter position is wired to the anode of tube M1 (pin 5) by means of a test lead. M1 is the follower for the OFF side of trigger M2, which is the last stage of the tertiary timer. Each time M2 goes OFF, a negative pulse is produced at the anode of M1, to cause *1* to add in counter position 1.

With the above connections, the counters connected in tandem will count the computations. Only six column shifts are required to complete a problem; however, the tertiary timer returns to *0* at the 8th pulse and it is necessary to go through 8 column shifts for each computation. This is of no consequence, because nothing happens during the 7th and 8th column shifts except for advancing the timers. This does mean, however, that for each computation 1280 pulses (16 x 10 x 8) are required instead of 960 pulses. (The fact that the first computation starts with the tertiary timer at *1* does not change the total number of cycles taken sufficiently to take it into consideration.) Then, knowing that each computation requires 1280 pulses, it is obvious that 1000 computations represent 1,280,000 pulses.

With the above setup, the manual control dial switch is set to OFF and the frequency control dial switch is set to 35 KC. Then a card is fed through the punch. The manual switch is set to MANUAL and the time is observed. By watching the tertiary timer indicator lights (or the compute stop trigger indicator light), it can be easily determined when computation stops, and the time is again noted. By dividing the elapsed time in seconds into 1,280,000, the frequency is obtained. For example, if 40 seconds are required to complete a computation 1000 times, then the multivibrator frequency is 1,280,000/40 or 32,000 cycles per second. This frequency is not critical. A tolerance of ± 10% from the rated frequency is permissible.

The above method provides a medium for a test of the electronic unit. Of course, only three positions of the multiplier (or multiplicand) counter can be used for computing. After the problem has been computed 1000 times, the result in the product counter should be the same as for one computation with the decimal stepped over three places to the right, that is, with three zeros to the right.

Use of Neon Indicator Bulb, Voltmeter, and Oscilloscope

A neon indicator bulb which requires at least 90 volts to glow is a very useful tool in analyzing certain troubles. With this indicator the status of any trigger or tube can be determined by placing the leads of the indicator bulb between the ground and the anode of the tube in question. If a tube is conducting, the bulb will not glow, since the potential at the anode is considerably below +90 volts. On the other hand, the indicator bulb will glow if a tube is cut off, since the potential at the anode will be essentially +150 volts. In using a neon indicator, it must be borne in mind that a pulse passing through a small capacitor (50 – 250 mmfd) will not indicate, because the duration of the pulse is not sufficiently long to be visible.

It is not necessary to have a neon indicator bulb in the tool kit; one of the unused indicator bulbs on the electronic unit may be used. For example, bulb 5 in the indicator block in the A13 position is not used; consequently this bulb can be used as an indicator. By plugging the cable extension plug in socket A13, the indicator block can be carried to the rear of the chassis for observation. (An extension cable for the indicator blocks is furnished with each machine.) Since one side of all the bulbs in the indicator block is already grounded, it is necessary only to clip one test lead to pin 5 of the socket in A13. To prevent damage to the bulb, at least 0.2 megohm should be wired in series with the test lead. If the test lead with a 0.2 megohm resistor internally wired is clipped to pin 5 of socket A13, then the prod can be used as a pointer and by observing bulb 5 in the indicator block, the status of various tubes can be determined.

A volt-ohmmeter is an indispensable tool in servicing the electronic unit. For most uses a meter with as low a sensitivity as 1000 ohms per volt can be used. However, in order to check potentials in very high resistance circuits, such as grid circuits, it is necessary to have a high sensitivity of around 20,000 ohms per volt. Since it is not often necessary to determine grid potentials, it is not necessary to have a meter with a sensitivity as high as 20,000 ohms per volt for ordinary trouble shooting.

The anode potential of the 25L6's varies from about +150 volts, when non-conducting to about +20 to +30 volts when conducting. The anode potential at either anode of a trigger changes from approximately +40 volts to approximately +140 volts as the trigger goes ON and OFF. The potential at the anode of 6SK7's and triode sections of 12SN7's varies between approximately +50 volts and +150 volts as the tube goes from conducting state to non-conducting.

As in the case of the neon indicator, a meter cannot follow a pulse through a capacitor. The fastest speed that a meter can be expected to follow is about 2-3 pulses per second. When computing at 5-cycle speed, it is possible to check most operations by means of a voltmeter, since most operations occur at speeds less than 3 per second. Remember, though, that *a meter cannot detect pulses through a capacitor.* Only an oscilloscope will show pulses through a capacitor. Another very important fact to remember is that a low sensitivity meter will draw sufficient current to cause a trigger to operate when the meter lead is touched to the anode of the non-conducting tube of a trigger. Therefore, care must be exercised when checking the status of triggers with a meter; a false impression may be obtained if the voltmeter causes a trigger to trip.

Since grid current prevents grid potential from rising above cathode potential, the actual potential that a voltage divider produces cannot be checked with a tube in place. It is convenient to have a dummy tube with all base pins clipped except the heater pins for such purposes as checking positive potentials at grids, or to stop certain operations. The heater pins must be left in place because the tube filaments are wired in strings, and tubes other than the desired one may be rendered ineffective.

As already mentioned in connection with trouble analysis, an ohmmeter is quite useful in checking for shorted capacitors and resistors, or for shorted tube elements. Resistance values can also be determined, as well as open resistors or open circuits of any type.

