① commercialized → mass-produced ?

calculator boom →

calculator wars

→ cut throat competition
in the Japanese calculator
market, which some called
'calculator wars'.

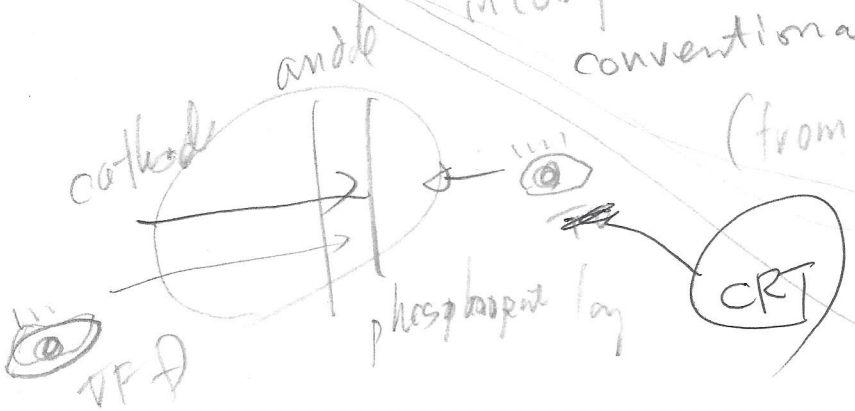
Frontier Spirit
cooperative → cooperative spirits

Are there evidence later? → yes in 4.4

Egg of Columbus(?)
→ A bit overblown

WRONG!

Viewing the display upside down
(from the cathode side)
in the opposite direction
in comparison to the
conventional CRT
(from the anode side)



(2) N/A

(2)

③ gaining
international recognition
→ evidence ??

research paths → research career (?

(3)

Nixie Tube visibility issues
→ mentioned elsewhere?
(comparative photos? would be nice)

?

patent fees → to whom ?

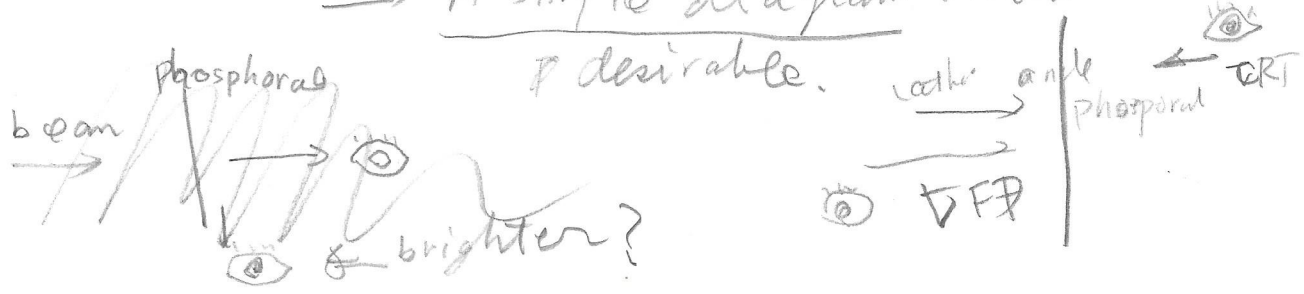
Should be mentioned explicitly here.

