April 11, 1961 J. P. ECKERT, JR., ET AL 2,978,977

HIGH SPEED PRINTER

Filed Feb. 4, 1955

6 Sheets-Sheet 1

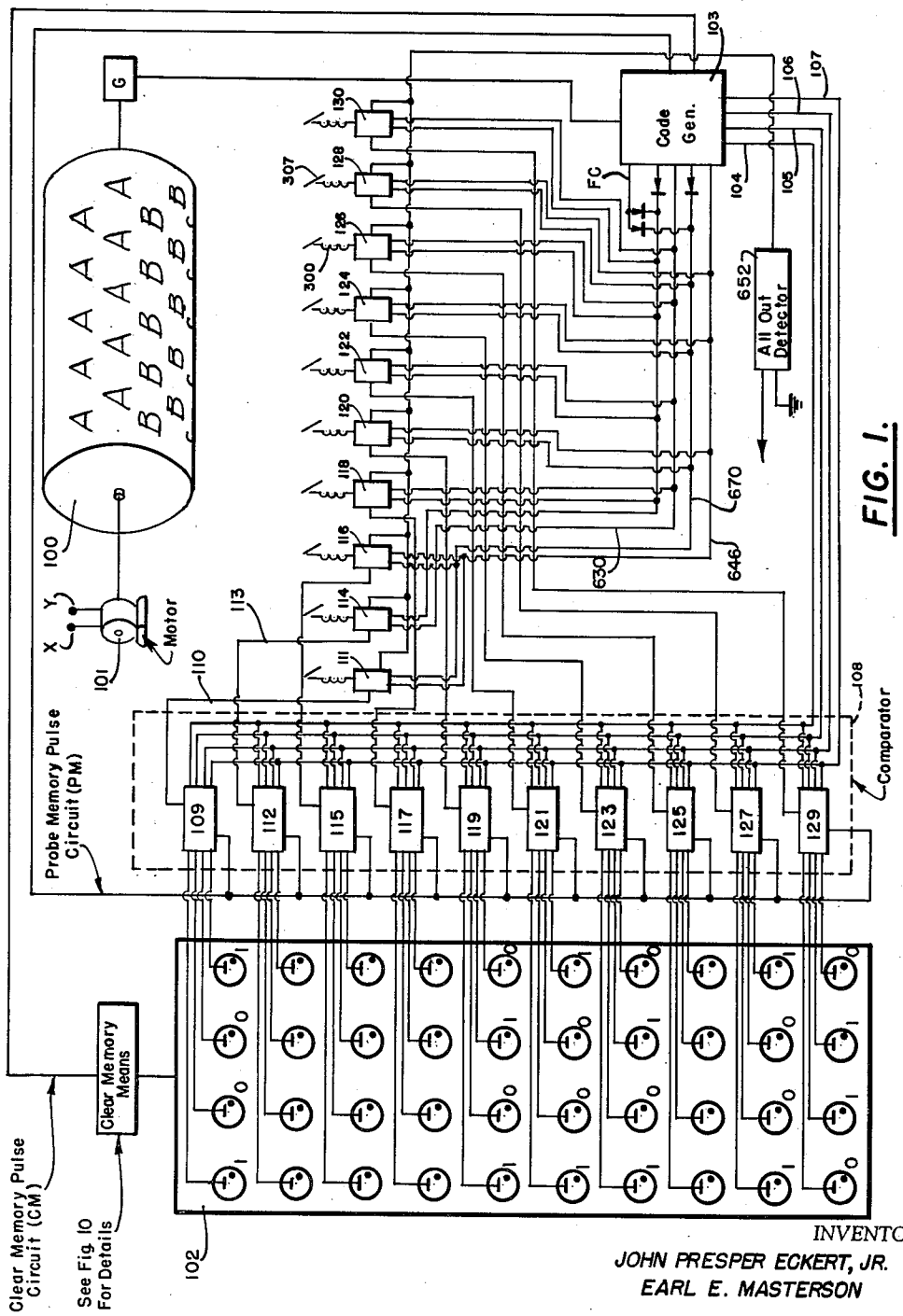


FIG. 1.

INVENTORS

JOHN PRESPER ECKERT, JR.

EARL E. MASTERSON

BY Charles E. English

AGENT

April 11, 1961 J. P. ECKERT, JR., ET AL 2,978,977

HIGH SPEED PRINTER

Filed Feb. 4, 1955 6 Sheets-Sheet 2

FIG. 2.

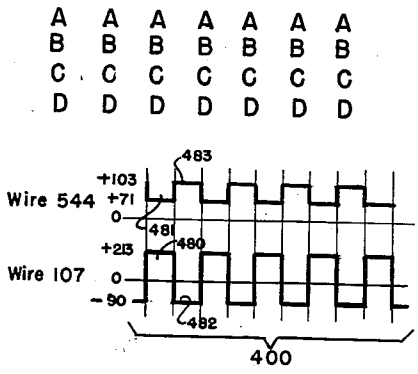
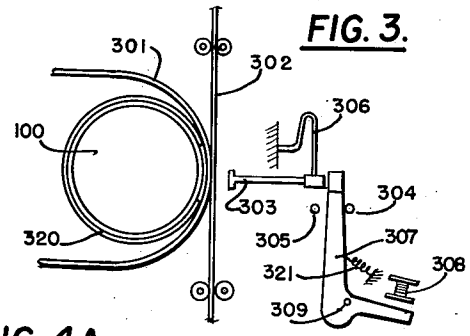


FIG. 4A.

FIG. 3.



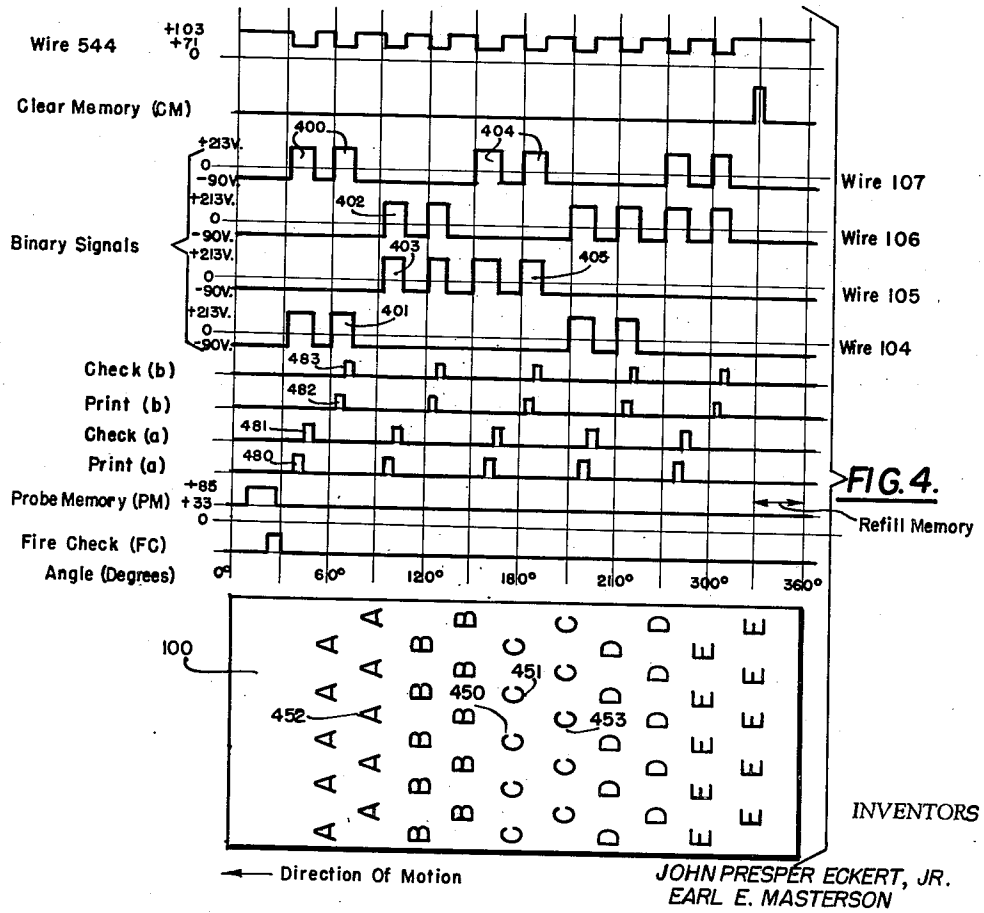


FIG. 4.

INVENTORS

JOHN PRESPER ECKERT, JR.
EARL E. MASTERSON

BY Charles C. English

AGENT

April 11, 1961 J. P. ECKERT, JR., ET AL 2,978,977

HIGH SPEED PRINTER

Filed Feb. 4, 1955 6 Sheets-Sheet 3

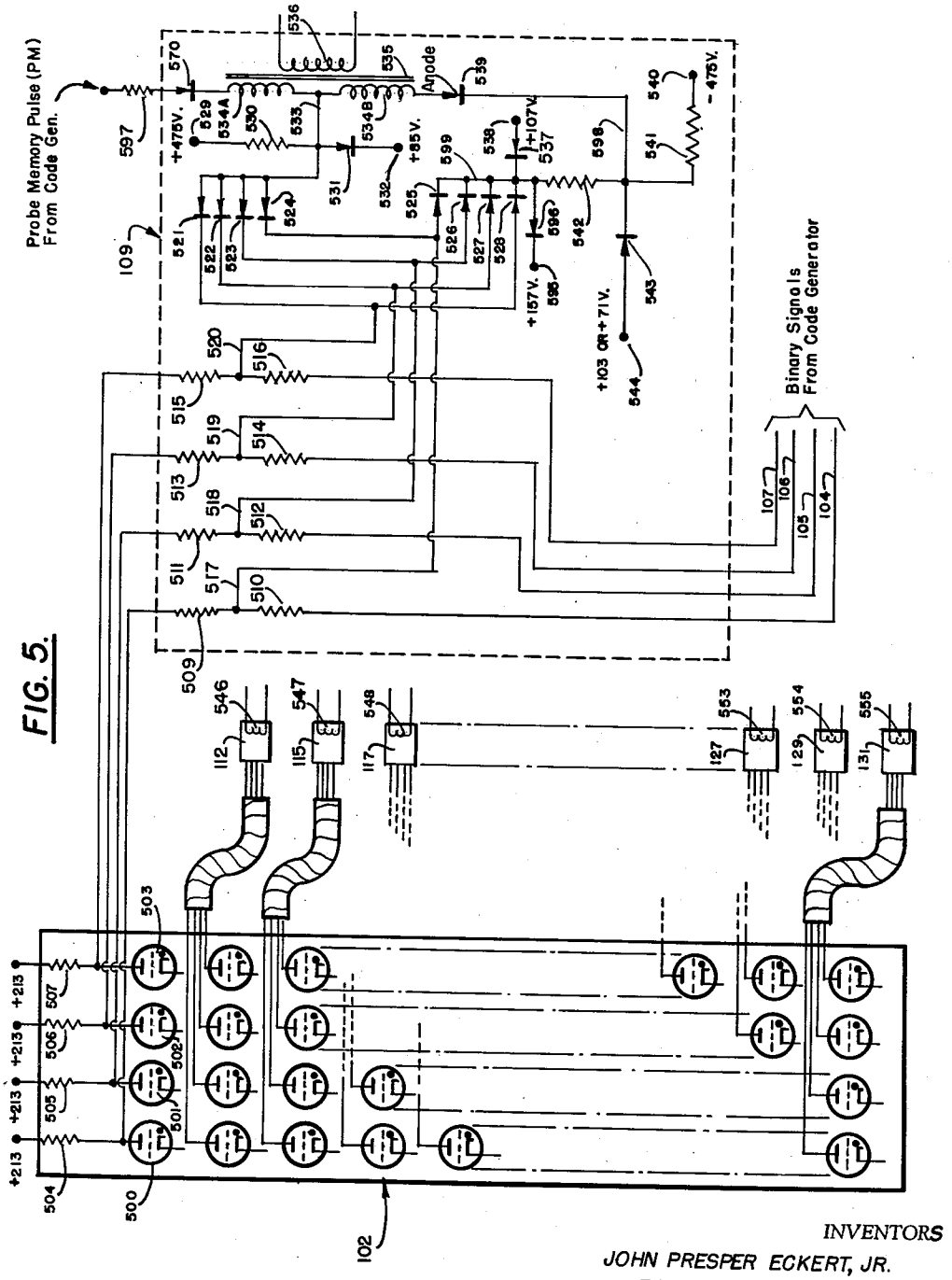


FIG. 5.