The discussion of the use of an oscilloscope is limited to the use for the particular job of locating trouble on the computing unit under actual operating conditions. If it is desired to accurately reproduce square waves, an oscilloscope (usually abbreviated scope) must have an amplifier with an extremely flat characteristic up to several megacycles. Other than exact reproduction of waveform, however, any reasonably good scope can be used to view operations at high speed.

In order to attach significance to the scope pattern, it is necessary to calibrate the screen both horizontally and vertically. The signal input is applied to the vertical deflection plates through the vertical amplifier. Since a vertical deflection represents voltage, it is possible to apply a known voltage and calibrate the screen. The Y-gain switch (vertical amplifier) can be adjusted to produce a desired deflection on A or B pulses (post A54 or A53) and then left at this setting. The A and B pulses are known to be approximately 120 volts; therefore, the two extremes of the pulses can be marked on the screen, and a center line can be indicated as the reference. (Care must be exercised to remain on the flat surface of the screen as much as possible.) With these marks as guides, the voltage of any applied pulses can be determined fairly accurately.

In order to show phase relationships, it is necessary to use external synchronization. The best point to connect for external synchronization is at the indicator light for the last stage of the primary timer (A29). This connection is desirable because the 1 megohm resistor between the indicator light and the trigger isolates the scope and prevents any possible interference with the operation of the primary timer.

Since one problem requires such a short time, it is necessary to keep the unit in a computing state to view the patterns on a scope screen. The easiest method of doing this is to disconnect the wire on post M46, which is the input to the tertiary timer. Thus, the column shift cannot advance and once computation starts, the problem is repeated over and over in the first column shift. If it is desired to view operations in any other column shift, the column shift may be advanced by turning M5 OFF and ON manually by using the test lead with a 0.2 megohm resistor internally wired.

The horizontal deflection represents time, and by proper setting of the frequency range switches and by proper synchronizing, a steady pattern of one cycle or hundreds of cycles can be shown on the screen. Since the basic adding cycle consists of 16 cycles of the multivibrator, it is desirable to calibrate the screen into 16 pulses to represent the 16 points of the adding cycle.

In order to set up a cycle that has significance, it is necessary to reproduce on the scope screen patterns that exist at known times in the electronic cycle. For instance, the last stage of the primary timer goes ON at 8 and OFF at 0; therefore the pattern produced by applying the potential at the anode of either tube of trigger A29 to the scope can be used to establish 0 and 8 points of the cycle. Similarly, the output from other triggers or tubes can be used to establish all the points of the cycle. These points are calibrated on the scope screen and can then be used for timing reference.

It may be found easier to establish a fixed pattern of one cycle on the screen by first setting up a fixed pattern of 32 pulses (two primary cycles). Then by means of the horizontal location switch and the horizontal gain switch, the pattern can be spread out and located exactly where desired. Once a fixed pattern for one cycle is established, by applying the potential at various points the pattern for the multiplier advancing pulse, multiplicand rolling pulses, carry pulse, etc. may be viewed on the scope screen.

The table below shows where to touch the scope input prod to obtain the pattern indicated:

A pulses	—Post A54
B pulses	—Post A53
Input to primary timer	—Midpoint of A25 load resistor
First stage of primary timer	—Pin 2 or 5 of A26
Second stage of primary timer	—Pin 2 or 5 of A27
Third stage of primary timer	—Pin 2 or 5 of A28
Last stage of primary timer	—Pin 2 or 5 of A29
Multiplier advancing trigger	—Pin 5 of A35
Multiplier advancing pulse (+12)	—Post A33
Pulses to B3 trigger (-10, -14)	—Post A49
*Half-entry pulses	—Post A34
B3 trigger	—Pin 2 or 5 of B3
B16 trigger (0.5-10.5)	—Pin 5 of B16
10A pulses to roll multiplicand	—Post B22
10B pulses to column shift switches	—Post B58
+10 pulse to turn OFF multiplicand output triggers	—Post B45
-14 pulse to turn OFF carry triggers	—Post B50
Carry control pulse	—Post B51
Input to multiplier counter	—Post E1, E6, F1, F6, G1, G6
Input to multiplicand counter	—Post I1, I6, J1, J6, K1, K6
Output from multiplicand counter	—Post I21, I26, J21, J26, K21, K26
Input pulses to column shift switches	—Post O61 (during CS1) O60 (during CS2) O59 (during CS3) O58 (during CS4) O57 (during CS5) O56 (during CS6)
Output from column shift switches (before clipping)	—Anode load resistors in N and O chassis for switch tubes in O chassis.
Input to product counter from column shift switches and carry	—Post P1, P6, R1, R6, S1, S6, T1, T6, etc.

* To view half-entry pulses a dummy tube must be inserted in place of A14 to prevent blocking the A22 trigger.

PURPOSE OF TUBES IN THE COMPUTING SECTION

A1. Not used.

A2. Not used.

A3. Neon indicating bulb for manual pulser.

A4. Dial switch.

A5. Jack-plug for manual pulsing contact.

A6. Test Socket position for MP counter input triggers in C chassis.

A7 (*VR-150*). Voltage regulator tube for multivibrator to maintain +150 volts at anodes of MV to insure frequency stability.