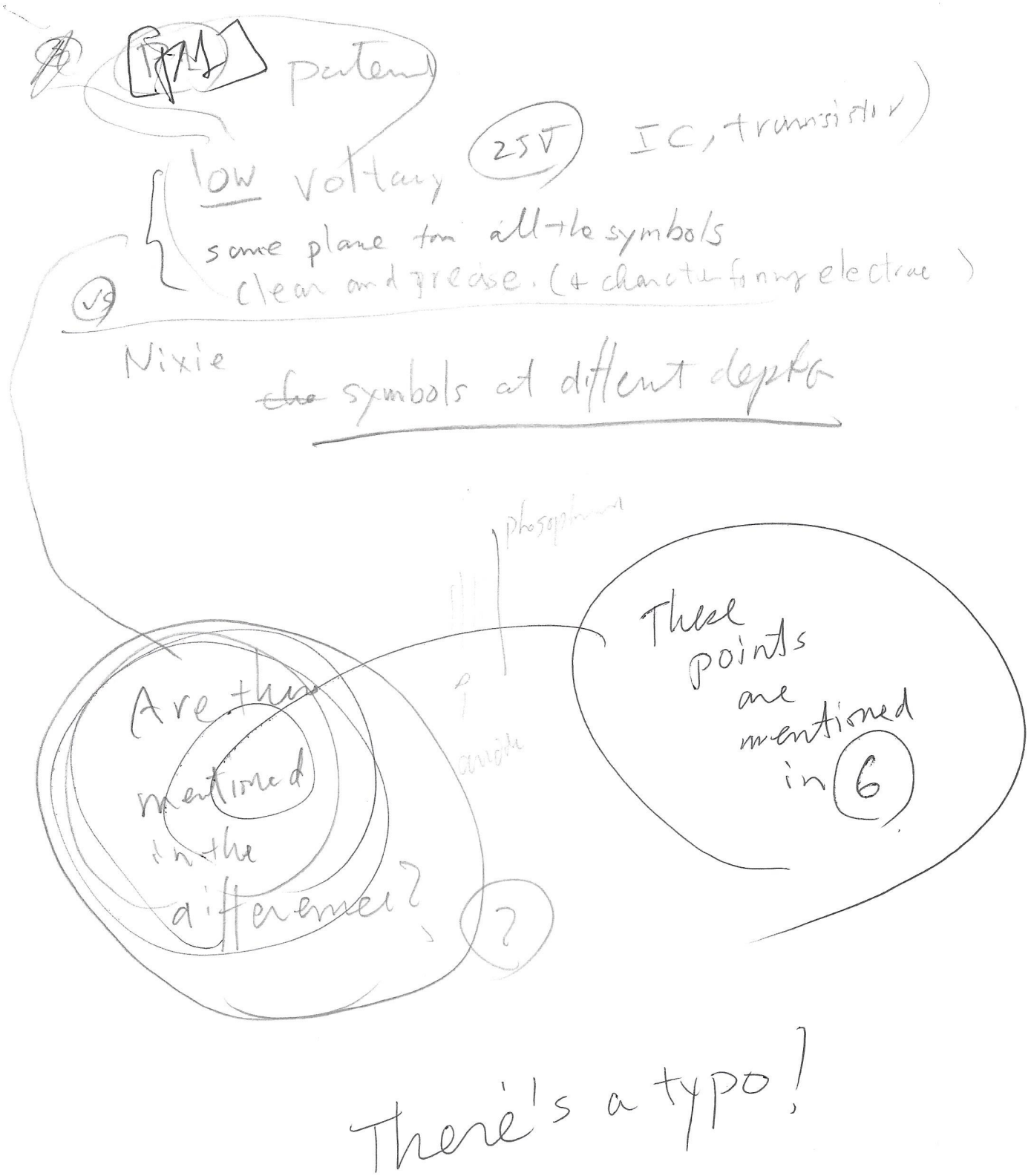
aiming to contribute local development as well.
→ meaning unclear (?) ?

The earlist VFDs
~~is this~~ are these which Dr. Nakamura created ?
unclear

lower voltages → lower than what ?

Furthermore, he knew ... as with CRT
→ A simple diagram would be desirable.





There's a typo!

