# United States Patent

[11] 3,571,655


[72] Inventor **Akira Tanimoto**
**Yamatokoriyama-shi, Japan**



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[73] Assignee **Sharp Kubushiki Kaisha**
**Osaka, Japan**



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[33] **Dec. 26, 1967**
[31] **Japan**
**42-79703, 42/79955 and 42/83761**


[54] **ELECTRONIC INDICIA DISPLAY SYSTEM**
**10 Claims, 18 Drawing Figs.**


[52] **U.S. Cl.** ..... **315/169,** 313/109.5, 250/217, 315/84.6
[51] **Int. Cl.** ..... **H05b 37/00,** H05b 39/00
[50] **Field of Search** ..... 313/109, 109.5, 108; 250/217; 315/169, 169 (FV), 84.6



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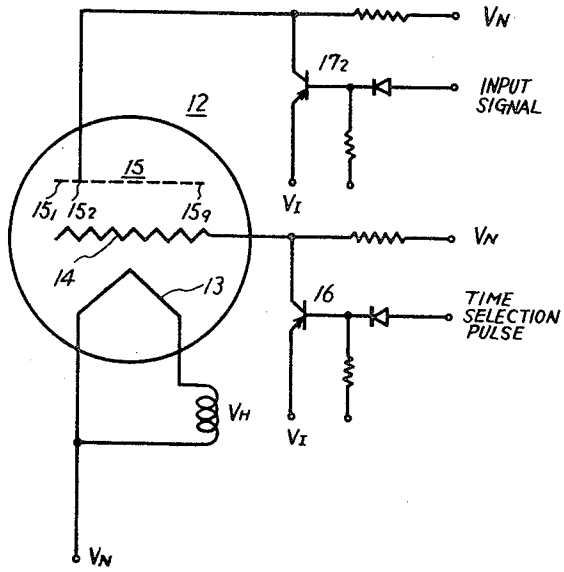
*Primary Examiner*—John W. Huckert
*Assistant Examiner*—Andrew J. James
*Attorney*—Eugene E. Geoffrey, Jr.



**ABSTRACT:** An indicia indicating system having an improved electrostatically shielded indicating tube of the luminescent type embodying single and multiple units, a filament circuit for a plurality of indicating tubes to enable the maintenance of proper interelectrode potentials and indicating tube driving circuitry to effect efficient dynamic numeral indicating and overcome abnormal luminescent functions heretofore encountered with such indicating tubes.