A8 (*12SN7*). Manual pulse trigger to provide true square wave output from manually controlled pulser.

A9 (*12SN7*). 5 cycle multivibrator used for visual observation of computation when dial switch is set to 5 cycles.

A10 (*12SN7*). 35,000 cycle multivibrator used as master timer for all computations; generates essentially square waves of 35,000 cycles per second frequency.

A11 (*12SN7*). Clipper for multivibrator output; provides square wave output at anode of second stage.

A12. Not used.

A13. Test socket position for control triggers in A chassis.

$A14_1$ (*12SN7*). Blocking tube for A22 trigger to prevent A22 from turning ON as long as $A20_1$ is non-conductive, and thus allows A22 to turn ON only in 6th column shift cycle.

$A14_2$ (*12SN7*). Follower tube which conducts when A15 trigger is ON; provided to block the A22 trigger from turning ON again at *0* of 2nd through 10th primary cycles during 6th column shift cycle.

A15 (*12SN7*). Trigger controlling single entry of half-correction pulses through $A14_2$ follower tube; allows five half-entry pulses to enter product counter only once. Turned ON at 5 during the 1st primary cycle of the 6th column shift cycle from a negative pulse from A22 trigger; turned OFF by cancelling.

A16 (*25L6*). Power tube controlled by clipper output; produces square wave A pulses for operation of computing section.

$A17_1$ (*12SN7*). Follower for right-hand tube of 5 cycle MV; provides 5 cycle pulses to clippers and is necessary because direct coupling is required for such slow operation.

$A17_2$ (*12SN7*). Inverter from second stage of clipper to provide pulses of proper phase to A16 power tube.

A18 (*25L6*). Power tube controlled by clipper output; produces square wave B pulses for operation of computing section. B pulses are 180° out of phase with A pulses.

A19. Not used.

$A20_1$ (*12SN7*). Normally non-conducting triode which controls $A14_1$ blocking tube; prevents A22 trigger turning ON until 6th column shift cycle when $A20_1$ is conductive.

$A20_2$ (*12SN7*). Follower tube for $A26_1$, the OFF tube of the first stage of the primary timer. Used to avoid loading of trigger; conducts when A26 trigger is OFF.

A21 (*6SK7*). Switch tube providing negative pulses at *5*, *7*, *13*, and *15*; turns trigger A22 OFF at 5 after A22 has been turned ON. Negative pulses at *7*, *13*, and *15* are not used.

A22 (*12SN7*). Trigger controlling five pulses for half-correction; ON from *0* through 5 of 1st primary cycle during 6th column shift and conditions A23 switch to accept 5 B pulses for half-correction.

A23 (*6SK7*). Switch controlling pulses for half-entry; suppressor receives continuous stream of B pulses but grid conditions switch only when A22 trigger is ON.

A24 (*25L6*). Power tube controlled by A23 switch; provides 5 positive pulses to half-entry switches in N chassis.

A25 (*6SK7*). Start switch providing pulses to primary timer under control of trigger A31; A pulses applied to suppressor are inverted to B pulses for primary timer.

A26 (*12SN7*). First stage trigger of primary timer which turns ON every odd-numbered pulse from A25 switch and turns OFF at every even-numbered pulse, thus going ON eight times in each primary cycle.

A27 (*12SN7*). Second stage of primary timer which triggers when A26 goes OFF, therefore going ON every 4 pulses from A25 switch beginning at *2* and going OFF every 4 pulses beginning at *4*.

A28 (*12SN7*). Third stage of primary timer which triggers when A27 goes OFF, therefore going ON every 8 pulses from A25 switch beginning at *4* and going OFF every 8 pulses beginning at *8*.

A29 (*12SN7*). Fourth stage of primary timer which triggers when A28 goes OFF, therefore being ON from 8 to 0 of each primary cycle.

A30 Test socket position for primary timer.

A31 (*12SN7*). Trigger controlling starting and stopping of computations by conditioning A-25 start switch to accept A pulses; turned ON when A32 trigger goes ON and turned OFF at end of computation by negative pulse from column shift control.

A32 (*12SN7*). Compute start trigger under control of P24 cam contact in punch unit; turned ON by P24 and cancelled OFF. This trigger is necessary to permit the computation to terminate before P24 (or the manual control switch) opens.

A33 (*6SK7*). Switch providing negative pulses at *10* and *14* under control of primary timer to turn B3 trigger ON *and* OFF.

A34$_1$ (*12SN7*). Follower tube for OFF side of A29 trigger in primary timer; used to relieve load on trigger.

A34$_2$ (*12SN7*). Follower tube for ON side of A29 trigger.

A35 (*12SN7*). Control trigger for A36 power tube; ON at *8* and OFF at *12*. Conduction through A36 stops at 12 when A35 goes OFF.

A36 (*25L6*). Normally conducting power tube which stops conducting at *12* when A35 goes OFF to provide a positive pulse to advance the multiplier counter *1* for each primary cycle.

B1. Not used.

B2 (*25L6*). Stops conducting at *10* under control of B9$_1$ to provide a positive pulse to the L chassis for stopping the output of pulses from the multiplicand when transferring the multiplicand to the product counter.

B3 (*12SN7*). Control trigger ON from *10* through *14;* controls other tubes through the follower tubes B9$_1$ and B9$_2$.