P1-1

April 21, 1970 MIKIHARU TANJI 3,508,101

CHARACTER INDICATING ELECTRON TUBE

Filed Oct. 19, 1967

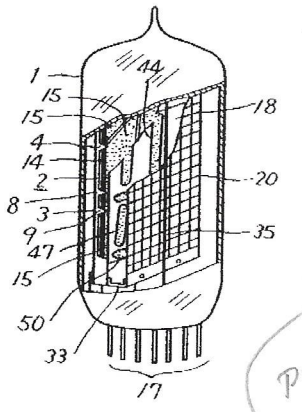


Fig. 1

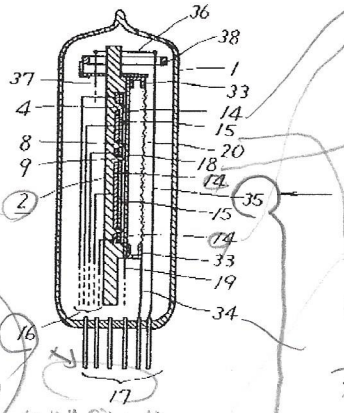


Fig. 2

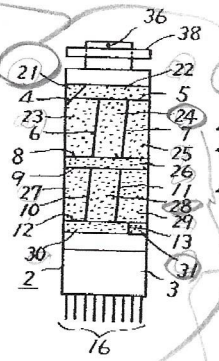


Fig. 3a

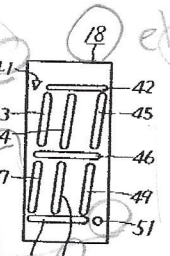


Fig. 3b

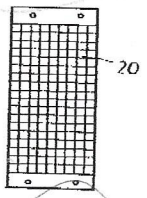


Fig. 3c

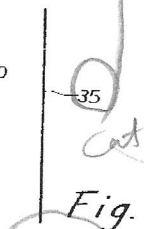


Fig. 3d

INVENTOR.
MIKIHARU TANJI
BY
ATTORNEY

P1-2

United States Patent Office 3,508,101
Patented Apr. 21, 1970

3,508,101

CHARACTER INDICATING ELECTRON TUBE

Mikiharu Tauji, Ise-shi, Japan, assignor to Ise Electronics Corporation, Ise-shi, Japan, a company of Japan

Filed Oct. 19, 1967, Ser. No. 676,580
Claims priority, application Japan, Mar. 27, 1967, 42/19,047
Int. Cl. H01j 7/42; H01k 1/60
U.S. Cl. 313—109.5 6 Claims

ABSTRACT OF THE DISCLOSURE

The character indicating tube in accordance with the invention includes a sectionalized anode, a grid and cathode and means for energizing selected anode sections to produce characters, such as the numerals 1–9 and 0, and the like.

This invention relates to an improved character indicating tube of the electron type which will provide an indication of any one of a group of numerals or characters and wherein all of the characters are formed in a substantially common plane.

Indicating tubes or devices for visually displaying numerals or other characters are widely used in computers, measuring apparatus, and the like, in order to provide a visual display of information. The structure for conventional indicating tubes generally embodies a plurality of numerals or characters displaced in depth and sealed within a gas-filled envelope. Voltages are applied to selected electrodes thereby causing the selected electrode to glow and provide an indication. Normally, the glowing electrode affords relatively low illumination and inasmuch as the electrodes are placed in spaced in depth within the enclosure, there is a variation in luminescence depending on the position of the electrode within the tube. Furthermore, when a plurality of such conventional indicating tubes are used for indicating a number of figures, the figures are not all displayed in the same plane and in many cases the displayed number cannot be easily read. Furthermore, conventional tubes require voltages as high as 170 volts in order to provide adequate luminescence. If the apparatus with which such tubes are utilized involves conventional vacuum tubes, then the provision of a high operating voltage does not afford any great difficulty. However, in the case of transistorized or integrated circuits, the operating voltages are very low and separate power sources are required for the indicating tubes.

Accordingly, one object of the invention resides in the provision of a novel and improved indicating device which overcomes the aforementioned disadvantages of known indicating tubes and provides an improved tube capable of operating at a relatively low operating voltage.

Another object of the invention resides in a novel and improved character indicating tube affording a relatively high degree of luminescence.

Still another object of the invention resides in the provision of a novel and improved indicating tube wherein all of the characters are disposed in substantially the same plane.

A still further object of the invention resides in the provision of a novel and improved indicating tube characterized by its simplicity, ease of manufacture and relatively long life.

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

In the drawings:

FIGURE 1 is a prospective view in partial section of an indicating tube in accordance with the invention;

FIGURE 2 is a vertical cross-sectional view of the tube shown in FIGURE 1; and

FIGURES 3*a*, 3*b*, 3*c* and 3*d* are front elevational views of the individual elements of the tube shown in FIGURES 1 and 2.

The improved tube in accordance with the invention includes a hermetically sealed vacuum envelope, at least one side of which includes transparent material, such as glass. A cathode is arranged within the container and adjoining the transparent side thereof. The cathode is arranged so that it will not interfere with the visual observation of any indicated characters and may be formed of a very fine, almost invisible wire capable of providing electronic emission when heated. A grid electrode formed of a plurality of very fine wires is positioned rearwardly of the cathode and controls electron emission emanating from the cathode. If desired, the next rearwardly positioned element may be a character forming electrode made of metal and having openings formed therein in a predetermined pattern to facilitate the formation of the characters. The rearwardmost element is a luminescent anode formed of a metal layer shaped in a contour corresponding to the contour of a character to be indicated on the surface and carrying a layer of fluorescent material. If the anode is to selectively indicate more than one type of character, the anode may comprise a plurality of mutually insulated anode elements, each having a fluorescent layer and forming a combined pattern. By selectively exciting different portions of the combined pattern, various characters can be visually displayed.

