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PATENT SPECIFICATION
DRAWINGS ATTACHED

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COMPLETE SPECIFICATION

Decimal Digit Indicating Device

We, HAYAKAWA DENKI KOGYO K.K., a Japanese Corporation of 22-22, Nagaike-cho, Abeno-ku, Osaka, Japan, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to an apparatus for providing a visual indication of decimal digits and more specifically relates to apparatus which is so constructed that the indicated digits can be read-off with ease especially in the case where a number of digits are indicated in a line at the same time.

In general, numeral indicating electronic tubes have mostly been used, for example, as an out-put indicating means for desk type electronic calculators in such a manner that the tubes are arranged in a line. In such example, the indicating tubes indicate the result of an operation or are used to indicate the value of a number, which is registered temporarily in a register, and which is applied to the said tubes through switching circuits.

Usually the number of digits in the numerals to be indicated is less than total number of digit spaces of the indicating means and the digit "0" is indicated in all the spaces beyond the most significant digit of the numeral. In such a case, there is a disadvantage that it is difficult to immediately perceive the effective numeral, as one cannot immediately pick out the most significant digit of the numeral.

In some cases, instead of indicating a "0" in the spaces beyond the most significant digit, the spaces are left blank but this involves the use of logical gates and "NOT" circuits connected to all the digit spaces of

the register, which requires complicated circuitry.

The principal object of the present invention is to provide a digit indicating means with which the effective numerals can be recognized with ease without providing any particular means for cancelling an undesired "0" by improving the numeral indication system so as to remove the above mentioned deficiencies.

With this object in view, the present invention provides a decimal digit indicating apparatus comprising an indicating device which can be energised to display illuminated outlines of the decimal digits 0 to 9 and an operating circuit connected to the device for selecting the digit to be displayed, wherein the height of the outline of the digit "0" when illuminated is substantially less than that of the other digits.

There are also some further difficulties which arise in the prior art indicating devices. One known form of indicating device comprises a gas filled discharge tube having therein a plurality of glow cathodes, each shaped as a digit. The problem with these devices is that the different digits cannot be indicated in the same plane, though a comparatively ideal shape of the digit is obtained as each glow cathode *per se* has the shape of the digit to be indicated.

Another known type of indicating device has a plurality of phosphor segments arranged in a form of, for example, a cross in a square or in the form of an "8". The different digits are formed by causing the segments to be illuminated in different combinations. However, there is a disadvantage that the appearance of the indicated digits is, in view of the restriction in the shape of the digit produced due to the arrangement of the segments, not in accordance with

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the ideal shape of the digits. This results in a problem in reading out the digits quickly. For example, in case of indicating means having segments arranged in a form of a cross in a square, distinguishing between "2", "3", "5", "6", "8", "9" and "0" is difficult. This is due to the fact that, since the light emitting segments are arranged in rectangular form, the effect of curvature 10 and continuity in the form of the digit is lost and therefore many digits resemble each other. Another reason is that the width of each segment is constant.

A preferred embodiment of the invention 15 has illuminable segments arranged and shaped and the operating circuit so arranged that these problems also may be alleviated.

The preferred embodiment of the invention will now be described with reference 20 to the accompanying drawings in which:—
Figure 1 is a front view of a decimal digit indicating device,

Figure 2 is a perspective side view of the device shown in Figure 1,

25 Figure 3 is an enlarged perspective view of part of the device shown in Figures 1 and 2,

Figure 4 is an enlarged front view of a digit indicating mask used in the device 30 shown in Figures 1-3, and

Figure 5 shows the form of the decimal digits as they are displayed according to the present invention.

In a base of an evacuated glass envelope 35 11, are mounted a plurality of lead wires 12. A rectangular ceramic insulating plate 13 is secured in an upright position in the said envelope and a series of ridges 14, are formed on the surface of the said plate 13 40 so as to divide the surface of the plate into a number of areas 15 each of which corresponds to one light emitting segment as hereinafter explained.

45 'L' shaped electrode terminals 16, are inserted through holes (not shown) bored in each of said areas 15 and then the whole of each area 15, is coated with a conductive paint and further coated with phosphor material such as ZnO to form a phosphor 50 layer 17.