B4 (*6SK7*). Switch tube for turning trigger *B16* ON at 0.5. Grid of B4 is conditioned by A34$_2$ from *0* through *8* and suppressor receives B pulses; only the *0.5* pulse is used to turn B16 ON.

B5 (*6SK7*). Switch providing 10 pulses from *0.5* through *10.5* under control of B11$_1$ and B11$_2$. A pulses are fed to the suppressor of B5; 10 are passed and fed to power tube B6 as B pulses.

B6 (*25L6*). Power tube providing ten A pulses for rolling multiplicand counter when transferring from MC to product counter. Ten B pulses applied to the grid of B6 appear as ten A pulses at the anode of B6.

B7 Test socket position for control triggers on B chassis.

B8 (*25L6*). Conducts at *14* under control of B9$_1$ to provide a negative pulse at *14* to turn OFF any carry triggers in W and X chassis which may be ON at end of adding cycle.

B9$_1$ (*12SN7*). Follower for ON side of trigger B3. Anode potential is low when B3 is ON from *10* through *14;* controls B8 and B2 power tubes.

$B9_2$ (*12SN7*). Follower for trigger B3 OFF side. Anode potential is high from *10* through *14* to condition B15 switch and B10 switch; also provides a negative pulse at *14* to advance the secondary timer.

B10 (*6SK7*). Switch controlling B16 trigger; turns B16 OFF at *10.5*. Grid of B10 is conditioned to conduct from *10* through *14* by $B9_2$ and suppressor receives B pulses, thus providing 4 negative pulses at *10.5*, *11.5*, *12.5*, and *13.5* to turn B16 OFF. Only the *10.5* pulse is used.

$B11_1$ (*12SN7*). Works in conjunction with $B11_2$ to condition the grid of B5 switch; allows B5 to accept A pulses only in the primary cycles following a carry-over in the multiplier counter. $B11_1$ is cut off and its anode is at high potential when trigger B17 is ON.

$B11_2$ (*12SN7*). Works in conjunction with $B11_1$ to condition the grid of B5 switch; allows ten A pulses to be passed by B5 provided B5 is not blocked by $B11_1$. $B11_2$ is cut off and its anode is at high potential when trigger B16 is ON.

B12 (*25L6*). Power tube providing ten B pulses to the column shift control tubes. The A pulses from B6 are inverted to B pulses for the column shift control tubes.

B13. Not used.

B14 (*25L6*). Cuts off from *10.5* through *14* under control of B15 switch to provide positive pulse for carry control; carry switches are conditioned to conduct by B14.

B15 (*6SK7*). Switch provided to control the carry control power tube B14; controlled by $B9_2$ and B16. $B9_2$ permits conduction from *10* through *14* by suppressor control, and B16 permits conduction from *10.5* through *0.5* by grid control, thus B15 can conduct only from *10.5* through *14*. The B16 control provides a half-cycle delay to insure that carry cannot occur until adding is complete.

B16 (*12SN7*). Trigger providing 10 pulse control; ON from *0.5* through *10.5* of every adding cycle under control of B4 and B10 switches.

B17 (*12SN7*). Multiplicand read-out control trigger provided to control the cycle during which the multiplicand starts receiving rolling pulses. B17 is turned ON by carry pulses from the multiplier counter at *12* and turned OFF by the secondary timer at the end of a column shift cycle.

B18. Test socket for secondary timer.

B19. Not used.

B20 (*12SN7*). First stage trigger of secondary timer which triggers at *14* of each primary cycle, going ON and OFF alternately.

B21 (*12SN7*). Second stage trigger of secondary timer which triggers when B20 goes OFF, therefore going ON at the second and sixth primary cycles. B27 blocks B21 on the tenth cycle.

B22 (*12SN7*). Third stage of secondary timer; triggers when B21 goes OFF, therefore going ON at the fourth primary cycle and remaining ON through the eighth.

B23 (*12SN7*). Fourth stage of secondary timer; ON during the 8th and 9th primary cycles under control of B20 and B22. When B23 goes OFF, a negative pulse is provided to turn B17 trigger OFF and to advance the tertiary timer.

B24 (*12SN7*). Follower for ON side of B23 trigger in the secondary timer. Provides advancing pulses for the tertiary timer (column shift control) at the end of the 10th primary cycle.

B25. This position is used for the voltage adjusting potentiometer in the +65 volt power supply.

B26 (*6SJ7*). Voltage control pentode for voltage regulating circuit providing +65 volt supply.

B27 (*12SN7*). Blocking tube to prevent B21 trigger from turning ON for the 10th primary cycle; used to make a scale of ten counter from a straight binary counter.

B28 (*25L6*). Normally non-conducting power tube which conducts when B29 trigger goes OFF; provides negative pulses at mid-index lines in synchronism with card movement through punch to turn OFF any carry and punch control triggers in W and X chassis which happen to be ON, thus preventing under-punching of card.

B29 (*12SN7*). Trigger providing 10 index lines pulses for read-out control; turns ON at punch index lines *9* through *0* when P7 and P8 make and turns OFF at mid-index points beginning at *9.5* when P5 and P6 make. Provides negative pulses at index lines to B30 power tube and positive pulses at mid-index lines to B28 power tube.