Appropriate lead wires are connected to each of the elements of the luminescent anode, the grid electrode and the cathode. These lead wires are, in turn, connected to pins extending through the sealed envelope to facilitate connection with external circuits.

With a character indicating tube as described above, upon the application of +10 to +25 volts to the grid with respect to the cathode and then upon the application of a positive voltage of a similar magnitude to selected elements of the luminescent anode, any one of a group of characters can be displayed. The luminescence can be observed from the exterior of the tube nothwithstanding the presence of the grid or cathode. In the event that the character forming electrode is provided the indicated character will be observed through the openings in that electrode. When the anode comprises a plurality of anode elements, it is apparent that any one of a number of characters can be selected and displayed. It will be observed that the operating voltage of about 25 volts is of the order of that utilized in the operation of semi-conductor and integrated circuits and, accordingly, affords a substantial advantage over prior known devices. Furthermore, since a single luminescent anode is utilized, all characters are displayed in the same plane, and, therefore, the distance between the observer and the indicated character will not vary, notwithstanding the particular character being displayed. Furthermore, a relatively high luminescence is obtained and the characters can be easily observed even with high ambient light. Still an additional advantage resides in the fact that a variety of fluorescent substances may be utilized so that a wide selection of colors is afforded.

Referring now to the drawings, the envelope **1** in the instant embodiment of the invention is formed of glass and it includes a luminescent anode **2** having a ceramic base plate **3** and a plurality of continuous ridges **4, 5, 6, . . . 12, 13** dividing the surface of the plate into eleven areas **21, 22, 23, . . . 30, 31**. Each of the areas **21–31** includes a conductive film **14** with such films being mutually insulated one from the other and coatings of fluorescent material **15** overlying each of the conductive films **14**.

P1-3

TYPO! 35!!

If the anode is to indicate a single character then a conductive film **14** would merely be applied to the ceramic base **3** in the configuration of the character and a fluorescent coating would be applied to the conductive film.

A plurality of lead wires **16** extend through the back side of the ceramic plate **3** and contact the conductive films **14**. The other ends of the leads are connected to pins **17** extending through the envelope **1**.

If desired, a character forming electrode **18** is disposed in front of the luminescent anode **2**. Though such electrode is not necessary for the operation of the tube, it does, however, afford improved appearance of the characters being displayed. When the character forming electrode is employed in a device for displaying a plurality of characters, such as the numerals 1 9 and 0, it would include a plurality of openings **41–51** as may be observed more clearly in FIGURE *3b*. The openings **41–51** are coordinated with the specific elements **21–31**, previously described. Electrode **18** is secured in overlying relationship to the anode by providing appropriate attaching means at the upper and lower portions of the ceramic base plate **3**. A separate lead wire is connected to the character forming electrode and to one of the pins **17**.

A very fine mesh type grid **20** is disposed in front of the character forming electrode **18** and has an area at least as large as the area of electrode **18**. The grid is held in position by supports **33**, **33** and is connected through a lead wire **34** to one of the pins **17**. A cathode **35** formed of a single fine wire of the order of 30–50 microns is disposed in front of the grid **20**. The upper end of the cathode is connected directly to one of the pins lead wire **37** to one of the pins **17** while the lower end of the cathode is connected directly to one of the pins **17**. A getter ring **38** is positioned at the top of the tube in order to remove residual oxygen remaining after evacuation.

In the indicating tube, as described above, approximately 0.8 volt is applied to the cathode **35** in order to to heat it to a dark red color. A voltage of about +25 volts is applied to the grid **20** and to the character forming electrode **18**. If the anode **2** is provided with a single character the application of a voltage of about +25 volts is applied to illuminate the character. If the anode contains a plurality of elements, as illustrated in the drawings, then by the application of a positive voltage of the order of +25 volts to selected elements, the selected elements will be illuminated by reason of the emission from the cathode which is accelerated by the grid and passes through selected openings in the character forming electrode to illuminate corresponding elements of the anode. For instance, if the numeral 1 is to be displayed, the positive voltage is applied to the anode elements **24** and **28**. The cathode emission then will pass through the holes **44** and **48** in the character forming electrode and excite to luminescence anode elements **24** and **28**. The indicating tube, of course, is viewed in the direction of the arrow as indicated in FIGURE 2.