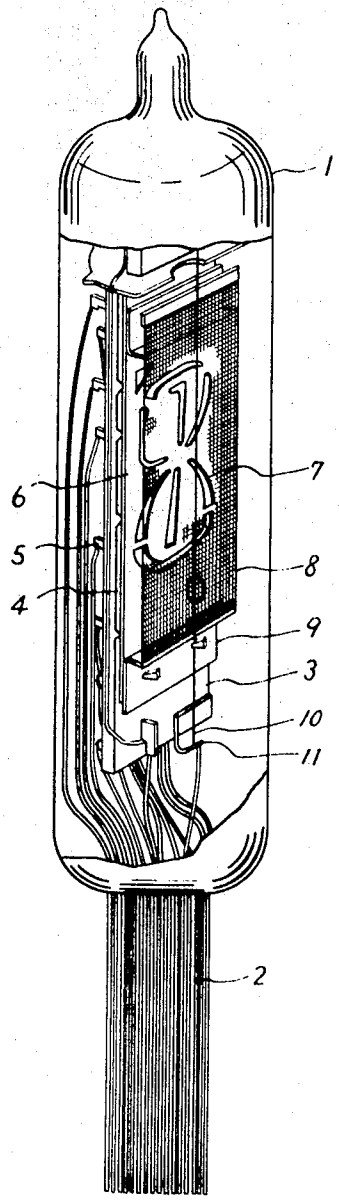



Fig. 1

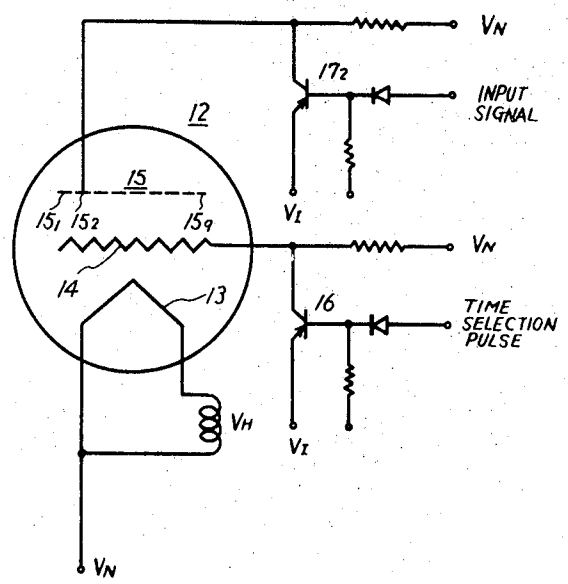



Fig. 2

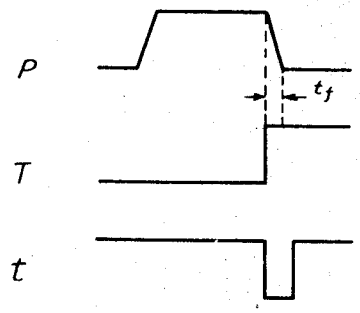



Fig. 5

INVENTOR.
AKIRA TANIMOTO
BY Eugene Hoffman
ATTORNEY

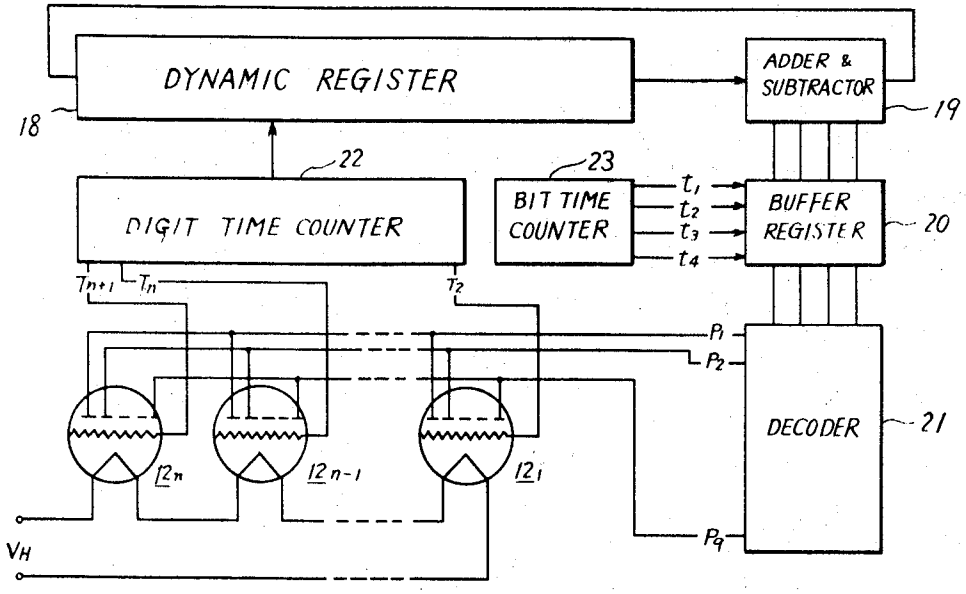



Fig. 3

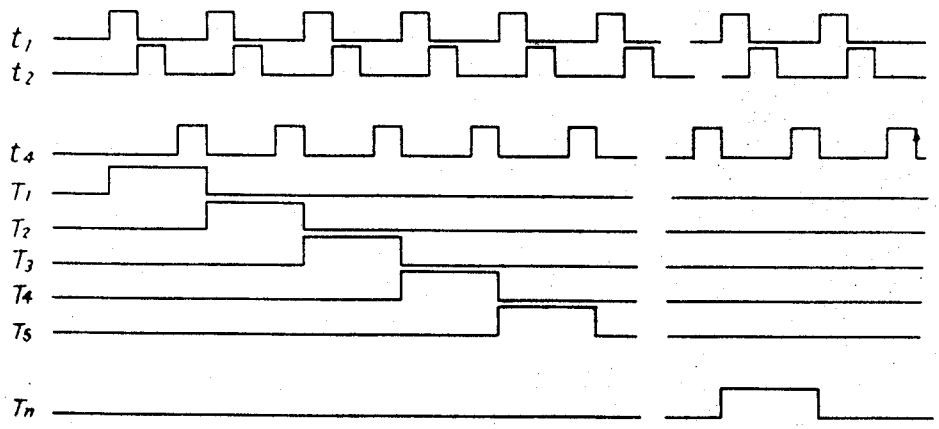



Fig. 4

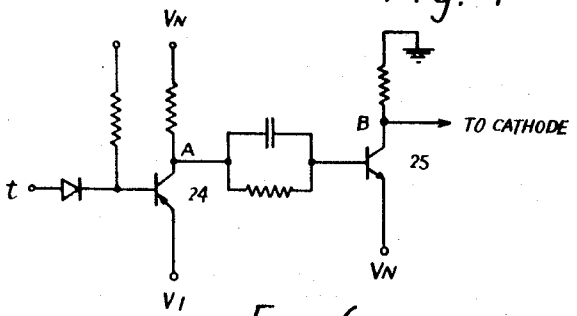



Fig. 6

INVENTOR.
AKIRA TANIMOTO
BY
ATTORNEY

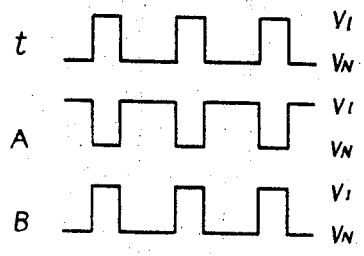



Fig. 7

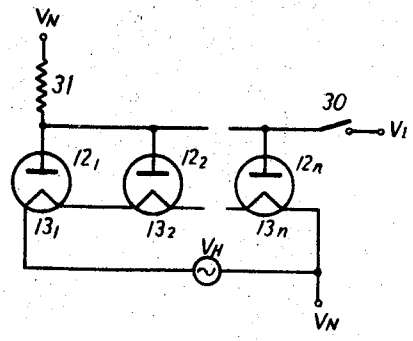