B30 (*25L6*). Normally conducting power tube providing 10 positive pulses at index lines in synchronism with card movement through punch for rolling the product counter when reading out. Negative pulses produced when B29 goes ON control B30.

B31 through B34 (*25L6*). Power tubes for voltage regulating circuit used to provide +*65* volts. Four tubes are used to furnish the necessary current demand.

B35 (*12SN7*). Trigger providing 9 pulses at punch mid-index time for read-in control from card; turns ON when P5 and P6 make at mid-index lines *9.5* through *1.5*, and turns OFF when P7 and P8 make at *8* through *0*. Negative pulses cut off B36 power tube each time B35 trigger goes ON.

B36 (*25L6*). Normally conducting power tube providing 9 positive pulses at mid-index times in synchronism with card movement through punch for read-in control. Positive pulses are applied to the suppressors of the multiplier and multiplicand read-in switches.

C1 (*12SN7*). Multiplier read-in trigger for units position of multiplier counter; turned ON when brush wired to this position makes contact through the hole in the card and turned OFF by cancelling.

C2 (*6SK7*). Multiplier read-in switch provided to control the number of pulses entering the units position of the multiplier counter; its grid is conditioned by C1 being ON and suppressor receives read-in pulses from B36.

C3 (*6SK7*). Multiplying control switch controlling entry of pulses for rolling the units position of the multiplier counter; its grid is conditioned by the column shift controls to conduct only during the 6th column shift cycle and its suppressor receives a positive pulse at *12* of each primary cycle from A36 to advance the multiplier counter by *1*.

C4, C7, C10, C13, and C16 (*12SN7*). Same as C1 for 2nd through 6th multiplier counter positions.

C5, C8, C11, C14, and C17 (*6SK7*). Same as C2 for 2nd through 6th counter positions.

C6, C9, C12, C15, and C18 (*6SK7*). Same as C3 for 2nd through 6th counter positions.

D1 (*12SN7*). Multiplicand read-in trigger for units position of multiplicand counter; turned ON when brush wired to this position makes contact through a hole in the card and turned OFF by cancelling.

D2. Test socket for multiplicand input triggers.

D3 (*6SK7*). Multiplicand read-in switch provided to control the number of pulses entering the units position of the multiplicand counter.

D4, D7, D10, D13, and D16 (*12SN7*). Same as D1 for 2nd through 6th positions of multiplicand.

$D5_1$ (*12SN7*). Read-in inverter to feed ten B pulses to first position of the multiplicand counter for rolling the counter when transferring the multiplicand to the product counter. Ten A pulses from B6 are inverted to B pulses for rolling the counter.

$D5_2$, D11, and D14 (*12SN7*). Same as $D5_1$ for 2nd through 6th position of multiplicand counter.

D6, D9, D12, D15, and D18 (*6SK7*). Same as D3 for 2nd through 6th positions of multiplicand counter.

D8 and D17. Not used.

E, F, G, chassis are the multiplier counter chassis. The purpose of any tube in any counter position is the same as the corresponding tube in the secondary timer, which is a decimal counter.

$H1_1$ (*12SN7*). Multiplier output inverter provided to signal carry-over from units multiplier counter position; negative pulse at anode of $H1_1$ turns B17 trigger ON when units position of multiplier counter carries.

H_2, H3 and H5 (*12SN7*). Same as $H1_1$ for 2nd through 6th positions of multiplier counter.

H2, H4, and H6. Not used.

I, J, K chassis are the multiplicand counter chassis.

L1. Not used; spare 12SN7 tube is mounted in this position.

L2 (*12SN7*). Output trigger for the units position of the multiplicand counter; turned ON when units position of multiplicand counter carries and turned OFF at *10* under control of $L4_2$ by pulse from B2. L2 controls the number of pulses passed to the product counter under control of the units position of the multiplicand counter.

L3. Not used; spare 12SN7 tube is mounted in this position.

$L4_1$ (*12SN7*). Follower for the OFF side of trigger L2, provided to condition all column shift switches connected to the units position of the multiplicand. When L2 is ON, $L4_1$ is nonconducting, and its high anode potential conditions the corresponding column shift switches.

$L4_2$ (*12SN7*). Blocking tube controlling the OFF side of L2 trigger. A positive pulse at *10* from B2 causes momentary conduction through $L4_2$ and the drop in the anode potential of $L4_2$ triggers L2 OFF, thus stopping further pulses from passing to the product counter through the column shift switches. Also, $L4_2$ blocks L2 from turning ON when transferring 0's. When transferring 0's, carry comes at *10* to turn $L2_2$ ON but $L4_2$ is conducting at *10* time and blocks L2 from turning ON.

L5. Test socket for multiplicand output triggers.

L6, L8, L10, L11, L13, L15, L16, L18, L20, L21, L23, L25, L26, L28, and L30. Not used; spare 12SN7 tubes mounted in these positions.

L7, L12, L17, L22, and L27 (*12SN7*). Same as L2 for 2nd through 6th positions of multiplicand.

L9, L14, L19, L24, and L29 (*12SN7*). Same as $L4_1$ and $L4_2$ for 2nd through 6th positions of multiplicand.

$M1_1$ (*12SN7*). Follower for OFF side of M2 trigger (third stage of tertiary timer) provided to control interpolating tubes in column shift control circuit.