If a signal voltage is applied to the anode elements **22**, **25**, **26**, **27** and **30**, the numeral 2 will be viewed through the openings **42**, **45**, **46**, **47** and **50** of the character forming electrode **18**. Similarly, through the selective application of the signal voltage to other anode elements the numerals 3–9 and 0 can be displayed. The illustrated embodiment of the invention further includes an element **21** in the upper left-hand corner of the anode as viewed in FIGURE *3a* and is aligned with the opening **41** of the character forming element shown in FIGURE *3b*. This element of the electrode may be used to indicate an apostrophe or for any other similar purpose. The element **31** on the anode is used to provide a decimal point and would be observed through the opening **51** in the character forming electrode **18**.

As described above, the numerals can be readily observed from the front of the tube, notwithstanding the presence of the cathode **25** or the grid **20** since they are both made of very fine wire. Further, although a voltage of about 25 volts is normally applied to the grid **20** of the character indicating tube, if the grid voltage is lowered to a potential equal to or lower than the voltage of the cathode, the cathode emission cannot reach the anode and thus luminescence of the anode is prevented. Thus, the grid **20** functions to diffuse the emissions from the cathode and also accelerate and decelerate emission from the cathode.

In the illustrated embodiment of the invention, the character forming electrode **18** is utilized and since it is polarized at a voltage of +25 volts, any particles evaporated from the cathode **35** will be generally absorbed by the character forming electrode. This minimizes deterioration of the fluorescent material on the anode and accordingly affords long tube life.

Advantages of the character indicating tube as described above are as follows:

(1) All characters and marks are indicated in the same plane which greatly facilitates reading of the characters being displayed and overcomes the disadvantage of conventional tubes having a plurality of electrodes displaced in depth.

(2) The tube can be operated at voltages of the order of 25 volts and is, therefore, readily adapted for use with low voltage circuits such as transistorized and integrated circuits.

(3) The indicated characters are bright and clear because each character is indicated by luminescence of fluorescent material on the anode surface and the outline of the character can be precisely defined by a character forming electrode.

(4) The structure of the tube is relatively simple and can be manufactured easily and inexpensively.

(5) The tube has relatively long life as compared with conventional character indicating tubes.

If desired, the character forming electrode may be coated with an insulating material, such as alumina (Al_2O_3), magnesium oxide (MgO), chromic oxide (Cr_2O_3), etc. These coatings increase the cathode emission reaching the anode and thus cause the fluorescent layers to luminesce more strongly. Further, the luminescent anode may be formed of beryllia ceramic or alumina porcelain and then coated with a conductive film and a fluorescent layer. Thereafter, grooves may be formed in the anode to provide a plurality of anode elements as previously described. Furthermore, although the cathode was described as one providing electron emission, it is understood that photoelectric cathodes and other cathodes which emit electrons into space may also be utilized.

While only certain embodiments of the invention have been illustrated and described, it is apparent that alterations, modifications and changes may be made without departing from the true scope or spirit of the invention as defined by the appended claims.

What I claimed is:

1. A character indicating tube comprising a hermetically sealed evacuated envelope having at least one transparent side portion, an elongated heated cathode adjoining the transparent side of said envelope, a conductive luminescent anode in substantially parallel spaced relationship to said cathode and facing said cathode and transparent envelope portion, said luminescent anode including a conductive portion and a layer of fluorescent material on said conductive portion, said fluorescent material facing said cathode, an accelerating grid interposed between said anode and cathode, said cathode and grid being formed to permit substantially unobstructed observation of said luminescent anode.

2. A character indicating tube according to claim **1** wherein said luminescent anode is formed with a plurality of mutually insulated conductive anode elements arranged in a selected pattern, a fluorescent layer overlying

P1-4

said conductive portions and means for selectively energizing said conductive portions.

3. A character indicating tube according to claim 1 wherein said cathode is a fine wire and said tube further includes means for heating said wire to effect electron emission therefrom.

4. A character indicating tube according to claim 1 including a character forming electrode positioned between said grid and said anode, said character forming electrode having a plurality of openings therein corresponding to the configuration of the fluorescent layer formed on the surface of said anode.

5. A character indicating tube according to claim 1 including means for applying potentials to said grid and said anode which are substantially equal and positive with respect to said cathode.

6. A character indicating tube according to claim 4 including means for energizing said grid, character forming electrode and anode positively with reference to said cathode.

References Cited

UNITED STATES PATENTS

1,928,407	9/1933	Batchelor	313—108 X
3,406,288	10/1968	Du Bois et al.	313—109.5 X
3,008,065	11/1961	Chamberlin	313—109.5 X
3,082,341	3/1963	Balaskovic	313—70
3,133,221	5/1964	Knochel et al.	313—108
3,201,634	8/1965	Weidel et al.	313—109.5
3,281,619	10/1966	Greene	313—109.5 X

FOREIGN PATENTS

11,265	5/1964	Japan.