INVENTORS
JOHN PRESPER ECKERT, JR.
EARL E. MASTERSON

BY Charles C. English
AGENT

April 11, 1961 J. P. ECKERT, JR., ET AL 2,978,977

HIGH SPEED PRINTER

Filed Feb. 4, 1955

6 Sheets-Sheet 4

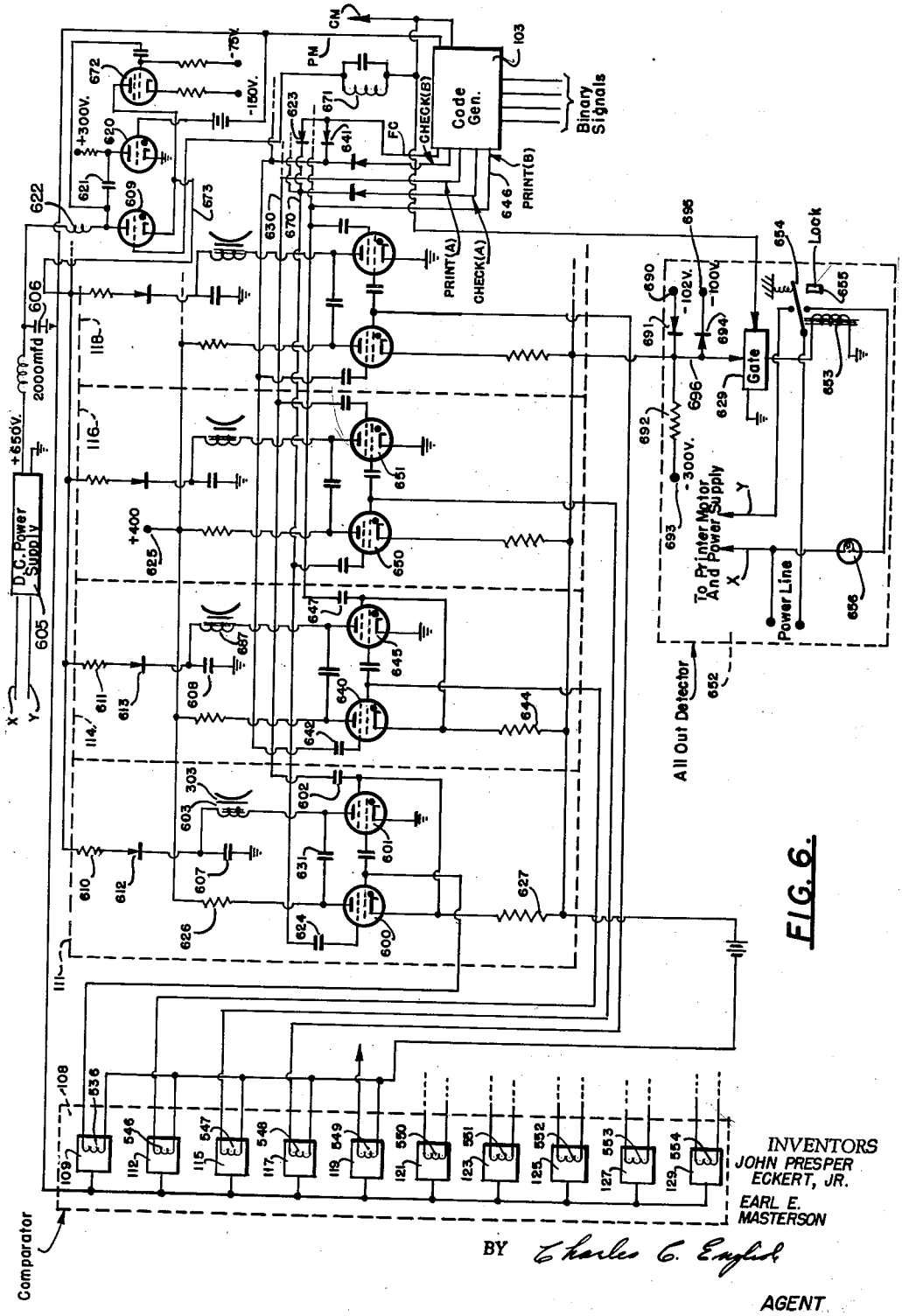


FIG. 6.

INVENTORS
JOHN PRESPER ECKERT, JR.
EARL E. MASTERSON

BY Charles C. English

AGENT

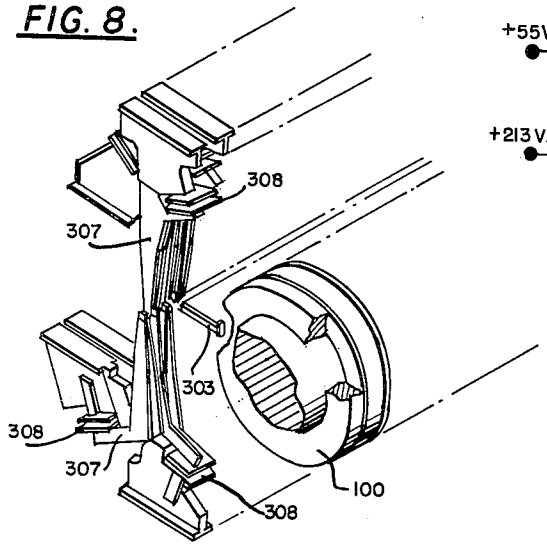
April 11, 1961 J. P. ECKERT, JR., ET AL 2,978,977

HIGH SPEED PRINTER

Filed Feb. 4, 1955

6 Sheets-Sheet 5

FIG. 8.



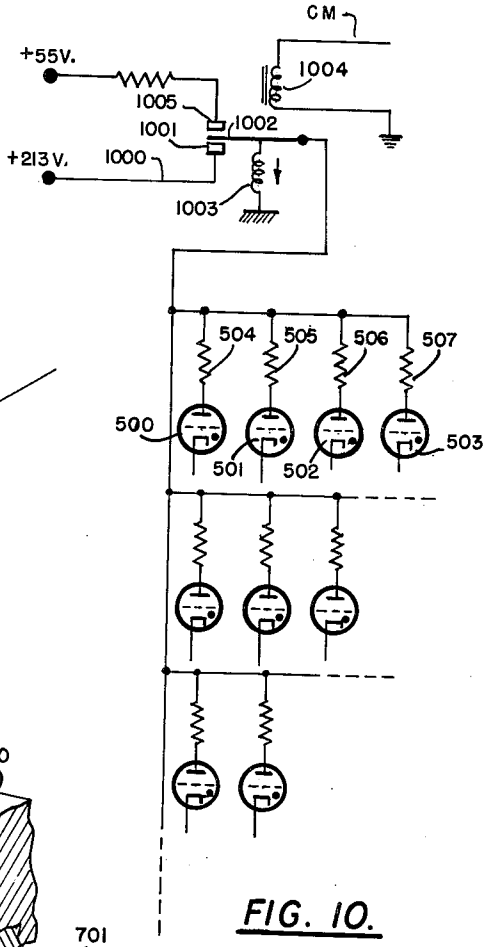


FIG. 10.

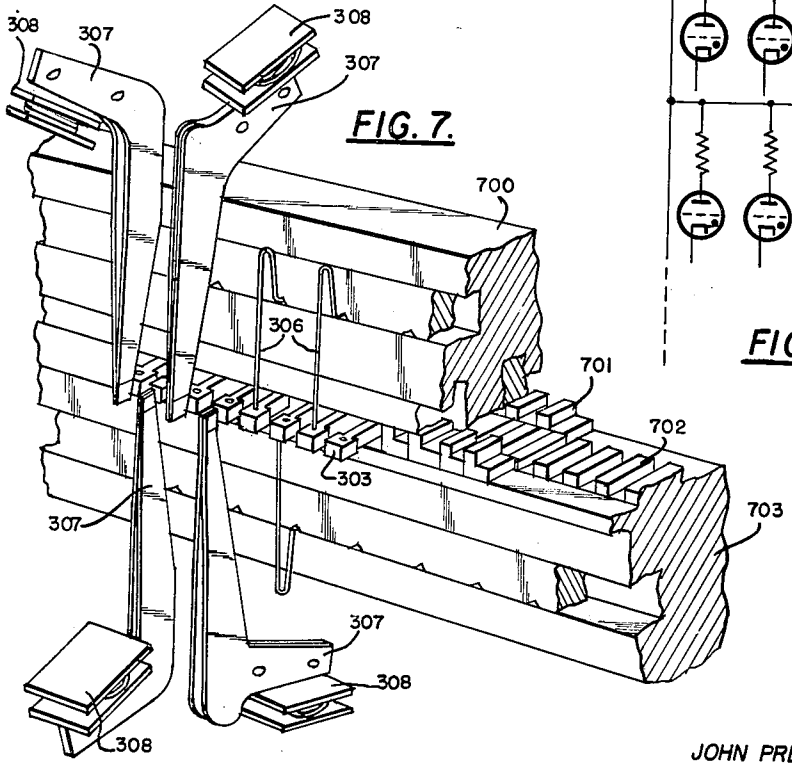


FIG. 7.

INVENTORS
JOHN PRESPER ECKERT, JR.
EARL E. MASTERSON

BY Charles C. English

AGENT

April 11, 1961 J. P. ECKERT, JR., ET AL 2,978,977

HIGH SPEED PRINTER

Filed Feb. 4, 1955

6 Sheets-Sheet 6

FIG. 9.

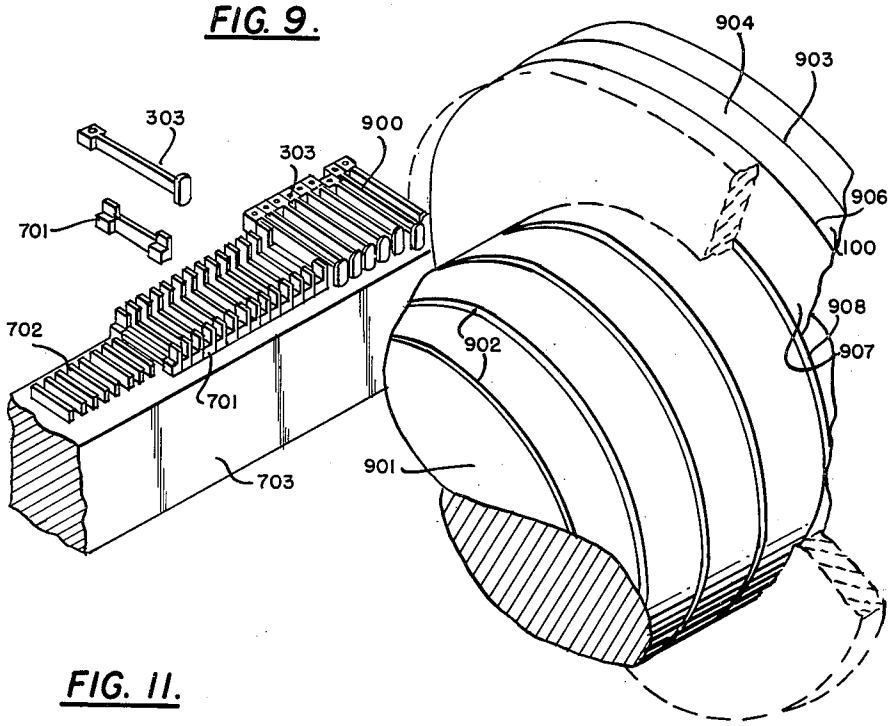
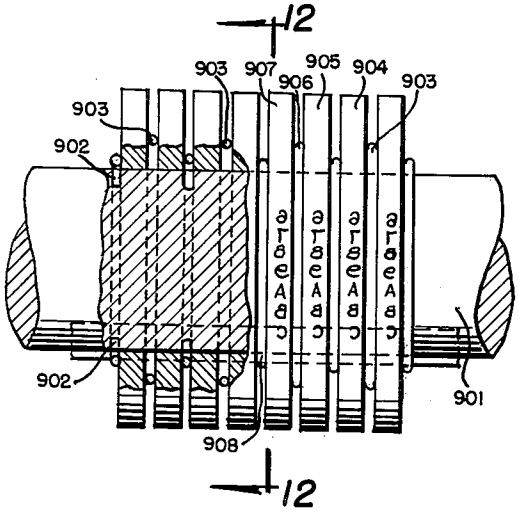


FIG. 11.



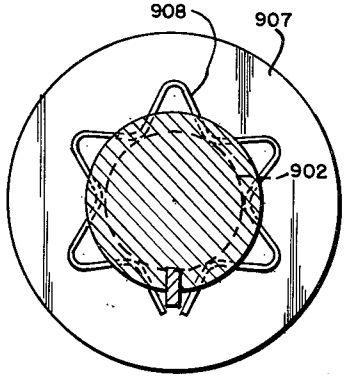


FIG. 12.

INVENTORS
JOHN PRESPER ECKERT, JR.
EARL E. MASTERSON

BY
Charles C. English
AGENT

United States Patent Office 2,978,977 Patented Apr. 11, 1961

2,978,977

HIGH SPEED PRINTER

John Presper Eckert, Jr., Philadelphia, and Earl E. Masterson, Bryn Mawr, Pa., assignors to Sperry Rand Corporation, a corporation of Delaware

Filed Feb. 4, 1955, Ser. No. 486,206

30 Claims. (Cl. 101—93)

This invention relates to high speed printers and more particularly to devices which print the information stored in a memory. The invention provides an improved electric circuit for transferring the information from the memory to the actuators of the printer, although there are other features hereinafter described and claimed.