Fig. 10

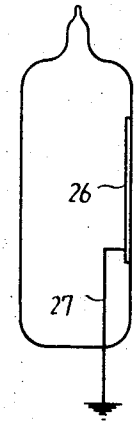



Fig. 8

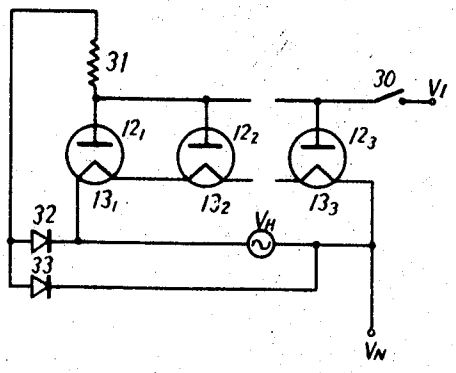



Fig. 11

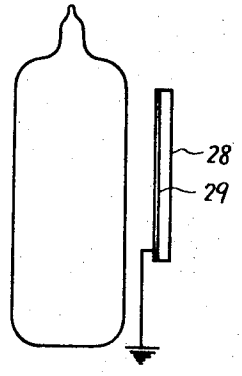



Fig. 9


Fig. 12


Fig. 13

INVENTOR.
AKIRA TANIMOTO

BY

ATTORNEY

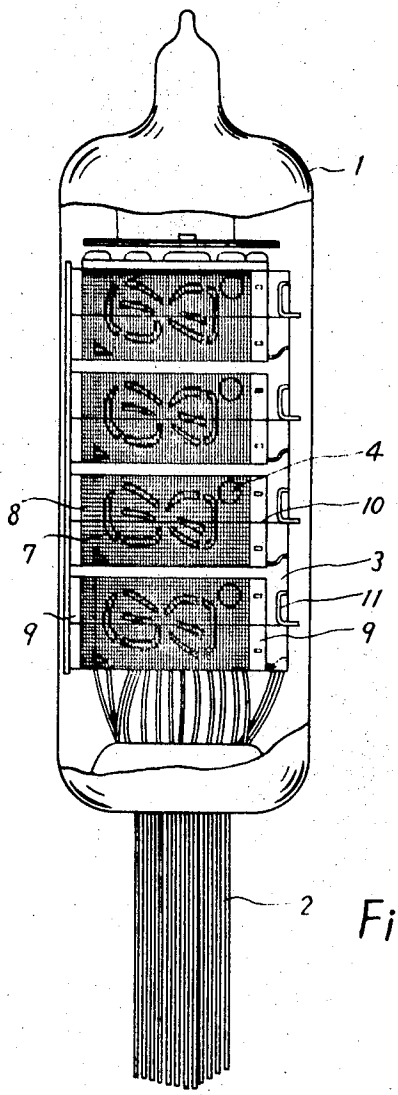



Fig. 14

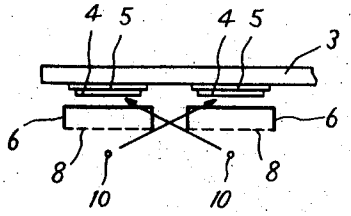



Fig. 16

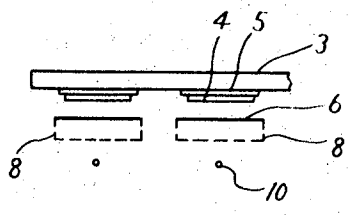



Fig. 17

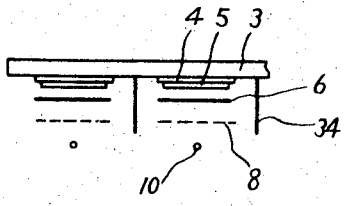
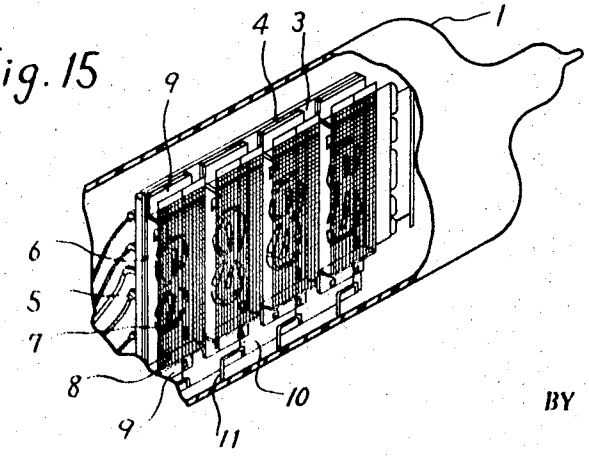