OTHER REFERENCES

"What's Up Front Counts," May 29, 1968 Electronics, vol. 40, pp. 212–213.

JAMES W. LAWRENCE, Primary Examiner
D. O'REILLY, Assistant Examiner

U.S. Cl. X.R.

313—108

(3) cont'd

Fig. 1. ↑ separat

Data sheet so that we can read

too small

establishment of what ??

Nakamura → who?

Dr. Ise founded a new company.

Was Nakamura invited to be the president?

?? clarify

(4)

Frontier → frontier

cooperative → cooperative spirit

Central Research Laboratories

of what? ??

?? during venture stage??

international partners → evidence?

[A1] [A2]
link does not work

[A1]
One sentence description of SID would be desirable

(4)

[A2]
One sentence description of ??

~~1991 KOIZUMI~~ ~~name only?~~

of Karl Ferdinand Braun Award is described SID page

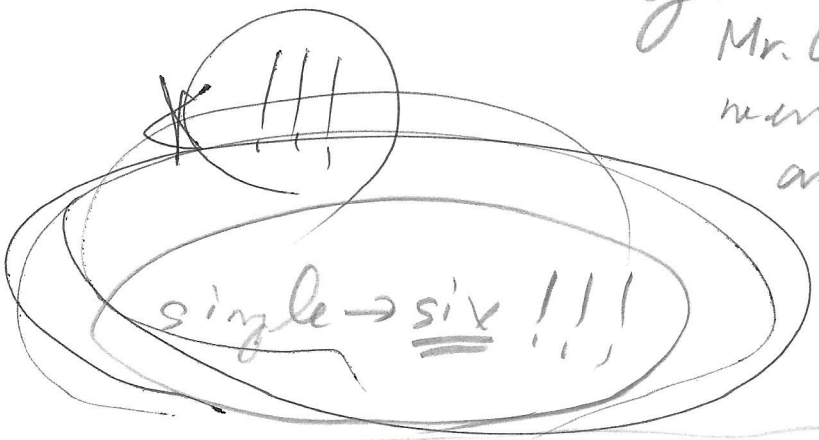
④ cont'd

the patent fees for Nixie tubes to whom
write in the main text!

during calculator wars =
→ in the very competitive calculator market.

~~[M1] link wake~~
~~[NR] [N2] link doesn't~~

[03] = ~~very~~ a somewhat confusing description of Mr. Ohkubo mentioned as the inventor of DFD, ?!



DFD structure
the view of DFD from the grid side
(cp as opposed to the anode side of CRT
should be mentioned

move the sentence in the next paragraph.

Ref [22]-1

8.3 / 9:50 A.M.: A 240-Character Vacuum Fluorescent Display and its Driving Ability

Kazuhiko Kasano, Tokuhide Shimojyo, Mitsuru Masuda and Kentaro Kiyozumi

Ise Electronics Corp., Ise, Japan

INTRODUCTION

A flat panel 240 character Vacuum Fluorescent Display (VFD) has been developed which can display full ASCII character font.

A great number of flat panel numerical VFDs which display bright green figures under relatively low driving voltage and power consumption have been used in calculator, clock and ECR markets. (1)

As the next step, we developed single line character VFDs having 20 to 40 characters where anode substrates are formed with multi-layer of thick conductive and insulating films. They are used in personal computers, POS terminals, etc.

Now, the single line character VFDs have successfully extended to the multi-line, capable of displaying 240 characters, in which both thin and thick film technologies have been adopted for the anode substrate.

DESIGN

Structure of this VFD is illustrated in Fig. 1, where 240 characters are divided into 6 lines of 40 characters, and each character consists of 35 dots (5 x 7) and a cursor. There are 40 grids for time-sharing control of the emission flow from the cathode; a column of 6 characters is covered by one grid. A selection of forty grids enables one to operate the VFD with duty factor of approx. 1/40 which leads to a reasonably low voltage to produce high brightness as found in Table 1. In this case, total of 258 lead-outs (36 x 6 = 216 leads for the anode, 40 for the grid and 2 for the cathode) are necessary.

The character size is 5(H) x 3.5(W) mm and the dot 0.5 mm square. Spacing of lines and columns are equivalent to 3 dots and 2 dots respectively. Display overall is 250(L) x 100(W) x 14.5(T) mm.