The present invention is particularly concerned with, although not limited to, that type of printing device having a continuously rotating typewheel cooperating with printing hammers. The paper is fed between the typewheel and the hammers, and at appropriate times the several hammers are independently actuated to print the different characters involved. This arrangement is now well known in the art as a means for printing the output of an electronic computer. In view of the fact that the electronic computer output operates the high speed printer automatically, it is desirable to prevent errors from occurring in the printing. Electronic computers in combination with high speed printers are often employed for determining and/or printing information which is of great importance in many business transactions and if an error should occur it may result in great financial loss. For example, it has now become the practice in some organizations to write checks with the high speed printer and a single error could cause the loss of a considerable amount of money. Other business decisions involving large amounts of money are often made based on the information obtained from an electronic computer and here again it is desirable to reduce the possibility of error.

It is a primary object of this invention to provide a checking circuit for a high speed printer which will give an indication in event of a printing error.

An additional object of the invention is to temporarily terminate the operation of the machine in event of a printing error.

Another object of the invention is to provide a checking circuit for a high speed printer which will give an indication in event of an unwanted noise signal.

Another object of the invention is to temporarily terminate the operation of the machine in event of an unwanted signal in the circuit.

Still another object of the invention is to provide a checking circuit of general application.

Another object of the invention is to insure that in response to each actuation of a printing hammer, only one character is printed, and that other characters not directly struck by the hammer are not printed.

Yet another object of the invention is to provide an improved comparator system for electronic digital apparatus.

Still another object of the invention is to provide an improved hammer actuator for high speed printers.

In carrying out the aforesaid objects, the characters on the typewheel are staggered in a manner very similar to the black spaces on a checkerboard. Each character to be printed preferably appears in two adjacent parallel horizontal rows on the typewheel. As the typewheel rotates, the printing hammers are actuated whenever the

desired character approaches printing position. The staggering prevents the operation of one printing hammer from moving the ribbon against an adjacent letter which has not been selected for printing. Hence, errors and smudging are avoided.

Another feature of the invention relates to addition of a checking device associated with each printing actuator. This checking device will give an indication in event the memory contains a character to be printed but the printing actuator is not operated by the signal from the memory. The checking device, moreover, gives an indication in event the memory contains a non-printable character. The checking device also gives a signal in event certain noise pulses occur in the circuit and cause a printing hammer to be actuated.

The printing operation is further improved by a novel printing hammer arrangement hereinafter shown and described.

Other features of the invention will appear as this description proceeds.

In the drawings:

Figure 1 is a block diagram of the invention.

Figure 2 illustrates the arrangement of characters on a certain prior art type of typewheel.

Figure 3 illustrates the relative relation of the typewheel, the ribbon, the paper, and the printing hammer.

Figure 4 shows a developed view of the typewheel placed alongside of the signals, which are generated by the code generator at different positions of the typewheel.

Figure 4A is a timing wave diagram illustrating the relationship between the potentials on the wires **107** and **544**.

Figure 5 is a schematic diagram of the comparator and its associated circuits.

Figure 6 is a schematic diagram of the printing circuits, together with the power supply therefor.

Figure 7 is a perspective view of the arrangement of the printing hammers, armatures, solenoids, supports therefor, etc.

Figure 8 is another perspective view of the arrangement of the printing hammers, armatures, solenoids, and supports therefor.

Figure 9 is a perspective view of the means for supporting the printing hammers and of the means for spacing the discs of the typewheel.

Figure 10 is a schematic diagram of the means for clearing the memory.

Figure 11 is a transverse sectional view of the typewheel.

Figure 12 is a sectional view of the typewheel along line **12—12** of Figure 11.

It is well known in the art of electronic computers that the output of the computer may be printed by a machine of the rotating typewheel class. In such a system, the output of the computer is normally stored in a memory. After the memory is filled, it contains all of the information necessary to print one horizontal line on the paper. This information is then fed to the printing hammers as the typewheel rotates. After one complete revolution of the typewheel, one complete horizontal line is printed, and the memory is now empty. The memory is then refilled with information for the next horizontal line. Following such refill, the typewheel makes another complete rotation during which time the second horizontal line on the paper is printed. This operation is repeated indefinitely to print additional horizontal lines on the paper. However, the present invention does not concern itself with the specific means for refilling the memory, moving the paper, etc. The present invention teaches how the information may be taken from the memory, checked by the automatic checking device hereinabove mentioned, and print at least a single horizontal line of information with-

out smudging. Therefore, so far as the present invention is concerned, any means available to skilled engineers for moving the paper, for moving the ribbon, and for refilling the memory, may be employed, and no detailed explanation of such means follows.

Figure 1 is a block diagram of the invention and shows a rotating typewheel **100** driven by a motor **101**. A memory **102**, when filled, has the information necessary to print one horizontal line of information. As the typewheel rotates, it operates a code generator **103**, which emits signals on its various output lines at different angular positions of the typewheel **100**. The shaft of the typewheel **100** may be connected to the code generator **103** in any well known way. It is usually directly connected thereto by a shaft but a gear box G may be employed if necessary. The relative positions of the characters on the typewheel and the signals produced by the code generator are shown in Figure 4. In Figure 4 the typewheel **100** is shown with its surface developed. As shown, there are ten vertical columns of characters, and five printing characters A to E inclusive. If it is desired to print the entire alphabet, twenty-six printing characters could be disposed around the typewheel in the same general fashion that the five characters are shown in Figure 4. If in addition to the twenty-six letters of the alphabet it is desired to also print numbers and/or punctuation marks, additional characters may be placed on the typewheel. In one actual embodiment of this invention there was a total of fifty-one characters spaced around the typewheel. In that partciular embodiment of the invention, instead of ten vertical columns, there were 130 vertical columns. It is understood, therefore, that for purposes of simplicity there has been shown only a few vertical columns and a few printing characters in Figure 4, and it is a simple matter to expand the principles there disclosed to employ any reasonable number of printing characters and vertical columns.

The number of tubes in the memory is related to the number of characters as well as to the number of vertical printing columns employed on the typewheel. It is necessary to store in the memory **102** enough information for one complete horizontal line. The information is stored in the memory in the form of binary signals. The memory contains, for example, one horizontal column of gas tubes for each vertical column to be printed. In Figure 1, there are ten horizontal columns of gas tubes and ten vertical columns on the typewheel. The tubes in the memory **102** are of the type which once fired remain ionized until the memory is cleared (by reducing the anode potentials avaliable at the tubes). These gas tubes store the binary information in the following form. First a different binary code is selected for each character to be printed. If the binary code 1001 is adopted to represent the letter A, one would store that letter in the upper horizontal row of the memory by firing the first and fourth tubes of the row and allowing the second and third tubes to remain unfired. This is illustrated by the symbol of a small zero adjacent each tube which has not been fired and a small number 1 adjacent each tube which has been fired. It is understood that other forms of memories may replace the one shown. After the memory has been filled and the typewheel is ready to start moving the letter A into printing position, the code generator **103** produces a binary signal. The binary signals and their relation to the characters to be printed are shown in Figure 4. In view of the speed of the rotation of the typewheel **100** and the delay involved in moving the printing hammer into contact with the paper, it is necessary that the signals involved in printing each character occur in advance of the time that the character actually arrives in printing position. Therefore, it is noted that the code generator starts producing binary signals when the typewheel is in an angular position slightly in advance of the angular position at which the character to be printed arrives at the actual printing position. For example, in Figure 4 the first row of characters is the letter A, and the binary signal representing the letter A begins to appear at an angular positon in advance of the arrival of the letter A. The binary signals shown in Figure 4, appear on output lines **104**, **105**, **106** and **107** of Figure 1, and are changed as each new character approaches printing position.

A comparator **108** of Figure 1 has one individual comparing unit for each vertical column to be printed. In other words, there is an individual comparing unit for each horizontal row of gas tubes in memory **102**. These comparing units are all identical and one of them is shown in detail in Figure 5. The first unit **109**, for example, compares the binary signal stored in the upper horizontal row of the memory with the binary signals produced by the code generator. Whenever it finds coincidence between the binary signal stored in the memory and the binary signal emitted by the code generator **103**, it transmits an actuation by line **110** to the printing actuator control and checking element **111**. The details of the latter element are shown in Figure 6. The comparing unit **112** compares the binary signal stored in the second horizontal row of the memory with the binary signals emitted by the code generator **103** and whenever it finds a coincidence it transmits a current on wire **113** to printing actuator and checking element **114**. The comparing unit **115** compares the binary signal stored in the third horizontal row of the memory with the signals emitted by the code generator **103** and whenever it finds a coincidence it transmits a signal to the actautor and control element **116**. In the form of the invention illustrated there are ten horizontal rows of the gas tube which are respectively associated with ten comparing units (all identical units **109**, **112** and **115**) and these ten comparing units are respectively similarly connected to the ten printing actuator controls and checking elements which are all identical with each other.

The comparing unit, such as **109**, compares the binary code of the memory with that of the code generator **103** and produces an output on wire **110** whenever the binary signal of the code generator coincides with the binary signal stored in the upper horizontal row of the memory. If the code generator **103** produces any signal other than the same one that is stored in the memory, there will be no output on wire **110**. As the two horizontal columns of A characters of the typewheel **100** approach printing position, all of the A's in these two whole horizontal lines will be printed before any other characters are printed. In the illustration shown, the letter A is stored in the first, sixth and ninth horizontal columns of the memory **102**. As soon as the letter A approaches printing position, the binary signals **400** and **401** of Figure 4 will appear and will represent the letter A, so far as the code generator **103** is concerned. The binary signals (from code generator **103**) representing A appear on the lines **104** to **107** which are connected to one side of each of the comparing units of the comparator **108**. Hence, comparing units **109**, **121** and **127** will all simultaneously show true coincidences. Therefore, actuators **111**, **122** and **128** will be simultaneously energized. After the usual delays due to movement of the printing hammers, etc., the characters A will be in printing position and will be printed. Following this, the letter B approaches printing position and at this time the binary signals from the code generators change and now produce signals **402** and **403** (see Figure 4) on the wires **105** and **106** (see Figure 1). This binary signal is compared with the binary signal stored in each horizontal row of the memory. If it be assumed that the bottom horizontal row of the memory has the letter B stored therein, as shown, the only comparing unit which will find a true coincidence when the code generator **103** is producing the binary signals representing the character B is the unit **129**. That unit then signals a coincidence to the actuator **130** which prints the character B when it arrives in printing position. The typewheel continues to

rotate and the letter C approaches printing position. The letter C is stored in the fifth and seventh horizontal rows of the memory **102**. As the character C approaches printing position, the binary signals **404** and **405** (Figure 4) are generated by the code generator **103** and are fed to each of the ten comparing units of comparator **108**, but only two of these comparing units, namely **119** and **123**, show a coincidence with the information stored in the memory **102**. Consequently, only two of the comparting units, **119** and **123**, produce outputs and they energize the two actuators **120** and **124** so that the letter C is now simultaneously printed in the fifth and seventh vertical columns on the paper.

It is noted that the characters on the typewheel are staggered in a checkerboard arrangement and the reason for this will now be explained. It is noted in connection with Figure 1 that the letter C was printed in the fifth and seventh vertical columns of the paper and that the letter A was printed in the intervening or sixth vertical column of the paper. If the characters on the typewheel had been arranged in accordance with the prior art arrangement of Figure 2, the letter A would have been printed in the sixth vertical column first and would be present at the time that the row of C characters arrived in printing position. There was one C character to be printed on each side (both to the right and to the left), of the letter A in the sixth column. Hence two printing hammers would simultaneously strike the two C characters on the columns on both sides of the letter A. When the printing hammers would so strike the two C characters, they would press the paper against the ribbon and therefore indirectly press the ribbon against the typewheel very firmly. Since the ribbon would be pressed firmly against the paper on both sides of the sixth vertical column, it is clear that the ribbon would be pressed against the character C in the sixth vertical column. This would smudge the letter A which had previously been printed in that column particularly in view of the fact that the ink on the letter A would still be wet. However, when the staggered arrangement of characters, best shown in Figure 4, is used, this cannot happen. For example, if the letter A has been printed in the sixth vertical column and it is then desired to print a letter C in the fifth and seventh vertical columns, there will be no type representing the letter C in the sixth vertical column. In other words, the letter C would be printed in the fifth and seventh vertical columns by the type elements **450** and **451** (Figure 4) whereas the letter A would be printed in the sixth vertical column by the type element **452**. Since the C character **453** for the sixth vertical column is staggered, the operation of the printing hammers against characters **450** and **451** cannot move the ribbon against the character **453**. In order to make this staggering arrangement effective in connection with high speed printing, it is necessary to delay the operation of the actuators in alternate vertical columns, that is actuators **114**, **118**, **122**, **126** and **130**. This delay is accomplished by means hereinafter shown in detail in connection with Figure 6.

As shown in Figures 1 and 4, prior to each printing cycle a "probe memory pulse" hereinafter referred to as PM, is emitted by the code generator **103** and passes to the comparator **108** and elsewhere. At the end of the printing cycle a "clear memory pulse" hereinafter referred to as CM, is fed by the code generator **103** to the memory **102** and operates to reduce the anode potential on all of the gas tubes in the memory so as to clear the memory and make it available for refilling. During the space between the clear memory pulse CM and the probe memory pulse PM, there is time available to refill the memory and prepare it for the next print cycle. Those skilled in the computer art understand that this can be done almost instantaneously and consequently no attention need be paid to the means for doing the same.