Fig. 18

Fig. 15




INVENTOR.
AKIRA TANIMOTO

BY Eugene G. Hoffman Jr.
ATTORNEY

# ELECTRONIC INDICIA DISPLAY SYSTEM

This invention relates to an improved indicating system and more specifically to an improved indicia display device and electronic circuitry for the operation thereof.

Electronic computers such as table-type computers and the like means for indicating numerals such as gas-filled, cold cathode discharge tubes of the type generally referred to as "-nixie" tubes. Such indicating tubes have not been entirely satisfactory since all of the numerals are not displayed in a common plane and a relatively high voltage is required for operation. Indicia indicating tubes generally referred to as fluorescent indicating tubes utilizing a heated cathode, a control grid, and phosphor indicating elements substantially overcome the difficulties encountered with prior types of tubes. However, the fluorescent indicating tube is easily affected by external electrostatic fields and known procedures for electrostatically shielding such tubes have not been found satisfactory because the required treatment for shielding the tube and at the same time permitting the indicia to be viewed renders the tube more fragile in that it is easily broken. Another difficulty entailed with indicia indicating tubes using heated filaments is that they must be connected either in series or in parallel. When a number of tubes are utilized the resistance of the wiring becomes significant and the filament voltages on all tubes will not be equal. In the case of a series connection, the potential between each tube and ground differs and it becomes extremely difficult to maintain the proper voltage relationship between the filament of such tube and the associated electrodes.

This invention overcomes the aforementioned difficulties or prior systems and provides a novel and improved indicia indicating system embodying improved fluorescent indicating tubes having electrostatic shields that will protect the tubes against external electrostatic fields and at the same time provide a stable durable indicating device. The invention further affords improved means for heating the filaments of the fluorescent indicating tubes which enables the maintenance of the proper voltage relationships between the filament, grid and fluorescent indicating surface or anode.

Another object of the invention is to provide novel and improved electronic circuitry for driving the tubes to afford highly efficient dynamic numeral indication and avoid errors occasioned by circuit time delays which often deform the electrical pulses required for the operation of the fluorescent indicating tubes.

A still further object of the invention resides in the provision of a novel and improved fluorescent indicating tube embodying means within a single envelope for displaying a plurality of indicia and combinations of indicia.

Still another object of the invention resides in the provision of a novel and improved indicia indicating apparatus including improved indicia indicating tube and electrical circuitry for the operation thereof that will afford a high degree of dependability, facilitate rapid operation and enable the components to be contained within a relatively small space.

The above and other objects and advantages of the invention will become more apparent from the following description and accompanying drawings forming part of this application.

In the Drawings:

FIG. 1 is a perspective view in partial section of a novel and improved indicating tube in accordance with the invention;

FIG. 2 is a circuit diagram illustrating an improved electronic drive for the tube illustrated in FIG. 1;

FIG. 3 is a block diagram illustrating a drive system for a plurality of indicating tubes in accordance with the invention;

FIG. 4 is a graph illustrating the time relationship of control pulses developed in accordance with the invention for driving a plurality of fluorescent indicating tubes;

FIG. 5 is a graph illustrating the relationship of pulses in accordance with the invention to prevent abnormal functioning of the indicating tubes;

FIG. 6 is a circuit diagram for preventing abnormal functioning of the indicating tubes;



FIG. 7 is a graph indicating the wave forms provided by the circuit illustrated in FIG. 6;

FIG. 8 is a diagrammatic view of an improved shielding system for fluorescent indicating tubes in accordance with the invention;

FIG. 9 is a modified embodiment of an electrostatic shielding system for indicating tubes in accordance with the invention;

FIG. 10 is a circuit diagram illustrating the method of heating filaments of fluorescent indicating tubes according to the prior art;

FIG. 11 is an improved circuit for heating the filaments of the tubes in accordance with the invention;

FIG. 12 illustrates the relationship between the anode and cathode voltages of the circuit shown in FIG. 10;

FIG. 13 illustrates the relationship of the anode and cathode voltages in accordance with the improved circuit shown in FIG. 11;

FIG. 14 is a view of a composite indicating tube in accordance with the invention;

FIG. 15 is a fragmentary perspective view of the tube illustrated in FIG. 14; and

FIGS. 16 through 18 are diagrammatic illustrations of shielding systems in accordance with the invention for use in connection with the composite indicating tube illustrated in FIGS. 14 and 15.