Each electrode terminal 16 protruding from the back of the plate 13 is connected to the corresponding lead wire 12. A metal plate 18, for example made of nickel is 55 then laid over the plate 13 being secured thereto by securing members 19, with a proper gap. The plate 18 constitutes and functions as a grid electrode and an optical mask.

60 The metal plate 18 is formed with a series of holes 20, which correspond in shape to parts of digits and to a comma and an apostrophe. A detailed explanation of the shape of these holes 20 will be given later.

65 A wire mesh 21 is supported in front

of the metal plate 18 by means of securing members 19, both the mesh and the plate 18 being supplied with the same potential. Further in front of the metal plate 18 is arranged a thermionic emitting filament 22 70 secured to the plate 13 by means of a securing member 23.

The plate 13 is supported inside the envelope 11, for example, by means of an insulating mica plate 24 fixed into the upper 75 part of the plate 13. Voltage of a given value is applied to the filament 22 and the filament 22 thus heated emits electrons.

After being accelerated and dispersed by the accelerating mesh 21, the electrons im- 80 pinge upon, and cause the emission of light from only the areas 15 of phosphor layer 17 to which an operational voltage is applied by means of the wires connected to the terminals 16. 85

The required terminal is selected in accordance with the digit to be indicated and thus the required digit is indicated clearly through the holes 20, of the plate 18. The mesh 21 and the metal plate 18 are supplied with 90 the same positive potential as that of the electrode terminals 19. More detailed explanation regarding their operation is given hereunder.

The electrons are emitted from the fila- 95 ment 22 concentrically. However, brighter illumination of the central areas of the phosphor layer 17 just opposite to the filament 22 relative to those areas away from the centre is avoided since the electrons are 100 dispersed by the positive potential applied to the mesh 21 and therefore can impinge uniformly upon the whole area of the phosphor layer 17.

The mesh 21 in addition functions so as 105 to accelerate the electrons in addition to the above.

In general, there is a tendency for the phosphor layer to increase in temperature due to thermal radiation from the filament 22 which decreases the brightness thereof, 110 if both of them are opposite directly to each other. However in the above embodiment, the metal plate 18 is positioned in front of the phosphor layer 17 and thus prevents 115 the increase of temperature at the phosphor layer 17. At the same time, the metal plate 18 decreases the chance of impingement upon the phosphor layer 17 of particles of barium oxide, with which in general the 120 filament 22 is coated but which is subject to emission because of the high temperature of the filament.

The holes 20 in the plate 18 serve to make the indicated digits sharply and accurately 125 outlined.

The digit indication system which is a most important feature of the present invention will now be described.

In the above embodiment, nine segments 130

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for forming the numerals to be displayed are defined by the holes 20, in the metal plate 18, which are so shaped and arranged that they match all required digits. The reason why the number of segments is so selected is that the number of lead wires at the base of the tube is restricted due to the size of the envelope and that too many segments cause the effect of continuity in the form of a digit to be lost and make the indicated digit unsightly.

Of these segments, as shown in Figures 4 and 5, three segments A, B, and C combine to form "0". Upper ends of the segments A and B are curved respectively toward the centre of the plate and the lower ends extend downward till a little above the bottom of the light emitting figure.

The segment B is slightly curved inward like a circular arc. The segment C has a form of a U with a slight slant to the right at both ends. Such shaped segments give much more effect of continuity between the segments of the digit than in known numeral display devices in which corresponding segments of the digits are segregated just at a corner.

Beside the "0" as a whole, segments A, B and C form the lower half part of the digits "6" and "8" and this is a greatly improved point compared to the prior art. Each digit has a characteristic shape, very similar to the ordinary shape of digit and the "0" does not define a fundamental contour to which the other digits conform and is made smaller in height than other digits, making it possible to recognise the indicated digit with ease.

"4" is formed with the four segments D, E, F and G each extending leftward, downward, rightward and upward respectively in radial direction from the centre of the plate.