Figure 5 illustrates in some detail the construction and mode of operation of the comparison unit **109**, and it is understood that the other comparison units **112**, **115**, **117**, **119**, **121**, **123**, **125**, **127** and **129** are identical with the unit **109**. The gas tubes **500**, **501**, **502** and **503** of the upper horizontal column, as well as all of the other gas tubes in the memory **102**, are of any well known type which once ionized remain in an ionized condition until the anode voltage is greatly reduced. One such tube is the RCA 5823. In event the grid of this tube is appropriately energized during the read-in period, the anode potential of 213 volts, as shown, is sufficient to ionize the tube and it will remain ionized until the clear memory pulse CM arrives and lowers the anode voltage generator from 213 to 55 volts. While any given tube is ionized, the current drawn therethrough is substantial and there is a large potential drop across the complementary input resistor **504** to **507**. However, when the tubes are not ionized, the full anode potential of 213 volts (less the drop across the anode resistor which is 60 volts when wires **104** to **107** are at −90 volts) is impressed on the anodes of these tubes.

The binary signals from the code generator appear on wires **104** to **107** inclusive. The potential of each of these wires varies from say −90 to +213 volts. For example, when the angular position of the typewheel is zero degrees (see Figure 4) the potentials on all four of wires **104** to **107** inclusive is −90 volts. When a binary "1" signal arrives on lines **104** and **107** as shown at an angle of about 30 degrees (see Figure 4), the potential on these two wires increases to +213 volts, while the potential on wires **105** and **106** remains at −90 volts. When the angular position of the typewheel is 120 degrees, the potentials on wires **104** and **107** are −90 volts and the potentials on wires **105** and **106** are +213 volts, etc. The anodes of memory tubes **500** to **503** inclusive are connected to the binary signal wires **104** to **107** inclusive by resistors **509** to **516** inclusive. These resistors have center taps **517** to **520** inclusive. The latter connect to the cathodes of rectifiers **521** to **524** inclusive and to the anodes of rectifiers **525** to **528** inclusive. The potential of the anodes of rectifiers **521** to **524** inclusive tend to be held at +85 volts by the positive source **529** acting through high resistance element **530** and limited by the limiter composed of rectifier **531** and positive source **532**. The voltage thus limited is fed by wire **533** to the center tap of the primary **534A** and **534B** of the transformer **535** which has a secondary **536**. The cathodes of the rectifiers **525** to **528** tend to go negative, due to source **540** which is at −475 volts, and this negative-going potential is limited by a limiter composed of rectifier **537** and positive source **538** which may have, for example, 107 volts. The rectifier **539** in series with primary **534B** has its potential controlled by that at the cathode of rectifier **537** as well as by the negative source **540**, resistors **541** and **542**, rectifier **543**, positive source **544**, and the potential on wire **533**.

As shown in Figure 4, each binary signal is composed of a series of two pulses although a greater number could be used. For example, the binary signal for character A is composed of two pulses **400** on wire **107** and two similar pulses **401** on wire **104**. The potential on wire **544** varies according to variations in the binary signals. When the binary pulses **400** and **401** are at +213 volts the potential on wire **544** is at +71 volts. When the binary pulses **400** and **401** are at −90 volts the potential on wire **544** is +103 volts. Similarly, the potential on wire **544** drops to +71 volts whenever the potential of pulses **402**, **403**, **404**, **405**, etc. rises to +213 volts, and rises to +103 volts whenever the potential of pulses **402**, **403**, **404**, **405**, etc. falls to −90 volts. In other words, if any of the binary signals is at +213 volts, the potential on wire **544** is at +71 volts, otherwise it is at +103 volts.

The values of the resistors used in the circuit of Figure 5 may be as follows:

	Ohms
504 to 507 incl.	39,000
509, 511, 513, 515	22,000
510, 512, 514, 516	100,000
530	850,000
541	530,000
542	50,000
597	4,700

Figure 4A is an enlarged diagram of the relationship of pulse 400 to the potential on wire 544. It is understood that when a binary "1" signal is on wire 107, an alternating current appears varying between −90 and +213 volts. In Figure 4, only two cycles of such an alternating current were shown to represent each binary signal 400 to 406 inclusive. However, it is understood that each said binary signal may consist of a number of cycles. For example, in Figure 4A, signal 400 is represented by five cycles which have positive-going excursions 480 and negative-going excursions 482. Whenever the signal 400 goes positive, as at 480, the potential on wire 544 drops to +71 volts, as shown at 481; and when the signal 400 goes negative as at 482, the potential on wire 544 rises to 103 volts, as shown as 483.

The operation of each comparator unit is as follows. If it be assumed that the binary signal A is generated by the code generator and appears on wires 104 to 107 at the same time that the upper horizontal row of memory tubes 501 to 503 contains the letter A according to its binary code, the operation will be as follows. Tubes 501 and 502 are de-ionized whereas tubes 500 and 503 are ionized. Moreover, wires 104 and 107 are at +213 volts while wires 105 and 106 are at −90 volts. The aforesaid data follows from the description previously given. Based on the foregoing assumption tube 500 is ionized and consequently the potential at its anode is lowered to just below 85 volts. Consequently, current tends to flow from wire 104 through resistors 510 and 509 to the anode of gas tube 500. This lowers the potential at wire 517 to a value between 85 and 107 volts. The potential on wire 105 is however −90 volts but since gas tube 501 is not ionized, the full potential of 213 volts which is impressed upon resistor 505 tends to pass current through resistors 511 and 512 and thus raises the potential of wire 518 to a value between 85 and 107 volts. Likewise, the potential on wire 106 is −90 volts but since gas tube 502 is not ionized, the full potential of 213 volts impressed on resistor 506 pulls tap 519 upwards to a value between 85 and 107 volts. Wire 107 is at +213 volts but since gas tube 503 is conducting, the potential at the lower end of resistor 507 is just below 85 volts and it lowers the potential on wire 520 to a value between 85 and 107 volts. The potential of wire 533 is held at +85 volts by the limiter 531—532, and since the potentials on the cathodes of rectifiers 521 to 524 inclusive are higher than this value, those rectifiers are cut off and wire 533 stands at +85 volts. At this time the lower side of secondary 534*b* is held to +71 volts by the limiter 543—544. Therefore the upper end of primary 534B is at +85 volts and the lower end at +71 volts, wherefore current flows therethrough and induces a pulse in the secondary 536.

As explained in connection with Figure 4A, the potential at terminal 544 varies between +71 and +103 volts. During the intervals when terminal 544 is at +103 volts, the potentials on all four lines 104 to 107 inclusive are at −90 volts and this causes the potential on wire 533 to drop below +71 volts, for reasons hereinafter mentioned, and therefore rectifier 539 is cut off. Its cathode is subjected to +103 volts by terminal 544 and its anode is held below +85 volts in view of the low potential on wires 517 to 520 inclusive. Hence, no current flows through primary 534B. During those periods when the potential of terminal 544 is at +71 volts, current will flow through primary 534B, assuming a coincidence between the code generator and the first horizontal row of the memory, all as hereinabove explained. Hence, in response to each coincidence between the code generator on the upper horizontal row of the memory, there will be a series of pulses through primary 534B which will produce an output in the secondary 536. If it now be assumed that there is not a coincidence between the binary signals stored in the memory and the binary signals on wires 104 to 107 inclusive, there will be no output current at secondary 536. In order to explain this, assume that the typewheel is moved until the character B arrives at printing position. In this case, the potentials on wires 104 and 107 will remain at −90 volts while the potentials on wires 105 and 106 will rise to +213 volts. Since the character A remains stored in the upper horizontal row of the memory 102, tubes 501 and 502 are not ionized and the potentials at their anodes are therefore near +213 volts. These potentials, together with the potentials on wires 105 and 106 raise wires 518 and 519 to +213 volts which is greater than the potential on the anodes of rectifiers 522 and 523, and therefore these rectifiers are cut off. The potentials on wires 104 and 107 being at −90 volts, and the potentials at the anodes of gas tubes 500 and 503 being below +85 volts due to the fact that these tubes are ionized, cause the potential on wires 517 and 520 to be very low, for example +30 volts. Therefore, current tends to flow from positive terminal 529 which is at +475 volts, through resistor 530, rectifiers 521 and 524, to the low potential wires 517 and 520. This current pulls wire 533 to about +30 volts. The potential of +213 volts which appears on wires 518 and 519 raises the potential of wire 599 above the potential of the lower clamp 537—538 which insures that wire 599 always remains above +107 volts. However, the potential of wire 599 is limited to +157 volts by the limiter 595—596. Consequently, the potential of wire 599 rises to +157 volts. The potential of wire 599 has greater effect than the negative potential of source 540, in view of the values of the resistors 541 and 542, and therefore raises the cathode of rectifier 539 well above 100 volts. Consequently, the potential at the cathode of rectifier 539 is positive and the potential at the anode (that is, the potential on wire 533 which was +30 volts) is lower than that at the cathode. Consequently, rectifier 539 does not conduct and there is no output from the secondary 536.

Next, assume that the character C approaches printing position, while character A is still stored in the memory. In that case there are, as shown in Figure 4, pulses 404 and 405 on wires 107 and 105, but wires 104 and 106 remain at −90 volts. In this situation, gas tube 500 is conducting and so the potential on its anode is lowered below +85 volts while the potential on wire 104 is −90 volts. Therefore, the potential on wire 517 drops below +85 volts. Wire 518 rises to about +213 volts since that is the potential on wire 105, and the tube 501 is not ionized. Since coincidence appears between the third and fourth binary signals of both the code generator and the memory, wires 519 and 520 tend to remain above +85 volts. However, since wire 517 is below +85 volts, diode 524 conducts, lowering the potential of wire 533 to a value substantially below +71 volts. Moreover, in view of the high potential on wire 518, rectifier 626 conducts, causing wire 599 to rise to +157 volts and in turn wire 598 is raised above +71 volts; and therefore, the potential at the cathode of rectifier 539 is more positive than at the anode and the rectifier does not conduct. Hence, there is no flow of current through the primary 534B. It follows that there is no output at wire 536.

It follows from the foregoing description that there is an output at the secondary 536 only when the binary code generator produces a signal representing the same

binary character as the one stored in the first horizontal row of gas tubes of the memory **102**.

The operation of the comparator circuit of Figure 5 may be summarized as follows. When the binary signals from the code generator coincide with the binary signals in the memory, the potentials on wires **517** to **520** inclusive are between +85 and +107 volts, and this cuts off rectifiers **521** to **524** inclusive. This causes wire **533** to stand at +85 volts, as determined by the limiter **531**—**532**. Terminal **544** is at +71 volts during the short intervals of the coincidence (due to the fact that coincidence can only occur during the positive excursions of the pulses of the signals on wires **104** to **107** inclusive). Under these circumstances terminal **544**, operating through rectifier **543** on to wire **598**, overpowers all of the other circuits (such as **540**—**541**) which tends to affect the potential of wire **598**. Therefore, the potential at the cathode of rectifier **539** is as the potential of terminal **544**, that is +71 volts. Consequently, current flows from wire **533** at +85 volts to wire **598** at +71 volts. This current recurs each time during the period of a given binary signal that terminal **544** drops to +71 volts. Hence, potential is induced in the output winding **536**.

Coincidence between a signal stored in a gas tube and a signal on one of the lines **104** to **107** can occur in two ways. For example, taking gas tube **500** and wire **104**, coincidence can occur if gas tube **500** is conducting so that its anode potential is low if the potential on wire **104** is high. Alternatively, coincidence may occur if the potential on wire **104** is low and the potential at the anode of the gas tube is high due to de-ionization thereof. In both cases there was a high potential at one end of the circuit and a low potential at the other, so that the wire **517** which is connected to the intermediate portion of the circuit has intermediate potential.

If the potential at the anode of the gas tube as well as the potential on wire **104** is high, the potential on wire **517** will be high. This will tend to raise the potential on wires **599** and **598** and cut off the cathode of rectifier **539** and thus prevent flow of current through the primary **534B**. This shows that there was no true coincidence. There may also be lack of coincidence if the potential on wire **104** as well as the potential at the anode of the gas tube is low. In this case, the potential of wire **517** drops to about +30 volts so that current now tends to flow from terminal **529** through resistor **530** and rectifier **524** to the wire **517**. This lowers the potential of wire **533** below +71 volts and therefore no current can flow through rectifier **539** and there is no output.

Figure 6 shows the connection of the comparing units to the actuator and checking units. The output of the comparing unit **109** is fed to the actuator unit **111**. The output of the comparing unit **112** is fed to actuator unit **114**. In similar manner, each of the comparing units, **115** on, respectively connect to the actuator units **116** on, as shown in both Figures 1 and 6. The actuator units **111**, **114**, **116**, **118**, **120**, **122**, **124**, **126**, **128** and **130** are all identical and consequently a description of one thereof will be sufficient.