The indicating tube utilized with this invention is illustrated in FIG. 1 and embodies an outer glass envelope 1 provided with a plurality of lead wires 2 extending from the bottom of the envelope. A ceramic insulating plate 3 extends lengthwise of the envelope and carries on its front fact a phosphor material 4 such as zinc oxide or the like. This phosphor is arranged in discrete sections or segments to permit the display of specific indicia such as numerals one through nine and zero. The discrete phosphor sections are each connected to individual anodes 5 extending through the ceramic plate 3 and are electrically connected to individual lead wires 2. As will become evident, each discrete phosphor section constitutes a separate anode. A plate 6 is disposed in front of the ceramic plate 3 and has openings therein which are arranged to enable the display of specific indicia such as numerals. The openings in effect form optical windows to view the phosphor materials 4 when excited to luminescence. One such optical window is denoted by the numeral 7. A mesh electrode 8 is disposed in front of the plate 6 and secured thereto by suitable brackets 9. The mesh 8 and the plate 6 together form the control grid. A directly heated filament or cathode 10 is disposed in front of the mesh 8 and is secured to the ceramic plate 3 by suitable brackets 11. The ends of the filament 10 and the grid comprising the plate 6 and the mesh 8 are also connected to individual lead wires 2.

In the operation of the tube illustrated in FIG. 1 a suitable voltage is applied to the filament 10 to cause it to emit electrons toward the phosphor 4. The electrons are accelerated and diverged by the mesh electrode 8 and upon energizing one or more of the anode phosphor segments connected with the terminals 5, the electrons uniformly bombard the energized phosphors and cause them to luminesce. When using zinc oxide as the phosphor, a voltage of the order of 50 volts is sufficient between the cathode 10 and the anode to effect luminescence and a pulse duration to period ratio of 1 to 16 is sufficient when using pulses for operation of the tube.

With this invention the grid electrode consisting of the plate 6 and mesh 8 can be maintained at a potential substantially equal to the cathode potential even though the phosphor anodes are located to the rear of the grid electrode and are supplied with a considerably higher voltage than that applied to the cathode.

An improved driving system for each of the indicating tubes which may be used in a computer is illustrated in FIG. 2. The circuit includes means for selectively energizing the several anodes, each connected to a terminal 5 and a second driving system for energizing the grid. The circuits are arranged so that it is possible to selectively energize certain of the anodes

and at the same time control the grid electrode to block the electron flow. More specifically, and with reference to FIG. 2, the indicating tube of FIG. 1 is generally denoted by the numeral 12 and includes a cathode or filament 13, the grid 14, and a plurality of anodes 15 which in the instant embodiment of the invention includes nine separate anodes denoted by the numerals $15_1$ through $15_9$. The filament or cathode 13 is energized by an alternating current supply $V_H$, one side of which is connected to a negative potential $V_N$ of the order of 50 volts negative. The grid 14 and each anode 15 are connected respectively through series resistors to the negative potential $V_N$. With reference to the anodes 15 each of the anodes for instance the anode $15_2$ is connected to the collector electrode of a transistor $17_2$, it being understood that there is one transistor for each of the anodes. The emitter electrode is connected to zero potential $V_I$ while the base is connected through a resistor to a negative potential between $V_N$ and $V_I$ as for example 24 volts negative. The base is also connected through a diode to an input signal. The grid 14 is similarly controlled by a transistor 16 having its collector connected to the grid and its emitter connected to zero potential $V_I$. The base of the transistor 16 is connected to a negative voltage of the same order as that applied to the base of transistor $17_2$. The base is driven by a time selection pulse through a diode in the same manner as described in connection with transistor $17_2$.

In the operation of the circuit both transistors 16 and 17 are in their nonconductive or cutoff states when input pulses are not applied to the base electrodes of the transistors. Under those conditions the grid 14 and the anodes 15 are both at negative potentials and electrons are not being emitted from the filament 13. When negative pulses are applied to the bases of the transistors 16 and 17, the transistors become conductive, and the collector potentials increase substantially to zero potential $V_I$. At this time the electrons are accelerated by the potential difference between the cathode or filament 13 and the anode 15 and strike selected anode or anodes 15 to cause the corresponding phosphors connected to the anodes to luminesce. When the input pulse applied to the base electrodes or either transistors 16 or 17 is interrupted, the transistor becomes nonconductive and the grid or anode potential as the case may be assumes the initial negative potential to block electron flow and thereby prevent luminescence. The driving circuit in accordance with the invention functions to maintain the cathode or filament electrode at a low potential and the grid and anode electrodes at relatively high potential at the time of luminescence and further applies a low potential to either the grid or anode electrode to render ineffective any potential difference between the cathode and anode when luminescence is not desired.