FABRICATION

Preparation of Anode

It is an important factor to reduce the cross over points in the anode wiring in order to increase yield and reliability of the device through forming a simple insulating layer. The anode substrate is formed with only three layers and there are only two cross over points per dot. A simple three layer structure which consists of the first Al-thin film conductive layer for lead wiring, the glass thick film insulating layer for cross over and the second Al-thin film conductive layer for anode electrode is formed on a glass plate.

Approx. 1.5 μm thickness Al-film is deposited on all over the surface of a normal soda-lime glass plate by DC magnetron sputtering. Then it is etched to the fine pattern as shown in Fig. 2 using photolithography, which is served as the first conductive layer.

The glass insulating layer having 20 to 30 μm in thickness is screen printed on the processed substrate so as to produce thru-holes only on the dots with the accuracy of the positioning within 75 μm.

The second conductive layer is deposited only on the thru-hole points of insulating layer by DC magnetron sputtering using a metal mask. Dot of the second conductive layer has a size of 0.5 mm square and contacts to the first conductive layer through thru-hole.

The cross section of the anode structure thus formed is illustrated in Fig. 3.

Assembling and Exhausting

This process is the same as our previous VFD: 1) phosphor is electrophoretically deposited on the anode electrodes, 2) mesh grids are fixed, 3) two filaments coated with cathode materials are stretched over a character line, 4) window glass is sealed with frit, 5) the bulb is exhausted and tipped off at approx. 1 x 10^{-6} Torr.

DRIVING

Driving diagram of this VFD is shown in Fig. 4.

A microcomputer and an external ROM/RAM have been adopted for this driving circuits.

CPU controls the whole driving circuits and I/O data to the host system.

ROM contains the full ASCII character patterns and the control program. RAM memorizes 240 character data which come from the host system.

Scanning of column from left to right is controlled by shift registers for the grid.

There are shift registers and latches for the anode. A series of 8 bit parallel signals from CPU is shifted 5 times to complete one character pattern. This process should be repeated 6 times to complete 6 characters in a column. And then, these patterns are latched. When grid scanning pulse selects the leftmost column position, the first latched 6 characters are pushed off to the display, and next 6 characters are input to the shift registers during this display timing.

The above cycle is repeated 40 times for one display cycle.

CONCLUSION

A new flat panel 240 character VFD having average brightness of 220 fL under standard operating condition (shown in Table 1) has been produced with a combination of thin and thick film technologies, which is proved to be effective for increasing of yield and reliability of this device.

Adopt of μP simplified the driving circuits, which opened the way for the wide applications, especially read-out of middle class of the intelligent terminals.

Reference:

1) K.Kiyozumi, et al. "Flat Panel Multi-Digit Fluorescent Display" SID 76 Int'l Symp. p130 & p131

Table 1

Electrical Characteristics

Item	Standard Operating Cond.	Note
Filament Volt.	8.8 Vac	r.m.s.
Filament Curr.	312 mAac	r.m.s.
Anode Volt.	50 Vp-p	du=1/45,p.w=100 μs.
Anode Curr.	4.5 mAp-p	per character
Grid Volt.	50 Vp-p	du=1/45,p.w=100 μs.
Grid Curr.	27 mAp-p	per column
Cut-off Volt.	-12 Vdc	against to cathode
Brightness	220 fL	average per dot