Each actuator unit has a check tube **600** and a print tube **601**. These are thyratons which require substantial positive potentials on both grids in order to fire, and once they fire they remain ionized as long as there is sufficient anode potential to maintain them in an ionized condition. The first grids of these two thyratrons are energized by the output transformer **536**. The second grid of the check thyratron **600** is controlled by two groups of pulses from the code generator. It is first controlled by the "fire check" pulse FC which occurs (as shown in Figure 4) shortly after the print cycle of the apparatus begins. Later in the print cycle this second grid is controlled by a plurality of "Check (*a*)" pulses as shown in Figure 4. The second grid of the print thyratron **601** is controlled through a condenser **602** by the "Print (*a*)" pulses from the code generator which occur repetitively as shown in Figure 4. This second grid is also controlled by the cathode potential of the check thyratron **600**. The output current of the print thyratron **601** energizes the solenoid **603** which in turn attracts the armature of print hammer **604**. This effects printing in the first vertical column. Solenoid **603** bears reference number **308** in Figures 3, 7 and 8

It is interesting at this point to see how the current for operating the solenoids, such as **603**, is made available without placing too large a surge on the incoming power line. The alternating current power supply X—Y is fed to the D.C. power supply **605** which has an output of about 650 volts and charges condenser **606**. This condenser may be rather large and in the case of a machine having 130 vertical columns as aforesaid, the capacity of this condenser would be approximately 2,000 microfarads. This same size of condenser could be used in event the number of vertical columns was reduced but it may even then be different. Since this condenser is connected across the D.C. power supply **605** at all times, it is charged throughout the entire print cycle. It is, however, arranged to supply current to the printing condensers **607**, **608**, etc. only for a limited time as will now be explained. The clear memory pulse CM passes through short delay line **671** to thyratron **609** causing the latter to conduct. The charge stored in condenser **606** may now flow through resistors **610**, **611**, etc., rectifiers **612**, **613**, etc., to printing condensers **607**, **608**, etc. These condensers have a capacity of about one microfarad. After these condensers have been sufficiently charged, the thyratron **609** is cut off. This is done as follows. The PM pulse from code generator **103** fires the thyratron **620** and thereby lowers the potential on its anode to practically ground potential. Since this anode is connected through condenser **621** to the anode of thyratron **609**, and since there is an inductor **622** in series with the anode of the latter thyratron, the sharp drop in potential at the anode of thyratron **620** draws with it downwardly the potential of the anode of thyratron **609** and holds it at a low enough potential for a long enough time to cut off this thyratron. Thyratron **620** is extinguished by the ringing of inductor **622**. Upon restoration of the normal anode potential of thyratron **609**, it is noted that the same cannot again become conducting until another CM pulse arrives thereat. Hence, once the print cycle has started and the condensers **607**, **608**, etc. have been charged, it is impossible for them to be charged again until a CM pulse arrives from the code generator at the end of the print cycle. In other words, the condenser **607**, **608**, etc. can only be charged once during each print cycle. If during such a print cycle the print thyratron which is complementary to the condenser **607** or **608**, etc. as the case may be, is fired, the charge of the condenser is dissipated through the associated solenoid. In the case of the first vertical column to be printed the charge on condenser **607** is dissipated through solenoid **603** (same as **308** of Figure 3) when the print thyratron **601** becomes conducting. This attracts the armature **307** (Figure 3) and moves the print hammer **303** into contact with the paper.

The check thyratron **600** may be of GE Type 5663 and the print thyratron may be of RCA Type 2050. However, any other suitable tubes may be employed.

If it be assumed that the upper horizontal row of gas tubes in the memory has the letter A stored therein, the operation of the apparatus used in order to print that character is as follows, particular reference being made to Figures 4 and 6. As already explained, the condensers **607**, **608**, etc. have been charged as the typewheel approaches the zero angle shown in Figure 4. The next event is that probe memory pulse PM is produced by the code generator and this does two things. First, it actuates thyratron **620** to cut off thyratron **609** and prevent further charging of the condenser **607**; and secondly and simultaneously, it probes the memory **102**. This latter action is best illustrated in Figure 5 where it is shown that the probe memory pulse enters along wire PM, passes

resistor 597, and then passes rectifier 570 and thence through the primary winding 534A of the transformer 535.

The potential on the probe memory wire PM is normally at a base value of +33 volts throughout the entire print cycle except for a short time early in the print cycle when it rises to +85 volts, see Figure 4. When it is at +33 volts, no substantial current flows through primary 534A since the center tap 533 never falls much below that potential.

If all four gas tubes 500 to 503 inclusive are de-ionized at the time the probe memory pulse PM arrives at the resistor 597, there will be no induced potential in the secondary winding 536. The reason for this is that when all four gas tubes 500 and 503 inclusive are de-ionized, their anode potentials are all high and consequently wire 533 stands at its limiting value of +85 volts.. Since this is equal to or greater than the potential of the probe memory pulse PM, no current flows through resistor 597, rectifier 570 and primary 534A. Likewise, at this time the terminal 544 is at +103 volts (see Figure 4) and therefore the cathode of rectifier 539 has higher potential than its anode and no current flows through the primary 534B.

However, if any one of the four gas tubes 500 to 503 inclusive is ionized at the time of arrival of the probe memory pulse PM, there will be an output potential induced in the secondary 536. Assume for purposes of illustration that gas tube 500 is ionized at the time of arrival of pulse PM. Since tube 500 is ionized, its anode is at a low potential. Wires 104 to 107 inclusive are all at −90 volts at the time of arrival of pulse PM (see Figure 4). The low potential at the anode of the gas tube 500, in cooperation with the negative potential of wire 104, brings wire 517 to a value in the neighborhood of +33 volts, as previously explained. Consequently, since the probe memory pulse rises to +85 volts at the start of the print cycle, it will, when at +85 volts, cause flow of current through resistor 597, rectifier 570, primary 534A, wire 533, rectifier 524, to wire 517 which is at +30 volts. Hence, there will be a flow of current through the primary 534A which will induce potential in the output winding 536.

Since the probe memory pulse PM is connected to all of the comparators 109, 112, 115, 117, . . . 131, it follows that there will be an output from those comparators corresponding to rows of gas tubes where one or more tubes are ionized. There will be no output from the secondaries of those comparators where none of the gas tubes were ionized.

Consider for purposes of examination that the probe memory pulse produces an output, hereinafter called a surge, from secondary 536. This surge continues for a substantial period of time, due to the inductance and capacity of the circuits involved, and before the termination of this surge there appears from the code generator the fire check pulse FC (see Figure 4) which passes through rectifier 623, wire 670, condenser 624 to the second grid of the thyratron 600. The aforesaid surge from secondary 536 is fed to the first grid of thyratron 600. Hence, the two grids of this thyratron are concurrently energized and current now flows from the source 625 through resistor 626 to the anode of the thyratron 600, thence through the cathode resistors 627, rectifiers 694, power supply 695, thence to ground. The thyratron 600 now becomes conducting and remains in that condition until its anode potential is lowered to a sufficient extent that the tube is extinguished. Before the thyratron 600 was ionized there was no current through resistor 627 and the second grid of thyratron 601 was held at substantially the voltage of source 695 (−100 volts), and hence was not in a condition to be fired. However, now that the check tube 600 has been fired, the potential at the cathode of the check tube, and therefore the potential of the second grid of the thyratron 601, is greatly increased and therefore the print thyratron 601 has been made ready to fire in event two things occur simultaneously. First, that its first grid receives appropriate energization; and secondly, that its second grid receives a further energization through condenser 602. In other words, the mere raising of the potential of the second grid of thyratron 601, as a result of the firing of thyratron 600, is not enough to enable thyratron 601 to fire even if the first grid thereof is appropriately energized.

The next event which occurs is that the typewheel approaches the printing position of the character A. As this position is approached, binary signals 400 and 401 (see Figure 4) pass to the comparator and, assuming that the character A is stored in the upper horizontal row of the memory, there is an additional surge produced as previously described. This surge results from a flow of current in the primary winding 534B. This additional surge appears in the secondary 536 and energizes the first grids of both the check tube 600 and the print thyratron 601. During the continuance of this surge another pulse appears from the code generator, on wire "Print (*a*)" which is also designated 630, and it flows through condenser 602 to the second grid of the thyratron 601. Hence, the thyratron now has all three of the potentials thereon which are required in order to fire it, namely, it has a potential on its first grid coming from the secondary 536, it has appropriate bias on its second grid by virtue of the fact that thyratron 600 is conducting and thus raising the potential of its cathode, and it has a third potential on it due to the pulse on wire 630. Hence, the thyratron 601 fires and causes flow of current from the condenser 607 through solenoid 603, thyratron 601 to ground. This moves the printing hammer 604 against the paper to print the letter A. Throughout the remainder of the period of a single rotation of the typewheel, no other character is to be printed in the column that 601 is associated with. If another were printed it would appear on top of the letter A, and this is not desired. Further characters cannot be printed during the remainder of the rotation of the typewheel since the condenser 607 has been discharged and cannot be recharged until the end of the print cycle when pulse CM fires the thyratron 609. When thyratron 601 fires, the potential of its anode approaches ground with the result that the potential of the anode of thyratron 600 also is drawn, with respect to its cathode potential, far negative by the condenser 631 so that the thyratron 600 is deionized. At the conclusion of the printing operation, condenser 607 is substantially discharged and therefore tube 601 is likewise cut off.

If it be assumed that the second horizontal row of tubes of the memory 102 contains the letter E, it would be printed as follows. As in the case of the letter A, at the beginning of the print cycle the code generator would produce the probe memory pulse PM which would produce a surge in all of the primaries, such as primary 534A, of the comparing units which are tied to ionized 5823's. It would therefore produce such a surge in the similar primary in the comparing unit 112 with the result that there would be an output from the secondary 546 of the unit 112. This output surge would overlap the fire check pulse FC coming from the code generator 103, and therefore the check thyratron 640 would be ionized since it would have the fire check pulse passing via rectifier 641 and condenser 642 to the second grid of this thyratron and it would have the surge from secondary 546 arriving at its first grid. Hence, the current would increase through resistor 644 and thus reduce the bias on the second grid of the print thyratron 645. Nothing further would happen toward the printing of this character until the typewheel rotated so far that character E approached printing position. When this occurs, the code produced by the code generator 103 would conform with the character stored in the second horizontal row of the memory in

which event there woud be a coincidence pulse leaving secondary 546 which would energize the first grid of the print thyratron 645. Since this comparison pulse is of very substantial duration, it will over lap the "Print (*b*)" pulse which appears on wire 646 and flows through condenser 647 to the second grid of the thyratron 645. Consequently, the thyratron 645 will be fired since it has all three potentials on its grids which are necessary for firing. Current will then flow from condenser 608 through printing solenoid 687 and thence through the thyratron 645.

It is noted that the printing pulses (*a*) and (*b*) are staggered the same as the characters on the typewheel are staggered. That is, the "Print (*b*)" pulses are delayed in time with respect to the "Print (*a*)" pulses to allow the typewheel to rotate the angular distance between rows of characters (in the illustration of Figure 4 this would be 30 degrees), before printing takes place. As further illustration of what was mentioned in the previous sentence, let it be assumed that there is stored in each of the ten horizontal rows of the memory the letter D. As the typewheel approached and became ready to print the letter D, all ten comparing units of comparator 108 would produce an output surge, which would appear at the grids of all ten print thyratrons. However, the thyratrons for the first, third, fifth, seventh and ninth vertical columns would be fired first since they are all connected to wire 630. After these thyratrons had fired, the typewheel would rotate an additional 30 degrees (assuming the relationship shown in Figure 4), before a print pulse would appear on wire 646. The surges from the secondaries of the comparator would again be present at this time, since a separate comparison is made for each row of type on the typewheel, as shown in Figure 4, and would overlap the signal on wire 646 and then the letter D would be printed in the secondaries for the second, fourth, sixth, eighth and tenth vertical columns. In this connection it is noted that the first of the two pulses 400 and the first of the two pulses 401 will cause a surge in the secondaries (such as 536) of the comparators to overlap the print and check pulses 480 and 481. The second of the two pulses 400 and the second of the two pulses 401 overlap the print and check pulses 482 and 483.