FIG. 3 is a block diagram of an indicating tube driving system utilizing the dynamic indicating system in accordance with the invention. The system embodies a plurality of indicating tubes identified as $12_1$ through $12_n$. The precise number of tubes being determined by the number of digits or numerals to be displayed. The grids of each of the indicating tubes are successively driven by a series of digit timing pulses T produced by the digit time counter 22. For purposes that will become apparent the tube $12_1$ receives a timing pulse $T_2$ while the tube $12_{n11}$ receives a timing pulse $T_n$ and the tube $12_n$ receives a timing pulse $T_{n+1}$. The anode electrodes are provided with potentials $P_1$ through $P_9$, it being observed that corresponding anodes of each of the indicating tubes are connected together and the pulses $P$ are provided by the decoder 21. The decoder 21 is controlled by the dynamic register 18 and the information produced by the dynamic register is preferably in the form of binary coded decimal numbers of $n$ digits. The information in the dynamic register 18 is circulated to effect a shift in time by means of the adder and subtractor 19. During the indicating cycle the adder and subtractor 19 does not exhibit its operational function since no input is applied thereto. The information from the dynamic register 18 is supplied to the decoder 21 through the buffer register 20. In addition, timing pulses $t_1$ through $t_4$ are generated by the bit time counter 23 and are fed to the buffer register 20. With this arrangement the information pertaining to the several digits and obtained from the adder and subtractor 19 is so arranged that the least significant digit occurs during the presence of the digit timing signal $T_2$ which activates the tube $12_1$. Information relative to the next significant digits is successively fed to the respective tubes so that the timing signal $T_n$ is fed to the tube $12_{n11}$ while the timing signal $T_{n+1}$ is fed to the tube $12_n$ and the circuitry introduces the appropriate delays. The binary coded decimal information is converted into a decimal output by the decoder 21 to select the anode segments of each tube required to form the desired numerals 0 through 9 on the indicating tubes. FIG. 4 represents the time relationship by the digit timing pulses $T_1$, $T_2$,... $T_n$ and the bit timing pulses $t_1$ through $t_4$.

It will be noted that notwithstanding the high frequencies of the timing signals their wave forms may be deformed as a result of the delay circuitry and often have inclined leading and trailing edges. When the wave forms are deformed and the anode is at the negative potential $V_n$ while the grid drops from a zero potential $V_I$ to a negative potential $V_N$ an abnormal luminescent effect characteristic of dynamic indication may occur. FIG. 5 shows the time relation of a deformed input pulse $P$, a time selection pulse $T$ and a bit timing pulse $t$. From this FIG. it will be observed that the time interval $t_f$ defines the time of the trailing edge of the pulse $P$. By providing a bit timing signal $t$ at a point in time corresponding to the change of each digit time and of a duration greater than $t_f$, the disadvantage occurring by reason of the deformed pulse $P$ is overcome. The production of the signals as described in connection with FIG. 5 may be accomplished by the circuit shown in FIG. 6. The collector electrode of a PNP transistor 24 is connected to the base of an NPN transistor 25 through a parallel RC network. The collector of transistor 24 is also connected through a resistor to a negative potential source $V_N$ as for example −50 volts. The emitter is connected to zero potential $V_I$. The base of transistor 24 is connected to the cathode side of a diode and the input signal $t$ is applied to the anode side of the diode. The base of the transistor 24 is also connected through a resistor to a potential between $V_N$ and $V_I$ as for example −24 volts. The emitter of transistor 25 is connected to the negative potential $V_n$ while the collector is connected to the cathode or filament of the indicating tube and also to a reference potential point through a resistor.

The operation of the circuit of FIG. 6 will be more clearly understood when taken in connection with the wave forms shown in FIG. 7. In FIG. 7, $t$ is a bit timing pulse, $A$ is the collector potential of transistor 24 and $B$ is the collector potential of transistor 25, the latter also being the cathode potential of the indicating tube or tubes as the case may be. In the absence of the bit timing pulse the transistor 24 is biased at a negative potential causing it to conduct and raise the collector to $V_I$. The transistor 25 is thereby driven into conduction and the collector potential of that transistor is then at $V_N$. Under these conditions the associated indicating tube will operate. If the bit timing pulse is applied the bias of the transistor 24 is removed causing it to cut off and effect a drop in the potential of the collector. This causes transistor 25 to cut off and the collector potential is raised substantially to zero thus cutting off the indicating tube. In this way the indicating tube is temporarily cut off only for the duration for a specific bit timing pulse and thereby abnormal luminescence is eliminated.

As previously pointed out, the indicating tubes utilized with this invention are activated by electrons emitted from the filament and accelerated by the grid to bombard the phosphor anodes in order to excite them to luminescence. If an external electrostatic field acts on an indicating tube, it can affect electron flow and possibly interrupt luminescence. While films such as a Nesa film have been used on the inner wall of the glass envelope to prevent the adverse effects of electrostatic fields such a film has not been found satisfactory as it renders the indicating tube more fragile and the glass envelope can be easily broken. Should the tube envelope be formed of acryl resin, the deposition of the Nesa film is difficult and it is also

difficult to obtain optimum resistivity for electrostatic shielding and at the same time provide adequate light transmission.