$M1_2$ (*12SN7*). Follower for ON side of M2 trigger (third stage of tertiary timer) provided to control interpolating tubes.

M2 (*12SN7*). Third stage of tertiary timer which turns ON when M3 goes OFF, stays ON for the 4th, 5th, and 6th column shift cycles, and is cancelled OFF.

M3 (*12SN7*). Second stage of tertiary timer which triggers when M5 goes OFF, therefore being ON for the 2nd, 3rd, and 6th column shift cycles.

$M4_1$ (*12SN7*). Follower for OFF side of M3 trigger.

M4 (*12SN7*). Follower for ON side of M3 trigger.

M5 (*12SN7*). First stage of tertiary timer which triggers each time secondary timer carries over; ON for the 1st, 3rd, and 5th column shift cycles.

$M6_1$ (*12SN7*). Follower for OFF side of M5 trigger.

$M6_2$ (*12SN7*). Follower for ON side of M5 trigger.

M7. Test socket for indicator lights for tertiary timer.

M8. Not used; spare 12SN7.

$M9_1$ (*12SN7*). Interpolating tube blocking tube $M16_1$ in conjunction with $M9_2$ and $M16_2$ to permit $M16_1$ to conduct only during the 6th column shift cycle.

$M9_2$ (*12SN7*). Interpolating tube which blocks $M16_1$ in conjunction with $M9_1$ and $M16_2$ to permit $M16_1$ to conduct only during the 6th column shift cycle.

$M10_1$ (*12SN7*). Interpolating tube blocking $M17_1$ in conjunction with $M10_2$ and $M17_2$ to permit $M17_1$ to conduct only during the 5th column shift cycle.

$M10_2$ (*12SN7*). Interpolating tube which blocks $M17_1$ in conjunction with $M10_1$ and $M17_2$ to permit $M17_1$ to conduct only during the 5th column shift cycle.

$M11_1$ (*12SN7*). Works with $M11_2$ and $M18_2$ to permit $M18_1$ to conduct only during 4th column shift cycles.

$M11_2$ (*12SN7*). Works with $M11_1$ and $M18_2$ to permit $M18_1$ to conduct only during the 4th column shift cycle.

$M12_1$ (*12SN7*). Works with $M12_2$ and $M19_2$ to permit conduction by $M19_1$ only during 3rd column shift cycle.

$M12_2$ (*12SN7*). Works with $M12_1$ and $M19_2$ to permit conduction by $M19_1$ only during 3rd column shift cycle.

$M13_1$ (*12SN7*). Works with $M13_2$ and $M20_2$ to permit conduction by $M20_1$ only during 2nd column shift cycle.

$M13_2$ (*12SN7*). Works with $M13_1$ and $M20_2$ to permit conduction by $M20_1$ only during 2nd column shift cycle.

$M14_1$ (*12SN7*). Works with $M14_2$ and $M21_2$ to permit conduction by $M21_1$ only during 1st column shift cycle.

$M14_2$ (*12SN7*). Works with $M14_1$ and $M21_2$ to permit conduction by $M21_1$ only during 1st column shift cycle.

M15. Not used; spare 12SN7.

$M16_1$ (*12SN7*). Conducts during 6th column shift cycle only, when all interpolating blocking tubes are non-conducting. Cuts off power tube M23 to provide high potential on 6th column shift at anode of M23.

$M16_2$ (*12SN7*). Works with $M9_1$ and $M9_2$ to permit $M16_1$ to conduct only during 6th column shift cycle.

$M17_1$ (*12SN7*). Conducts during 5th column shift cycle, when all blocking tubes are non-conducting, to cut off power tube M24.

$M17_2$ (*12SN7*). Works with $M10_1$ and $M10_2$ to permit $M17_1$ to conduct only during 5th column shift cycle.

$M18_1$ (*12SN7*). Conducts during 4th column shift cycle when all blocking tubes are non-conducting, to cut off M25.

$M18_2$ (*12SN7*). Works with M11 to permit $M18_1$ to conduct during the 4th column shift cycle.

$M19_1$ (*12SN7*). Conducts during the 3rd column shift cycle when all interpolating blocking tubes are non-conducting to cut off M26.

$M19_2$ (*12SN7*). Works with M12 to permit $M19_1$ to conduct during the 3rd column shift.

$M20_1$ (*12SN7*). Conducts during 2nd column shift cycle when all interpolating blocking tubes are non-conducting to cut off M27.

$M20_2$ (*12SN7*). Works with M13 to permit $M20_1$ to conduct during the 2nd column shift cycle.

$M21_1$ (*12SN7*). Conducts during 1st column shift cycle only when all blocking tubes are non-conducting to cut off power tube M28.

$M21_2$ (*12SN7*). Works with M14 to permit $M21_1$ to conduct only during the 1st column shift cycle.

M22. Not used; spare 12SN7 tube mounted in this position.

M23 (*25L6*). Power tube controlling 6th column shift; stops conducting when $M16_1$ conducts and thus conditions units position multiply input switch C3, column shift control switch M30, and half-entry control $A20_1$ for conduction during 6th column shift cycle. M23 also turns A31 OFF at end of 6th column shift cycle to stop computations.

M24 (25L6). Stops conducting when $M17_1$ conducts during 5th column shift cycle to condition multiply input switch C6 and column shift control switch M31.