The function of the check thyratrons will now be described in more detail. The probe memory pulse PM only energizes the primary (534A for example) when any one tube of the horizontal row of the memory corresponding to the comparing unit (for example 109) is involved. For example, if there are certain horizontal rows in which no binary signal is stored, there will be no current flow through the primary of the transformer of the complementary comparator and hence no output from the comparator. In other words, in response to the probe memory pulse there are outputs from the transformer secondaries 536, 546, 547, 548, 549, etc. only when there is information stored in the complementary horizontal row of the memory. Hence, in response to the probe memory pulse PM, there are surges in those transformer secondaries corresponding to rows of the comparator containing binary signals other than 0000. These surges fire the check thyratrons corresponding to the rows of the memory having binary signals other than 0000. As for those actuator elements 111, 114, 116, etc. which will be inactive so far as the printing is concerned, by reason of the fact that nothing is stored in the memory corresponding thereto, the check tube will not be ionized. For example, if the first word to be printed is AB followed by a space and then the word CD, it is noted that the probe memory pulse PM would cause surges in secondaries 536, 546, 548, and 549 but there would be no surge in secondary 547. Hence, check tubes 600 and 640 would be energized but check tube 650 would not. The check tubes in stages 118 and 120 would also be energized. Since the check tube 650 is not energized by the probe memory pulse PM, no printing can occur in the third vertical column even if at some later period in the print cycle a noise pulse should occur which would be impressed on the grids of the thyratrons 650 and 651. As soon as the letter A had been printed in the first vertcial column, the check tube 600 would be extinguished. As soon as the letter B had been printed in the second vertical column the check tube 640 would be extinguished. Likewise, after the printing of the letters C and D in the fifth and sixth vertical columns, the check tubes for those columns would be extinguished. Hence, at the end of the printing cycle, all check tubes should be extinguished, since where printing occurred the check tubes were once on, but later turned off, and where there was no printing the check tube was never on. If any check tube remains on at the end of a printing cycle, it may be that an error has occurred. The "All-Out Detector" 652 is intended to determine whether all check tubes are out at the end of a printing cycle. If at the end of a printing cycle any one of the check tubes is still on, it will draw current through its cathode resistor. This current, through the cathode resistor, will continue to flow until the next clear memory pulse CM arrives at gate 629. When there is a flow of current through a cathode resistor simultaneously with the appearance of a clear memory pulse CM, the gate 629 will open and pass a current to solenoid 653 of the relay, shutting down the apparatus and turning on an error light 656. The mode of operation of gate 629 and its associated parts will now be explained in detail.

In the absence of ionization of one of the gas check tubes 600, etc., whereby no current flows through the cathode resistors 627, etc., the wire 696 is held at −102 volts by virtue of the negative source 693 which is at −300 volts, together with resistor 692 and limiter 690—691. The source 690 is at −102 volts. In event one of the check tubes, such as 600, remains energized after the printing cycle has been completed, current will continue to flow through its complementary cathode resistor, such as 627, for example. This current also flows through wire 696, resistor 692, to negative source 693, and therefore tends to raise the potential of wire 696 from the lower limiting valve of −102 volts established by source 690, to the upper limiting valve of −100 volts as established by limiter 694—695. This two volt change appearing at the input of the gate is a sufficient signal to the gate to cause the gate to open upon the arrival of the next clear memory pulse CM. In other words, if the input potential at the lefthand input of the gate is −100 volts (as distinguished from −102 volts), at the time of arrival of the clear memory pulse CM, the gate will open and current will flow to solenoid 653 of the relay. This will attract armature 654 downwardly against permanent magnet 655, and will thereby lock the armature in the down position. It will remain in locked condition until it is manually released. When the armature is in its down or locked position, current from the power line flows through error light 656 and indicates that a mistake has been made by the apparatus. The power lines X and Y, to the direct current supply 605, are also deenergized and therefore further printing cannot take place.

Either of two circumstances can cause a check thyratron to remain energized at the end of a printing cycle. Assuming the previous condition where A and B are printed in the first and second vertical columns respectively and nothing is printed in the third vertical column, if it be also assumed that the apparatus operates in the normal way and the letter A is printed but that following the printing of the letter A an unwanted noise signal appears in the secondary 536, the apparatus would operate as follows. This noise pulse cannot energize the print thyratron directly without previously energizing the check thyratron 600, since it is necessary for the check thyratron to be turned on before the second grid of the print thyratron has proper bias for firing. The noise signal cannot energize the check thyratron until another

pulse is transmitted by the code generator over wire 670 to the second grid of thyratron 600. When such a pulse arrives on wire 670, it, together with the noise signal, will again turn on the check thyratron 600, but it cannot turn on the print thyratron 601 because it has already fired and discharged its associated condenser 607. That condenser cannot be recharged until the next CM pulse arrives at thyratron 609, so the print thyratron 601 remains off and the check thyratron 600 remains on. Therefore, at the end of the print cycle the check thyratron 600 is on and draws a current which operates the all-out detector 652 and shuts down the apparatus.

The mode of operation described in the preceding paragraph would be essentially the same in event a character was to be printed which is located in the typewheel near the end of the print cycle. For example, if the letter E was to be printed and the noise pulse occurred early in the print cycle, the noise pulse would cause another letter, for example A, B or C, to be printed and when the typewheel reached the letter E, another surge would appear in the output of secondary 536 which, together with the pulse on wire 670, would turn on the check tube 600 and the letter would remain on to operate the all-out detector. Another function of the check tube is to give an indication in event a noise signal appears on one of the channels where no printing is to take place. For example, assume that the letters A and B were to be printed in the first two vertical columns, but nothing was to be printed in the third vertical column. In this situation, the check tube 650 would not normally be energized in response to the probe memory pulse PM. Hence, it would remain de-energized until the unwanted noise signal arrived. In a conventional circuit, such an unwanted noise signal might energize the print thyratron and thus print a character in this third vertical column, but this is impossible in view of the operation of the check thyratron.

The print thyratron 651 does not have sufficient potential on its second grid to perform a printing operation until the check thyratron 650 is first energized, but the check thyratron 650 cannot be energized ahead of the print thyratron 651 if the printing cycle has progressed beyond the appearance of the fire check pulse FC (see Figure 4). This follows from the fact that the triggering pulses on the second grids of the printing thyratrons precede in time the triggering pulses on the second grids of the check thyratrons, as shown in Figure 4. Hence, the only thing that the noise pulse can do upon its arrival is to place a potential on the grid of the check thyratron 650 and if this potential persists until a signal appears on wire 670 from the code generator, the check tube 650 will fire and will remain fired until the end of the print cycle at which time it will energize gate 629 which will in turn energize the relay 653 and shut down the apparatus and turn on the error light 656. In order to insure that the gate 629 is concurrently energized by the error signal, and the clear memory signal, before the clear memory signal re-ignites the thyratron 609, a very short delay line 671 may be placed in series with the grid of the thyratron 609.

An additional function of the check tube is to give an indication and shut down the apparatus in event a non-printable binary signal is stored in the memory. If, for example, there should be stored in the first horizontal row of the memory 102 the binary signal 0111, it is clear that some error has been made, since there is no similar binary signal produced by the code generator 103. If such a non-printable signal appeared in the memory prior to the arrival of pulse PM, that pulse would produce an output in the secondary 536 and thereby ionize the check tube 600. Since code generator 103 never produces a binary signal similar to the one stored in the memory, the coincidence circuit 109 would never show a coincidence and accordingly print tube 601 would never be energized. It follows that check tube 600 would never be de-ionized and therefore would continue to draw current through its cathode resistor 627 until arrival of pulse CM at which time gate 629 would shut down the apparatus and turn on the error light 656.

In other words, when the condensers 607, 608 are being charged from the condenser 606, the flow of current sharply lowers the potential on the anode of tube 609 and draws down with it the potential on the control grid of tube 672, thus cutting it off. At the end of the charging period, any leakage current from the condensers 607, 608, etc. tending to flow through rectifiers 612, 613, etc. will flow through tube 672, thence through its cathode resistor to the cathode's source of −150 volts. The flow of current through said cathode resistor will raise the cathode potential above −150 volts, but not sufficiently high so as to render inoperative the bias of +75 volts which is connected to the control grid. This bias being quite positive with respect to the cathode potential, insures the tube will be capable of conducting off all of the leakage current that may flow from condensers 607, 608 through their complementary rectifiers 612, 613, etc. The bus 673 is therefore kept at substantially ground potential.

Figure 10 illustrates the operation of the clear memory means of Figure 1. The purpose of the clear memory means of Figure 1 is to normally allow a potential of +213 volts to be impressed on the anode resistors of the tubes of the memory. However, just prior to refilling the memory, it is necessary to de-ionize all of the gas tubes so that they will be in a condition ready to be selectively ionized again, according to the new information to be placed in the memory. Therefore, source 1000, having a potential of +213 volts, is fed to lower contact element 1001 against which armature 1002 is normally biased by a spring 1003. This normally holds the upper ends of the anode resistors 504, etc. at +213 volts. For a short interval at the end of each print cycle, the clear memory pulse CM energizes solenoid 1004 and moves the armature 1002 against contact 1005 which is connected through a suitable resistor to a source of +55 volts. Preferably, the contacts 1001 and 1005 are so positioned that the armature meet one of them before it leaves the other. As a result, throughout the print cycle, the potential fed to the memory is +213 volts. When the print cycle is completed, it drops to +55 volts, where it remains for a sufficient period to insure that all of the gas tubes stand de-ionized and then it is restored to +213 volts so that the memory is ready to be refilled.

The function of tube 672 will now be explained. In the absence of this tube it is possible that in some situations the charge on some of the condensers 607, 608, etc. might place such a large back voltage on the selenium cell rectifiers 612, 613, etc. as to tend to charge other condensers which have already been discharged. For example, if the letter A is printed first so that condenser 607 is immediately discharged, the other condensers 608, etc. may remain charged for a short interval thereafter. During this interval the condensers 608, etc. may place such a large back voltage on rectifier 613, etc. as to tend to pass a leakage current into condenser 607 which would charge it up enough so it might prepare the print thyratron for another firing action. This situation is not likely to occur, but if it is desired to prevent the possibility of its occurrence, the tube 672 may be added which forms a low resistance path from bus 673 to ground during the printing cycle. However, during the charging period of the condensers 607, 608, etc. the grid of 672 is cut off so that it cannot shunt current around the condensers being charged.

Figure 3 is a schematic diagram of the relation of the typewheel and the printing hammer. The typewheel 100 has a ribbon 301 which may have the same width at the typewheel and which moves past the typewheel at a suitable rate. The paper 302 is also moved past the

typewheel **100** at a suitable rate and is preferably advanced one or more spaces after the printing of each line. The paper may be advanced by any well known means. The hammer **303** is biased away from the typewheel **100** by the spring **306**. This spring presses the armature **307** against the stop **304**. However, in response to energization of solenoid **308**, the armature **307** is moved smartly forward until it strikes stop **305**. The momentum gained during this movement, which may be approximately 50 mils, accelerates the hammer **303** to such a high velocity that the hammer continues through the remaining 30 mils of its travel out of contact with the armature **307**, and strikes the paper **302** driving it against the ribbon **301** and the latter against the type of the typewheel **100**. The spring **306** promptly returns the hammer **303** from contact with the paper. This arrangement insures that the hammer strikes the paper ony once and eliminates minor collisions between the hammer and the paper which might smudge the typing. The hammer strikes the typewheel approximately one millisecond after the triggering signal has been applied to the print thyratron which controls the particular solenoid involved. It requires approximately 8 milliseconds for the hammer and armature to return to rest. Spring **321** returns armature **307** into contact with stop **304**.

Figure 7 is a perspective view showing the arrangement of a plurality of armatures **307**, springs **306** and printing hammers **303**. The printing hammers **303** are guided by the members **700** and **701**. The guides **701** for the hammers are composed of nylon and they are held in slots by projections **702** which are integral with the steel supporting member **703**. As shown in Figures 9 and 11, the typewheel is composed of a series of discs, each disc supporting one or more columns of type. If the individual discs were merely stacked on a shaft, the thickness tolerance would have to be held to a small fraction of an inch in order to keep the over-all accuracy within proper limits, especially when a large number of vertical columns are to be printed, thus necessitating a large number of discs on the same typewheel. As mentioned above, in one form of the invention, a total of 130 columns of type are employed and this requires 130 discs. Instead of stacking the discs on the shaft, the shaft **901** has a plurality of accurately spaced grooves **902** in which a snap ring is located. In assembling the typewheel, a snap ring is placed in the first groove. The first disc is then pushed against said first snap ring and is followed by spring washer **903** and then a second typewheel **904**. This brings the last surface of the second disc in line to accommodate the second snap ring. The third disc **905** is placed on, followed by another spring washer **906** and then a fourth disc **907**, followed by another snap ring **908**. This process is repeated until the typewheel shaft is full. In Figure 9 one of the hammers **900** is shown in printing position, that is the position it assumes after being struck by its associated armature. The spring washers hold the discs in firm contact with their associated snap rings and thus accurately position the discs.

Various changes in the construction and mode of operation may be made without departing from the scope of the invention. For example, the memory may be any of various types including magnetic memories. Moreover, it is not necessary that the information stored in the memory be printed on the paper as a single horizontal line. A means, controlled by a plug board, located between the comparator **108** and the actuators **111**, **114** and **116**, etc., can be provided so that the operator may, at his option, print the entire information stored in the memory at one time into a single horizontal line or into several shorter horizontal lines one above the other, etc. In addition to changes in the interconnection of the parts such as just suggested, the individual components of the system may be changed within substantial limits without departing from the scope of the invention, as defined by the appended claims.

What is claimed is:

1. A cylindrical type wheel having type thereon staggered in axial rows and circumferential columns in a checkerboard fashion, one of said columns containing a plurality of different type faces, and others of said columns containing a like plurality of type faces corresponding to said type faces of said one column.