With this invention it has been found that a thin film of metal or other electroconductive material will function effectively as an electrostatic shield. More specifically, the thickness of a film of metal or other electroconductive material can be chosen to provide a resistivity sufficient to effect excellent shielding and at the same time minimize the loss of light transmission so that the indicia being indicated by the tube can be readily observed by the eye. Materials that have been found satisfactory are gold or an alloy of gold and antimony, the latter being preferred. With the use of gold a resistivity of several ohms per square centimeter has been obtained while retaining a light transmission of the order of 70 percent to 80 percent of that of glass. The film thickness was approximately 100 angstroms.

Two modifications of an improved electrostatically shielded envelope are illustrated in FIGS. 8 and 9. In FIG. 8 the thin film 26 is evaporated onto the inner wall of the tube envelope and is connected through a conductor 27 to a shielding potential. In FIG. 9 the thin film 29 is evaporated onto a glass plate 28 positioned in front of the tube and connected through a conductor to a shielding potential. With this arrangement excellent shielding of the tube is provided and the shielding can be formed on either glass or resin envelopes and produces a durable structure.

As previously pointed out, indication systems utilizing a plurality of tubes are preferably connected in series. In such cases however the cathode or filament potentials vary from tube to tube and seriously affect stable and dependable operation of the apparatus. FIG. 10 represents a conventional system showing the indicating tubes $12_1$ through $12_n$ having filaments $13_1$ through $13_n$ connected in series and to a source of alternating current $V_H$. One end of the source is connected to a negative potential $V_N$. For convenience each of the tubes is shown with a single anode and all of the anodes are connected in parallel and connected to a switching circuit diagrammatically represented by a conventional switch 30 for applying zero potential $V_I$. The anodes are also connected through a resistor 31 to a negative potential $V_N$.

With the foregoing arrangement as shown in FIG. 10 and with the switch 30 open, the anodes are all at the same potential and all of the indicating tubes 12 should be in a cutoff condition. It will be observed however that the cathode 13 of the tube $12_n$ is at the negative potential $V_N$. The cathode $13_1$ of the tube $12_1$ however will be at a potential $V_N \pm V_H$. Since $V_H$ is equal to the number of tubes times the voltage of each tube, the potential difference between each filament and its associated anode will differ. Since $V_H$ is an alternating current, no affect occurs when this voltage is positive but a forward dias is applied between each cathode and its anode when the filament voltage becomes negative. Under this condition certain of the tubes such as $13_1$ cannot be maintained in a cut off condition. Because of the AC frequency, undesirable conditions occur and the indicating tubes at the left end of the group as illustrated in FIG. 10 always show some luminescence and are never completely cut off.

FIG. 11 represents an improved circuit in accordance with the invention for overcoming the disadvantages described in connection with FIG. 10. In FIG. 11, however, the anodes of the tubes are connected through resistor 31 and diodes 32 and 33 to opposite sides of the AC source $V_H$. With this arrangement the anodes can never become more positive than the cathodes or filaments when the switch 30 is in an off position and thus all indicating tubes will be completely cut off. FIGS. 12 and 13 illustrate the voltage wave forms at each anode and cathode of FIGS. 10 and 11 respectively at the time switch 30 is open.

The indication system in accordance with the invention can be effectively utilized particularly with table-type electronic computers. Miniaturization of table type computers has developed rapidly and the circuits have been integrated so that relatively small and at the same time highly reliable devices can be manufactured. However, the indicating means, the power supply section and the input keys have materially limited the minimum size of the computers. This invention provides an improved indicating device having a plurality of indicating tubes formed within a single envelope which not only decreases the space required for indication but also simplifies the wiring. Thus the improved indicating tube therefore facilitates further miniaturization and provides a more stable and dependable operation.

The improved luminescent indicating tube is illustrated in FIGS. 14 and 15. For convenience, a four digit tube has been shown through it is to be understood that the tube can be made with any number of digits.

The filaments, grids and anodes of the tubes shown in FIGS. 14 and 15 are the same as those illustrated and described in connection with FIG. 1, and accordingly, like numerals have been utilized to denote like elements. More specifically the glass envelope is denoted by the numeral 1 and would be normally disposed in a horizontal position with the lead wires 2 extending from one end thereof. A single elongated rectangular plate 3 extends throughout the length of the envelope and carries a plurality of groups of phosphor layers 4 deposited thereon in the manner previously described. Anode terminals extend from the back of the ceramic plate 3 and are connected to the sets of phosphor layers.

The pattern configurations for the indicating portions for each digit are similar and corresponding anodes of the several digits are interconnected within the tube. Each grid plate 6 having windows 7 and an accelerating mesh electrode 8 is connected to an individual lead 2 while the cathodes or filaments 11 are connected in series within the tube and the ends are also brought out of the tube through individual leads 2.