Segment D is shaped like a letter L with a slight rightward gradient and is slightly thicker than other segments. The segment E is situated upright in the middle of the segments A, B, C and the width of the segment E is made wider toward the bottom of the figure so as to give the visual effect of looking longer than it actually is.

The segment F is situated on a rightward extension line of the horizontal part of the segment D. Likewise, the segment G is on an upward extension line of the segment E and is bent acutely leftward at the uppermost part, resulting in the effect of looking slightly longer than it actually is.

Segments H and I, together with segment D, forms an almost circular figure. The segment H is situated at the uppermost position and is curved downward at the left end so as to face the upper end of the segment D.

The segment I is situated on an upward extension line of the segment A and is

curved to the centre of the figure and is tapered gradually toward the lower end.

The segment J is a comma for indicating the digit grouping in a displayed numeral and the segment K is for the indication of a decimal point. The table below shows the relation between the digit to be displayed and the corresponding required segments:

Digit	Segment	
0	ACB	75
1	GE	
2	HIAC	
3	HIBC	
4	DFGE	
5	HDBC	80
6	IACB	
7	HIE	
8	HDBCAI	
9	HDIE	

Binary code emitted from a register is a calculator for example is decoded to decimal code by a decimal decoder and the required segments are selected by a decoder having a matrix circuit constituted of diodes in accordance with the said code table.

After the selection is made, the selected areas 15 of the plate 13 to which the selected segment corresponds, are supplied with DC or a pulse operating voltage.

For example, a DC voltage of 20 volt or a pulse voltage of 50 volt having a pulse proportion of 1 to 50 is suitable for a phosphor utilizing ZnO in the above embodiment.

The mesh 21 and the metal plate 18 are both supplied with the same positive voltage as the areas 15. In either case a voltage of 0.8 volt is sufficient for the filament voltage.

The form of all the digits thus indicated, as is clear in the Figure 5, bears a close resemblance to the ordinary form of the digits which one is accustomed to see and can be recognized and read out with extreme ease.

Digits "1", "4" and "7" are, as a result of being particularly considered to give such a visual effect; almost the same height as the other digits. Further, as the gaps between the segments of any figure are made at a position slightly away from the exact corner, an effect of continuity is achieved particularly in the case of the numerals "2", "3", "5" and "6".

As "2" and "5" are not symmetrical to each other there is no possibility of their being confused with each other. "5" and "6" have few segments (only two) which are in common with each other and can be said to be quite free from similarity between them. Likewise, there can be no confusion between "8" and "9" and further between "0" and "8".

A plurality of indicating tubes mentioned above may be provided in, for example, a desk type of electronic calculator in a line so as to be observed through indicating windows and are connected to switching circuits which are further connected to a register or a memory.

Although an example of a numeral indicating tube of the phosphor layer type has been described in the above as a light emitting means with which a characteristic form of the digit according to the present invention is indicated, the present invention, can be applied to other examples of display devices. For example the EL type, the glow discharge type, and the pilot lamp type. Further, the same effect is obtained even in case of a phosphor of a phosphor layer type being coated so as to assume the shape of the segments without using a metal mask 18.

WHAT WE CLAIM IS:—

1. A decimal digit indicating apparatus comprising an indicating device which can be energised to display illuminated outlines of the decimal digits 0 to 9 and an operating circuit connected to the device for selecting the digit to be displayed, wherein the height of the outline of the digit "0" when illuminated is substantially less than that of the other digits.

2. Apparatus as claimed in claim 1 having a plurality of segments illuminable in different combinations to form the different digits, wherein the segments which are illuminated to form the outline of the digit "0" are the same as those illuminated to form the lower circular parts of the digits "6" and "8".

3. Apparatus as claimed in claim 2 wherein the segments are shaped and arranged substantially as shown referenced A to I in Figure 4 of the accompanying drawings, and the operating circuit is arranged to illuminate the segments in the combinations illustrated in Figure 5 of the drawings to form the digits.

4. A decimal digit indicating apparatus substantially as described herein with reference to the accompanying drawings.

5. Means for displaying numbers containing a plurality of digits, comprising a row of decimal digit indicating apparatus according to any preceding claim.

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