M25 (25L6). Stops conducting when $M18_1$ conducts during 4th column shift cycle to condition multiply input switch C9 and column shift control switch M32.

M26 (25L6). Stops conducting when $M19_1$ conducts during 3rd column shift cycle to condition multiply input switch C12 and column shift control switch M33.

M27 (25L6). Stops conducting when $M20_1$ conducts during 2nd column shift cycle to condition multiply input switch C15 and column shift control switch M34.

M28 (25L6). Stops conducting when $M21_1$ conducts during the 1st column shift cycle to condition multiply input switch C18 and column shift control switch M35.

M29. Not used; spare 12SN7 mounted in this position.

M30 (6SK7). Switch controlling stream of 10 pulses to column shift switches for adding into product counter on 6th column shift cycle; suppressor is conditioned to conduct by M23 and grid receives ten B pulses.

M31 through M35 (6SK7). Same as M30 for 5th through 1st column shift cycles.

M36. Not used; spare 12SN7 tube mounted in this position.

M37 (25L6). Power tube supplying ten B pulses to column shift switches in O chassis during the 6th column shift cycle under control of switch M30.

M38 through M42 (25L6). Same as M37 for 5th through 1st column shift cycles.

N1 (6SK7). Half-entry input switch for first position of products counter; 5 pulses from A24 during first primary cycle of last column shift cycle are passed to units position of product counter provided the units position is wired for half-entry.

$N2_1$ (12SN7). Inverter controlling read-out pulses from B30 to units position of the product counter for rolling product counter when punching; positive pulses from B30 are inverted to negative pulses for operating the triggers in the counter.

$N2_2$, N5, N8, N11, N14, and N17 (12SN7). Same as $N2_1$ for 2nd through 12th positions of the product counter.

$N3_1$ (12SN7). Clipper for re-shaping the output from column shift switches in O chassis to 1st position of product counter. Because of the internal capacity of the parallel switches in the O chassis, the waveform leaving the O chassis is far from a square wave and the voltage amplitude of different positions varies; therefore the output from the O chassis must be re-shaped before entering the products counter.

$N3_2$ (12SN7). Inverter for clipper $N3_1$. Required because of phase reversal by clipper; the A pulses leaving the column shift switches are inverted to B pulses by the clipper, hence they must be inverted again to A pulses before entering the products counter.

N4, N7, N10, N13, and N16 (6SK7). Same as N1 for 2nd through 6th positions of product counter.

N6, N9, N12, N15, and N18. Same as $N3_1$ and $N3_2$ for 2nd through 6th positions of product counter.

O1 through O6 (6SK7). Column shift switches controlling exit from first position of multiplicand counter to 1st through 6th positions of product counter. Grids of these switches are all conditioned by multiplicand output trigger and follower $L4_1$; suppressors successively receive stream of ten B pulses in reverse order O6, O5, etc. from proper column shift control power tube in M chassis.

O7 (*12SN7*). Dummy tube for filling out filament string.

O8 through O13 (*6SK7*). Same as O1 through O6 for exit from 2nd position of multiplicand to 2nd through 7th positions of product.

O14 (*12SN7*). Same as N3; clipper and inverter for output to 7th position of products counter.

O15 through O20 (*6SK7*). Same as O1 through O6 for exit from 3rd position of multiplicand to 3rd through 8th positions of product.

O21 (*12SN7*). Clipper and inverter for output to 8th position of product counter.

O22 through O27 (*6 SK7*). Same as O1 through O6 for exit from 4th position of multiplicand to 4th through 9th positions of product.

O28 (*12SN7*). Clipper and inverter for output to 9th position of product.

O29 through O34 (*6SK7*). Same as O1 through O6 for exit from 5th position of multiplicand to 5th through 10th positions of product.

O35 (*12SN7*). Clipper and inverter for output to 10th position of product.

O36 through O41 (*6SK7*). Same as O1 through O6 for exit from 6th position of multiplicand to 6th through 11th positions of product.

O42 (*12SN7*). Clipper and inverter for output to 11th position of product.

P, R, S, T, U, V, chassis are the product counter chassis.

W1 (*12SN7*). Carry and read-out trigger which turns ON when 1st position of product counter carries. Controls read-out from 1st position of product counter and carry from 1st to 2nd position. When carrying, W1 turns OFF at *14* of each adding cycle by pulse from B8; when reading out, turned OFF by B28 at punch mid-index point following carry.

W2 (*6SK7*). Carry switch controlling carry from 1st to 2nd position of product counter; W1 trigger conditions grid and suppressor is raised above cutoff from *10.5* through *14* by B14 to permit carry.

W6, W11, W16, W21, and W26 (*12SN7*). Same as W1 for positions 2 through 6 of product counter.

W7, W12, W17, W22, and W27 (*6SK7*). Same as W2 for positions 2 through 6 of product counter.

W13. Test socket for carry and read-out triggers in W chassis.

All other tubes in W chassis not used; spare 6SK7 and 25L6 tubes are mounted in these positions.

X1, X6, X11, X16, X21, and X26 (*12SN7*). Same as W1 for positions 7 through 12 of product counter.

X2, X7, X12, X17, and X22 (*6SK7*). Same as W2 for positions 7 through 11 of product counter.