With the composite indicating tube as described above, it is possible that electrons emitted from one cathode of filament may be attracted by the anode potential of an adjoining unit and thereby excite the phosphors or each adjoining unit since the interval therebetween is very small. This invention further includes means for preventing such electron interference.

FIGS. 16, 17, and 18 illustrate three embodiments for preventing electron interference between adjoining indicating units. Referring to FIG. 16 the side edges of the grid plate 6 are bent forwardly to form in effect a channel or U-shaped construction and the side edges function to prevent electrons emitted from one filament 10 from interfering with the adjoining indicating unit. In FIG. 17 the side edges of the accelerating mesh electrode are folded backwardly toward the plate 6 to achieve the same effect as that achieved with the structure illustrated in FIG. 16. In FIG. 18 a separate shield 34 is positioned between adjoining units to electrically isolate them. With those embodiments of the invention it is of course desirable to utilize the shielding system described in connection with FIGS. 8 and 9 and when using the structure shown in FIG. 18 the shielding plates 34 should be connected to the shielding film 26 on the tube wall.

While only certain embodiments of the invention have been illustrated and described, it is understood that various changes, modifications and alterations can be made without departing from the scope of the invention. For example, the number of segments of the characters to be indicated may be varied and any number of indicating units may be included within the single composite indicating tube. Furthermore, it would also be possible in the composite tube to connect the filaments in parallel or if desired provide separate leads 2 for each of the filaments and anodes.

I claim:

1. An indicating system for displaying indicia comprising a plurality of indicating devices each having a filament, a plurality of anode segments shaped to display predetermined indicia and a grid for controlling the flow of electrons from the filament to the anodes, means applying a low potential to said filaments, circuit means interconnected with the anode segments of each device for applying a high potential to selected anode segments of said devices in response to the input signal

fed to said circuit means and means connected with the grids of said devices for operating selected devices by applying a high potential to the grids of the selected devices and a low potential to the other devices whereby only said selected devices will luminesce to display indicia.

2. An indicating system according to claim 1 including means for applying a high biasing potential pulse to said filaments of said devices just prior to the termination of said input signal said pulse having a time duration greater than the time required for the termination of said input signal.

3. An indicating system according to claim 1 wherein each indicating device is enclosed within an envelope and a thin film of electroconductive material such as a metal, metal alloys and the like at least partially surrounding said envelope, said film having a resistivity sufficient to effect electrostatic shielding and a relatively high light transmission characteristic.

4. An indicating system according to claim 1 including means connecting said filaments in series and to an alternating current source of energy, means including rectifiers connecting said anodes to each side of said alternating current energy source to counteract a forward bias between said anodes and filaments when said filament voltage is in a direction preventing said devices from being maintained in cutoff state.

5. An indicating system according to claim 1 wherein said indicating devices are enclosed within a common envelope.

6. An indicating system according to claim 5 wherein corresponding anodes of said indicating devices are interconnected within said envelope and lead wires connected to said interconnected anodes and each of said grids are connected to individual conductors extending outwardly through said envelope.

7. An indicating system according to claim 5 including electrostatic shields between adjoining devices within said envelope prevent electronic interference between adjoining devices.

8. An indicating system for displaying indicia comprising a plurality of indicating devices each including a cathode, a plurality of phosphor coated anode segments shaped to display predetermined indicia and a grid between said cathode and anode segments for controlling electron flow to said segments, means including a power source connected with said cathodes to constantly maintain them at a selected operating temperature for the emission of electrons and at a relative low potential, connections between corresponding anode segments of said devices, an anode selecting circuit connected to said anode connections and applying a high potential relative to the cathode potential to selected sets of anode segments, means feeding a numerical input signal to said anode selecting circuit to cause the latter to apply said high potential to selected sets of anode segments while the remaining sets of anode segments remain at a low potential, a timing pulse generator for generating a plurality of timing pulses shifted in phase and synchronized with the input signal, grid timing circuit means connected with the grids of said devices and with the timing pulse generator to apply a high potential relative to the cathode potential to the grids of selected devices while the grids of the remaining devices remain at a low potential whereby selected devices wherein both anode segments and the grid are at a high potential will luminesce to display the selected indicia.

9. An indicating system according to claim 8 including means connected to said cathodes for applying a high potential thereto at selected switching times to momentarily drive said devices into a cutoff state.

10. An indicating system according to claim 8 wherein said anode selecting circuit includes a plurality of transistors each having a collector connected to one set of anode segments and to a low voltage source, an emitter connected to a high voltage source and a base connected to said input signal means, and said grid timing circuit means includes a plurality of transistors each having a collector connected to one of said grids and to a low voltage source, an emitter connected to a high voltage source and a base connected to the timing pulse generator.