2. In combination, a cylindrical rotating typewheel, said typewheel having its type elements in rows which are parallel to the axis of the typewheel, at least one of the rows having a space between two type elements thereon and a type element outside of said row but aligned with said space, and in which the last-named type element and the type elements in said one row each print the same character, and in which type elements in other rows print other characters.

3. In combination, a cylindrical rotating typewheel, said typewheel having its type elements in rows which are parallel to the axis of the typewheel, there being two rows of type elements for each character to be printed, there being spaces between the type elements in each row which contain no type element and which are wide enough to permit a character to be printed therein and the two rows of type for each character having their type elements relatively staggered so that the second of the two rows may rotate into a position wherein its type elements may print in the spaces where the first row was unable to print.

4. In combination, a cylindrical rotating typewheel, said typewheel having its type elements in rows which are parallel to the axis of the typewheel, there being two adjacent rows of type for each character to be printed, alternate rows of the typewheel having their type elements staggered so that alternate rows of the typewheel print alternate columns of the printed matter.

5. The combination of claim 4 including a printing hammer for each space along a given line where printing may occur, and means for actuating the printing hammers to print the desired characters including means to delay the actuation of the printing hammers in alternate columns to compensate for the delays in the type elements arriving at printing position due to said staggering.

6. The combination of claim 4 including a printing hammer for each space along a given line where printing may occur, driving means for each printing hammer, an actuator for each driving means, means for simultaneously conditioning all of the actuators that are to effect printing of the same given character in advance of the arrival of that character into printing position, and means controlled by the angular position of the typewheel for triggering all of said actuators each time a new character moves into printing position, said last-named means delaying the triggering of the actuators in alternate columns to compensate for said staggering and to allow the second row of printing elements of the particular character involved to move into printing position, each of said actuators applying driving energy to its complementary driving means only when it is first conditioned as aforesaid and then triggered by said last-named means.

7. The combination of claim 4 including means to rotate the typewheel, a row of printing hammers with one hammer for each space along a given line where printing may occur, a solenoid for each printing hammer to move it into printing position when the solenoid is energized, an electron discharge device for each solenoid and connected to control its complementary solenoid, each electron discharge device having two grids, means for applying a permissive signal to one of the control grids of each said device when that device is to effect printing of a character on the typewheel that is approaching printing position, and means connected to another grid of each electron discharge device to apply triggering signals thereto, the last-named means having the timing of its signals controlled by the angular position of the typewheel and producing two recurring signals one of which is fed to alternate electron discharge devices and the other of

which is fed to the remaining electron discharge devices, the second of the two signals being supplied to the electron discharge devices complementary to those alternate rows of type elements that reach printing position last, the second of the two signals being delayed with respect to the first by the time that the typewheel requires to rotate from one row to the next.

8. The combination of claim 4 including means to rotate the typewheel, a row of printing hammers with one hammer for each space along a given line where printing may occur, a solenoid for each printing hammer to move it into printing position when the solenoid is energized, an electron discharge device for each solenoid and connected to control its complementary solenoid, each electron discharge device having two grids, a memory having separate storage elements for each electron discharge device, means controlled by the typewheel for generating a differential signal as each different character on the typewheel approaches printing position, separate comparison elements for each storage element in the memory for comparing said signals with information stored in the memory and for giving an indication when coincidence occurs, means in response to such coincidence to energize one of the grids in the electron discharge device complementary to the storage element where said coincidence occurred, the last-named means including triggering means for producing a first triggering signal each time the first row of a new character approaches printing position and a second triggering signal when the other row of said character approaches printing position, the first triggering signal being fed to the other grids of the electron discharge devices which control the printing so far as the first rows of type elements of each character is concerned and the second triggering signal being fed to the other grids of the electron discharge devices which control the printing so far as the other rows of type elements are concerned.

9. In combination a typewheel having a plurality of printing characters around its periphery, means for rotating the typewheel, a code generator for producing various signals as the typewheel rotates one of which is a binary signal which changes so as to indicate the arrival of the different characters as they approach printing position and another of which is a probe pulse and occurs near the beginning of each print cycle, a memory for storing the information to be printed by each printing hammer, a plurality of printing hammers cooperating with the typewheel, a solenoid for each printing hammer, a thyratron for controlling each solenoid, an ionizable check tube for each thyratron, means connecting each check tube to its complementary thyratron so that the thyratron is biased to cut off in the absence of energization of the check tube, means which in response to the probe pulse energizes a check tube when the memory contains information indicating that the printing hammer complementary to the check tube is to be energized in the printing cycle that has just started, means connecting each check tube to its complementary thyratron so that the latter extinguishes the check tube after the thyratron has energized its complementary solenoid, means for firing the thyratrons in response to presence of information to be printed in the memory, and means for indicating whether all check tubes have been deionized at the end of the printing cycle.

10. In an electrical circuit, a plurality of thyratrons having output circuits, an ionizable check tube for each thyratron, means which in advance of energization of the thyratrons ionizes all of the check tubes which are complementary to the thyratrons which are later to be fired, means for firing certain of the thyratrons to produce the desired outputs, means for deionizing the check tube complementary to a thyratron that has just fired, and means subsequent to said firing which indicates when all of the check tubes have been deionized.

11. In an electrical circuit, a plurality of thyratrons having output circuits, an ionizable check tube for each thyratron, means whereby each thyratron can fire only when its complementary check tube is ionized, means for storing signals which determine which of the thyratrons are to be fired, means responsive to the stored signals for first ionizing all of the check tubes which are complementary to the thyratrons that should be fired according to said signals, means for subsequently ionizing the thyratrons according to said signals, means for extinguishing a check tube when its complementary thyratron has fired, and means for subsequently giving an indication when any check tube is still ionized.

12. In an electrical circuit, a plurality of ionizable discharge devices having output circuits, a plurality of ionizable check tubes, one for each of the discharge devices, each of the discharge devices being cut off in absence of bias signals from its complementary check tube, means for supplying said bias for each discharge device when its complementary check tube is ionized, means for separately storing information which is to control the ionization of each discharge device, means which ionizes all the check tubes complementary to those devices which are to be ionized by the stored energy, means which within a predetermined time tends to ionize the devices when there is information stored indicating that such ionization is desirable, means which in response to each ionization of a discharge device deionizes the check tube complementary to such device, and means which after the end of said predetermined time indicates whether any of the check tubes are still ionized.

13. In combination, a typewheel, a plurality of printing elements cooperating with the typewheel, means for storing information to be printed, means for normally actuating said printing elements according to said stored information, and means which indicates if the second-named means fails to actuate one of the printing elements when the stored information was calling for such an actuation.

14. In combination, a typewheel, a plurality of printing elements cooperating with the typewheel, means for separately storing information to be printed by each printing element, and electrical means tending to energize each printing element according to its complementary stored information, the electrical means including indicating means which indicates when a noise signal occurs which operates one of the printing elements.

15. In combination, a typewheel, a plurality of printing elements cooperating with the typewheel, means for separately storing information to be printed by each printing element, electrical means tending to actuate each printing element according to the stored information complementary to said element, said electrical means including indicating means which gives an indication in case the electrical means fails to supply actuating energy to the printing element when there was information stored in the first-named means calling for such an actuation and also gives an indication in case a noise signal appears in the electrical means.

16. In combination, a memory, a code generator, said memory having binary signals stored therein, said code generator producing changing binary signals, and means which gives an indication when there is a predetermined relation between the binary signals of the memory and of the code generator comprising all of the following, separate channels for the binary signals in memory, separate channels for the binary signals from the code generator, and means for connecting the complementary channels of the code generator and of the memory to each other and including means for indicating a given relative correspondence between the binary signals from said memory and the binary signals from said code generator.

17. In combination, a typewheel having a plurality of

printing characters around its periphery, a plurality of printing hammers cooperating with said typewheel, means for rotating said typewheel, a memory for storing the information to be printed by each printing hammer, an actuating device for each printing hammer, a control circuit for each actuating device, means connecting each control circuit to its associated actuating device so that the device is inoperative to actuate its printing hammer when an output is absent from said control circuit, means energizing a control circuit when said memory contains information indicating that the printing hammer associated with the control circuit is to be energized in the printing cycle that commences, means connecting each control circuit to its complementary actuating device so that the latter extinguishes the control circuit after the actuating device has actuated its complementary printing hammer, means for energizing said actuating devices in response to presence of information to be printed in said memory, and means for indicating whether all control circuits have been extinguished at the end of the printing cycle.

18. In combination, a typewheel having a plurality of printing characters around its periphery, a plurality of printing hammers cooperating with said typewheel, means for rotating said typewheel, a memory for storing the information to be printed by each printing hammer, a solenoid for each printing hammer, an actuating device for controlling each solenoid, a control circuit for each actuating device, means connecting each control circuit to its associated actuating device so that the device is inoperative to actuate its solenoid when an output is absent from said control circuit, means energizing a control circuit when said memory contains information indicating that the printing hammer associated with the control circuit is to be energized in the printing cycle that commences, means connecting each control circuit to its complementary actuating device so that the latter extinguishes the control circuit after the actuating device has actuated its complementary solenoid, means for energizing said actuating devices in response to presence of information to be printed in said memory, and means for indicating whether all control circuits have been extinguished at the end of the printing cycle.

19. In combination, a typewheel having a plurality of printing characters around its periphery, a plurality of printing hammers cooperating with said typewheel, means for rotating said typewheel, a memory for storing the information to be printed by each printing hammer, a solenoid for each printing hammer, a coincidence device for each printing hammer for providing an output upon the coincidence of signals present at its inputs, said output operable to energize the associated solenoid, a two-state circuit for each coincidence device having a connection to one input of its associated device so that said device does not provide said output to its solenoid when said circuit is in one of its two states, means for placing said circuit in the other of its two states when said memory contains information indicating that the printing hammer associated with the control circuit is to be energized in the printing cycle that commences, means connecting the output of said device to said circuit to place said circuit in one of its two states after said device has actuated its complementary solenoid, means coupled to a second input of said device responsive to the presence of information to be printed in said memory, and means for indicating whether all two-state circuits are in their said one of their two states at the end of the printing cycle.

20. In combination, a typewheel having a plurality of printing characters around its periphery, a plurality of printing hammers cooperating with said typewheel, means for rotating said typewheel, a memory for storing the information to be printed by each printing hammer, a solenoid for each printing hammer, a thyratron for controlling each solenoid, an ionizable check tube for each thyratron, means connecting each check tube to its complementary thyratron so that the thyratron is biased to cut off in the absence of energization of the check tube, means energizing a check tube when said memory contains information indicating that the printing hammer complementary to the check tube is to be energized in the printing cycle that has just started, means connecting each check tube to its complementary thyratron so that the latter extinguishes the check tube after the thyratron has energized its complementary solenoid, means for firing said thyratrons in response to presence of information to be printed in said memory, and means for indicating whether all check tubes have been deionized at the end of the printing cycle.

21. In combination, a typewheel having a plurality of printing characters around its periphery, a plurality of printing hammers cooperating with said typewheel, means for rotating said typewheel, a code generator for producing a signal which changes so as to indicate the arrival of the different characters as they approach printing position, a memory for storing the information to be printed by each printing hammer, a comparator for comparing the information stored in said memory with the code represented by said signal, a solenoid for each printing hammer, a thyratron for controlling each solenoid, an ionizable check tube for each thyratron, means connecting each check tube to its complementary thyratron so that the thyratron is biased to cut off in the absence of energization of the check tube, means energizing a check tube when said memory contains information indicating that the printing hammer complementary to the check tube is to be energized in the printing cycle that has just started, means connecting each check tube to its complementary thyraton so that the latter extinguishes the check tube after the thyratron has energized its complementary solenoid, means for firing said thyratrons in response to comparisons produced by said comparator, and means for indicating whether all check tubes have been deionized at the end of the printing cycle.

22. In combination, a typewheel having a plurality of printing characters around its periphery, a plurality of printing hammers cooperating with said typewheel, means for rotating said typewheel, a generator for producing a signal to indicate the arrival of the different characters as they approach printing position, a memory for storing the information to be printed by each printing hammer, selective means for comparing the information stored in said memory with the character represented by said signal, an actuating device for each printing hammer, a control circuit for each actuating device, means connecting each control circuit to its associated actuating device so that the device is inoperative to actuate its printing hammer when an output is absent from said control circuit, means energizing a control circuit when said memory contains information indicating that the printing hammer associated with the control circuit is to be energized in the printing cycle that commences, means connecting each control circuit to its complementary actuating device so that the latter extinguishes the control circuit after the actuating device has actuated its complementary printing hammer, means for energizing said actuating devices in response to presence of information to be printed in said selective means, and means for indicating whether all control circuits have been extinguished at the end of the printing cycle.