X3. Test socket for carry and read-out triggers in X chassis.

X27 (*6SK7*). Dummy tube to fill out filament string.

All other tubes in X chassis not used.

Y1. Not used.

Y2, Y3 (*25L6*). Power tubes in parallel used to energize punch magnet wired to 1st position of product counter under control of $Y4_1$.

$Y4_1$ (*12SN7*). Inverter controlling Y2 and Y3 power tubes; conducts normally and is cut off when carry and read-out trigger for units position of product counter goes ON. When $Y4_1$ stops conducting, the positive pulse at its anode is transmitted to the grids of Y2 and Y3 to allow conduction and thus energize the punch magnet.

$Y4_2$ (*12SN7*). Same as $Y4_1$ for 2nd position of product counter.

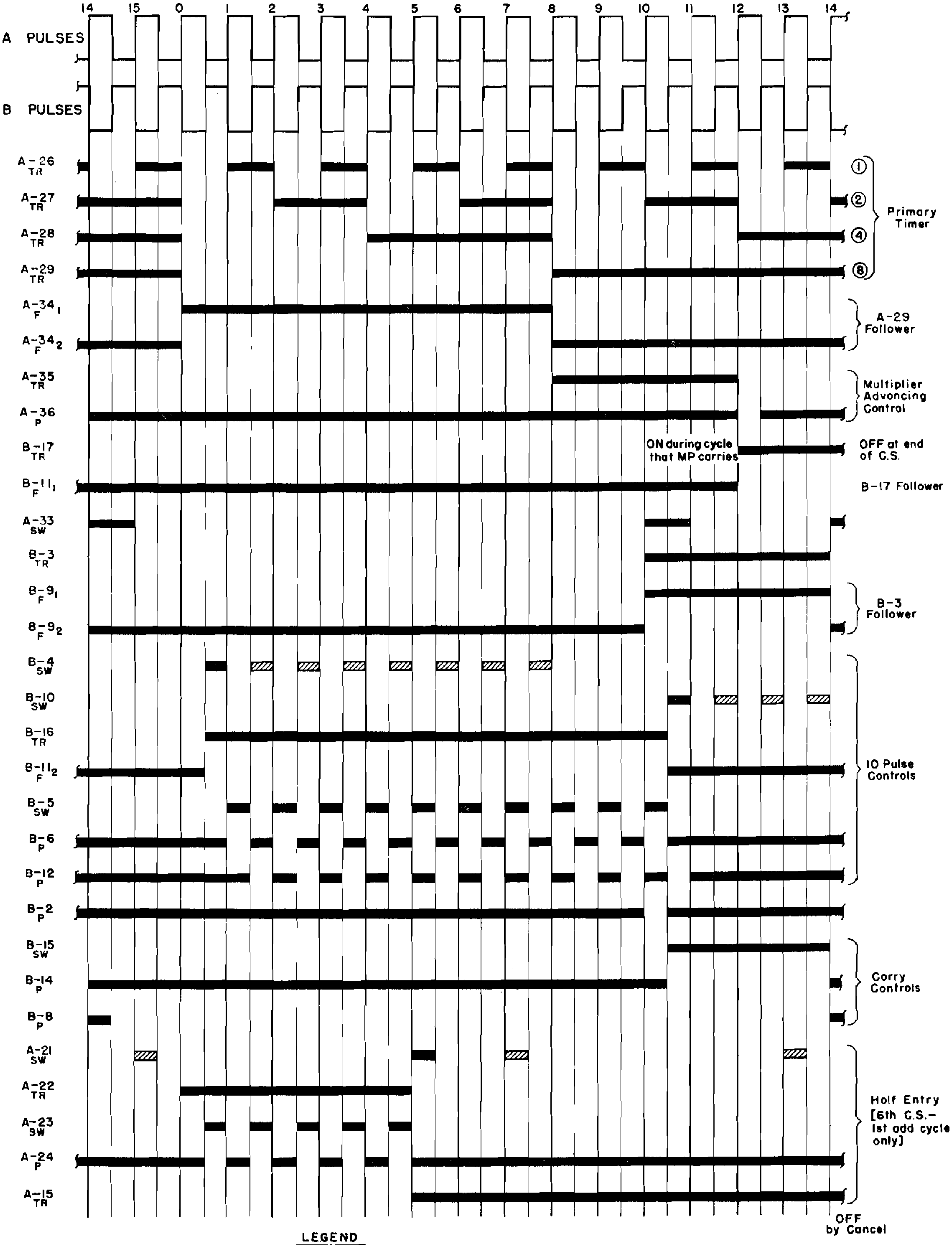
Y5, Y6, Y8, Y9, Y11, Y12, Y14, Y15, Y17, and Y18 (*25L6*). Same as Y2 and Y3 for 2nd through 6th positions of product counter.

Y7, Y16. Not used.

Y10, Y13 (*12SN7*). Same as $Y4_1$ for 3rd through 6th positions of product counter.

Z chassis is arranged just like the Y chassis and serves exactly the same purpose for product counter positions 7 through 12.

603 ELECTRONIC TIMING CHART



LEGEND

TR – Trigger
SW – Switch
F – Follower
P – Power Tube

■ Indicates tube is conducting (ON side in case of trigger)
▨ Indicates pulses produced but not used