23. In combination, a typewheel having a plurality of printing characters around its periphery, a plurality of printing hammers cooperating with said typewheel, means for rotating said typewheel, a memory for storing the information to be printed by each printing hammer, means for receiving a direct current supply, a plurality of capacitors, a gating circuit, said circuit adapted to open to charge said capacitors immediately prior to a printing cycle and said circuit adapted to close to prohibit further charging of said capacitors upon the commencement of a

printing cycle, a solenoid for controlling each printing hammer, a thyratron for controlling each solenoid, said thyratron adapted to be actuated when its associated capacitor carries a charge, an ionizable check tube for each thyratron, means connecting each check tube to its complementary thyratron so that the thyratron is biased to cut off in the absence of energization of the check tube, means energizing a check tube when said memory contains information indicating that the printing hammer complementary to the check tube is to be energized in the printing cycle that has just started, means connecting each check tube to its complementary thyratron so that the latter extinguishes the check tube after the thyratron has energized its complementary solenoid, means for firing said thyratrons in response to information to be printed in said memory, said thyratron being quenched after firing due to the discharge of its associated capacitor through said solenoid and said thyratron, and means for indicating whether all check tubes have been deionized at the end of the printing cycle.

24. In combination, a typewheel having a plurality of printing characters around its periphery, a plurality of printing hammers cooperating with said typewheel, means for rotating said typewheel, a memory for storing the information to be printed by each printing hammer, means for receiving a direct current supply, a storage condenser coupled to said receiving means, a gating circuit coupled to said condenser and adapted to provide an output for a period immediately prior to a printing cycle until the commencement of the printing cycle, a plurality of capacitors adapted to be charged only during said period by said gating circuit, a solenoid for controlling each printing hammer, a thyratron for controlling each solenoid, said thyratron adapted to be actuated when its associated capacitor carries a charge, an ionizable check tube for each thyratron, means connecting each check tube to its complementary thyratron so that the thyratron is biased to cut off in the absence of energization of the check tube, means energizing a check tube when said memory contains information indicating that the printing hammer complementary to the check tube is to be energized in the printing cycle that has just started, means connecting each check tube to its complementary thyratron so that the latter extinguishes the check tube after the thyratron has energized its complementary solenoid, means for firing said thyratrons in response to information to be printed in said memory, said thyratrons being quenched after firing due to the discharge of its associated capacitor through said solenoid and said thyratron, and means for indicating whether all check tubes have been deionized at the end of the printing cycle.

25. In combination, a typewheel having a plurality of printing characters around its periphery, a plurality of printing hammers cooperating with said typewheel, a memory for storing information to be printed by each printing hammer, a solenoid for each printing hammer, a thyratron for controlling each solenoid, an ionizable check tube for each thyratron, means connecting each check tube to its complementary thyratron so that the thyratron is biased to cut off in the absence of energization of the check tube, means energizing a check tube when said memory contains information indicating that the printing hammer complementary to the check tube is to be energized in the printing cycle that has just started, means connecting each check tube to its complementary thyratron so that the latter extinguishes the check tube after the thyratron has energized its complementary solenoid, means for firing said thyratrons in response to presence of information to be printed in said memory, means for indicating whether all check tubes have been deionized at the end of the printing cycle, and means synchronous with said typewheel for clearing said memory at the end of each print cycle.

26. In combination, a typewheel having a plurality of printing characters around its periphery, a plurality of printing hammers cooperating with said typewheel; means for rotating said typewheel; a code generator for producing a probe memory pulse at the beginning of a print cycle, for producing a fire check pulse at the beginning of a print cycle, for producing a signal which changes so as to indicate the arrival of the different characters as they approach printing position, and for producing a print pulse followed by a check pulse as the different characters approach printing position; a memory for storing the information to be printed by each printing hammer; a comparator for comparing the information stored in said memory with the code represented by said signal; a solenoid for each printing hammer; a thyratron for controlling each solenoid; an ionizable check tube for each thyratron; means connecting each check tube to its complementary thyratron so that the thyratron is biased to cut off in the absence of energization of the check tube; means controlled by said probe memory pulse to transfer information from said memory to said check tubes; means coupling said fire check pulse to said check tubes, so that only those check tubes will fire upon the coincidence of information stored in the memory and fire check pulse thereby indicating that the printing hammer complementary to the check tube is to be energized in the print cycle that has just started; means connecting each check tube to its complementary thyratron so that the latter extinguishes the check tube after the thyratron has energized its complementary solenoid; means controlled by said print pulses for firing said thyratrons in response to comparisons produced by said comparator, so that said thyratrons fire upon the coincidence of comparisons produced by said comparator, the ionization of the associated check tube, and the receipt by the thyratron of a print pulse; means coupling said check pulses to each of said check tubes so that the check tube ionizes in the event of a spurious output from said comparator; and means for indicating whether all check tubes have been deionized.

27. In combination, a typewheel having a plurality of columns of printing characters around its periphery, said printing characters being in rows which are parallel to the axis of the typewheel, there being two adjacent rows of type characters for each symbol to be printed, alternate rows of the typewheel having their characters staggered so that alternate rows of the typewheel print alternate columns of printed matter; a first plurality of printing hammers cooperating with alternate columns of characters on said typewheel; a second plurality of printing hammers alternately interposed with said first hammers and cooperating with the remaining alternate columns of characters on said typewheel; means for rotating said typewheel; a code generator for producing a probe memory pulse at the beginning of a print cycle, for producing a fire check pulse at the beginning of a print cycle, for producing a signal which changes so as to indicate the arrival of the different characters as they approach printing position, and for producing a print pulse followed by a check pulse as each row of characters on said typewheel approaches printing position; alternate print pulses being provided on a first print line from said generator and remaining alternate print pulses being provided on a second print line, alternate check pulses being provided on a first check line and remaining alternate check pulses being provided on a second check line; a memory for storing the information to be printed by each printing hammer; a comparator for comparing the information stored in said memory with the code represented by said signal; a solenoid for each printing hammer; a thyratron for controlling each solenoid; an ionizable check tube for each thyratron; means connecting each check tube to its complementary thyratron so that the thyratron is biased to cut off in the absence of energization of the check tube; means controlled by said probe memory pulse to transfer information from said memory to said check

tubes; means coupling said first check pulse to said check tubes, so that only those check tubes will fire upon the coincidence of information stored in the memory and the fire check pulse thereby indicating that the printing hammer complementary to the check tube is to be energized in the print cycle that has just started; means connecting each check tube to its complementary thyratron so that the latter extinguishes the check tube after the thyratron has energized its complementary solenoid; means controlled by print pulses on said first print line for firing alternate thyratrons and means controlled by print pulses on said second print line for subsequently firing the remaining alternate thyratrons in response to comparisons produced by said comparator, so that alternate thyratrons fire upon the coincidence of comparisons produced by said comparator, the ionization of the associated check tube, and the receipt by the thyratron of a print pulse on said first print line and that the remaining alternate thyratrons fire upon the coincidence of comparisons produced by said comparator, the ionization of the associated check tube, and the receipt by the thyratron of a print pulse on said second print line; means coupling said check pulses on said first check line to alternate check tubes and means coupling said check pulses on said second check line to the remaining alternate check tubes, so that the check tubes ionize in the event of a spurious output from said comparator; and means for indicating whether all check tubes have been deionized.

28. In combination, a typewheel having a plurality of printing characters around its periphery, a plurality of printing hammers cooperating with said typewheel, means for rotating said typewheel, a memory for storing the information to be printed by each printing hammer, a solenoid for each printing hammer, a thyratron for controlling each solenoid, an ionizable check tube for each thyratron, means connecting each check tube to its complementary thyratron so that the thyratron is biased to cut off in the absence of energization of the check tube, means energizing a check tube when said memory contains information indicating that the printing hammer complementary to the check tube is to be energized in the printing cycle that has just started, means connecting each check tube to its complementary thyratron so that the latter extinguishes the check tube after the thyratron has energized its complementary solenoid, means for firing said thyratrons in response to presence of information to be printed in said memory, and means for interrupting said rotating means when any check tube remains ionized at the end of a printing cycle.

29. In combination, a typewheel having a plurality of printing characters around its periphery; a plurality of printing hammers cooperating with said typewheel; means for rotating said typewheel; a code generator for producing, at every printing cycle, a probe memory pulse at the beginning of a print cycle, a fire check pulse at the beginning of a print cycle, a signal which changes so as to indicate the arrival of the different characters as they approach printing position, a print pulse followed by a check pulse as the different characters approach printing position, and a clear memory pulse at the termination of a print cycle; a memory for storing the information to be printed by each printing hammer; means for receiving a direct current supply; a storage condenser coupled to said receiving means; a gating circuit coupled to said condenser and adapted to provide an output during the period commencing with the generation of said clear memeory pulse and terminating with the generation of said probe memory pulse; a plurality of capacitors adapted to be charged only during said period by said gating circuit; a comparator for comparing the information stored in said memory with the code represented by said signal; a solenoid for each printing hammer; a thyratron for controlling each solenoid, said thyratron adapted to be actuated when its associated capacitor carries a charge; an ionizable check tube for each thyratron; means connecting each check tube to its complementary thyratron so that the thyratron is biased to cut off in the absence of energization of the check tube; means controlled by said probe memory pulse to transfer information from said memory to said check tubes; means coupling said fire check pulse to said check tubes, so that only those check tubes will fire upon the coincidence of information stored in the memory and the fire check pulse thereby indicating that the printing hammer complementary to the check tube is to be energized in the print cycle that has just started; means connecting each check tube to its complementary thyratron so that the latter extinguishes the check tube after the thyratron has energized its complementary solenoid; means controlled by said print pulses for firing said thyratrons in response to comparisons produced by said comparator, so that said thyratrons fire upon the coincidence of comparisons produced by said comparator, the ionization of the associated check tube, the receipt by the thyratron of a print pulse, and the presence of a charge on said capacitor, said thyratrons being quenched after firing due to the discharge of its associated capacitor through said solenoid and said thyratron; means coupling said check pulses to each of said check tubes so that the check tube ionizes in the event of a spurious output from said comparator; means for indicating whether all check tubes have been deionized at the end of the printing cycle; and means including said clear memory pulse for clearing said memory at the end of each print cycle.

30. In combination, a typewheel having a plurality of columns of printing characters around its periphery, said printing characters being in rows which are parallel to the axis of the typewheel, there being two adjacent rows of type characters for each symbol to be printed, alternate rows of the typewheel having their characters staggered so that alternate rows of the typewheel print alternate columns of printed matter; a first plurality of printing hammers cooperating with alternate columns of characters on said typewheel; a second plurality of printing hammers alternately interspersed with said first hammers and cooperating with the remaining alternate columns of characters on said typewheel; means for rotating said typewheel; a code generator for producing, at every printing cycle, a probe memory pulse at the beginning of a print cycle, a fire check pulse at the beginning of a print cycle, a signal which changes so as to indicate the arrival of the different characters as they approach printing position, a print pulse followed by a check pulse as each row of characters on said typewheel approaches printing position, and a clear memory pulse at the termination of a print cycle; alternate print pulses being provided on a first print line from said generator and remaining alternate print pulses being provided on a second print line, alternate check pulses being provided on a first check line and remaining alternate check pulses being provided on a second check line; a memory for storing the information to be printed by each printing hammer; means for receiving a direct current supply; a storage condenser coupled to said receiving means; a gating circuit coupled to said condenser and adapted to provide an output during the period commencing with the generation of said clear memory pulse and terminating with the generation of said probe memory pulse; a plurality of capacitors adapted to be charged only during said period by said gating circuit; a comparator for comparing the information stored in said memory with the code represented by said signal; a solenoid for each printing hammer; a thyratron for controlling each solenoid, said thyratron adapted to be actuated when its associated capacitor carries a charge; an ionizable check tube for each thyratron; means connecting each check tube to its complementary thyratron so that the thyratron is biased to cut off in the absence of energization of the check tube; means controlled by said probe memory pulse to transfer information from said memory to said check tubes; means coupling said fire check pulse to said check tubes, so that only

those check tubes will fire upon the coincidence of information stored in the memory and the fire check pulse thereby indicating that the printing hammer complementary to the check tube is to be energized in the print cycle that has just started; means connecting each check tube to its complementary thyratron so that the latter extinguishes the check tube after the thyratron has energized its complementary solenoid; means controlled by print pulses on said first print line for firing alternate thyratrons and means controlled by print pulses on said second print line for subsequently firing the remaining alternate thyratrons in response to comparisons produced by said comparator, so that alternate thyratrons fire upon the coincidence of comparisons produced by said comparator, the presence of a charge on the associated capacitor, the ionization of the associated check tube, and the receipt by the thyratron of a print pulse and that the remaining alternate thyratrons fire upon the coincidence of comparisons produced by said comparator, the presence of a charge on the associated capacitor, the ionization of the associated check tube, and the receipt by the thyratron of a print pulse on said second print line; said thyratrons being quenched after firing due to the discharge of the associated capacitor through said solenoid and said thyratron; means coupling said check pulses on said first check line to alternate check tubes and means coupling said check pulses on said second check line to the remaining alternate check tubes, so that the check tubes ionize in the event of a spurious output from said comparator; means for interrupting said rotating means when any check tube remains ionized at the end of a printing cycle; and means including said clear memory pulse for clearing said memory at the end of each print cycle.

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