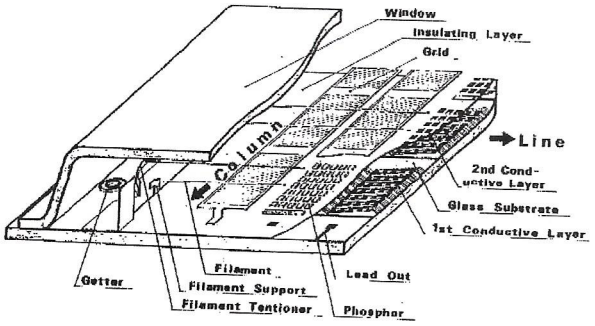


Fig. 1 Display perspective view

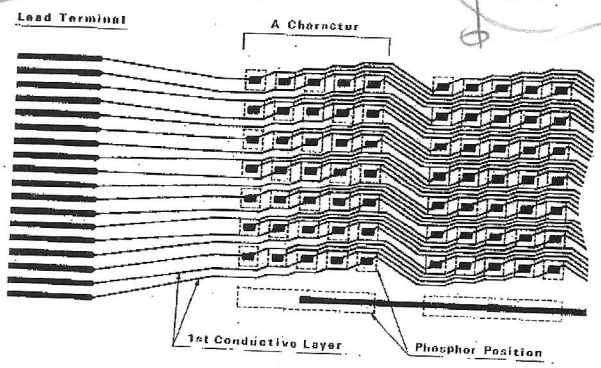


Fig. 2 Wiring Pattern of the Anode Dots

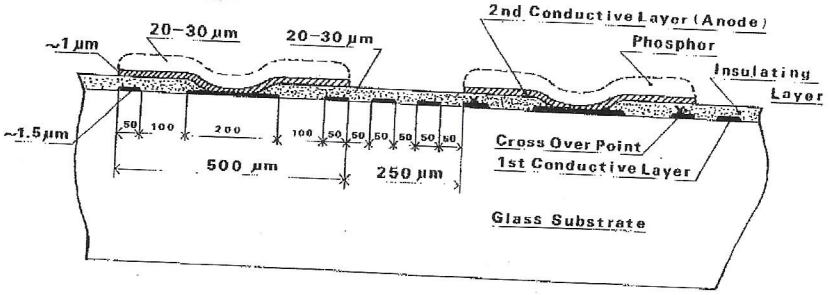


Fig. 3 Layer cross section: Detailed illustration of the anode structure

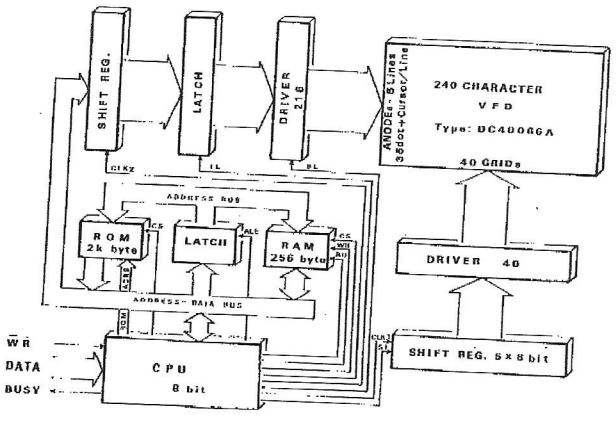


Fig. 4 An example of driving block diagram

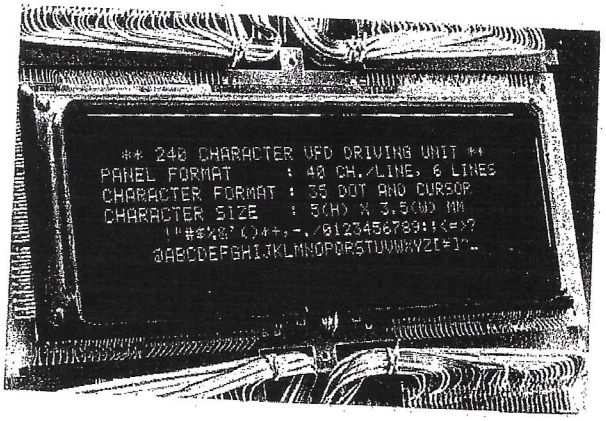


Fig. 5 An engineering model

(5)

Figure 3

when were they developed.

---

(5)

Automotive Meters

~~Wic~~ Nice to have **References** to give ~~credits~~ credibility to the description

- Subaru
- Prius Cars

(Evidence)!

Game Machines

Nice to have references to these ~~mach~~ game machines

low-speed excitation

→ high speed ?!

low-latency ??

Digital Signage: Izukyuko 8000 series

reference!

---

(5)

Large Display.

Is Sony's work VFD? State clearly.

(6)

production ~~co~~ consignment agreements

what?

→ Production agreement

better

Japan Electronic Material Corp

Dai Nippon Toryo Co. Ltd.

Professor Takagi at faculty of Engineering, Shizuoka University

Nice to have reference if any

(6)

(7)

low-temperature-fired ⟹ heated ?

optimize firing → heating ?

not ~~flat~~

→ add something like

, ~~each digit was~~ sho

~~different numerals were shown~~

digits 1, 2, 3, etc were shown at different depth,

cf. readers in 21st century may not understand "flat"

(8) Monsanto ~~MANTA~~ MAN-1A. when? reference?

world's first production quality seven segment display

Some references are missing!

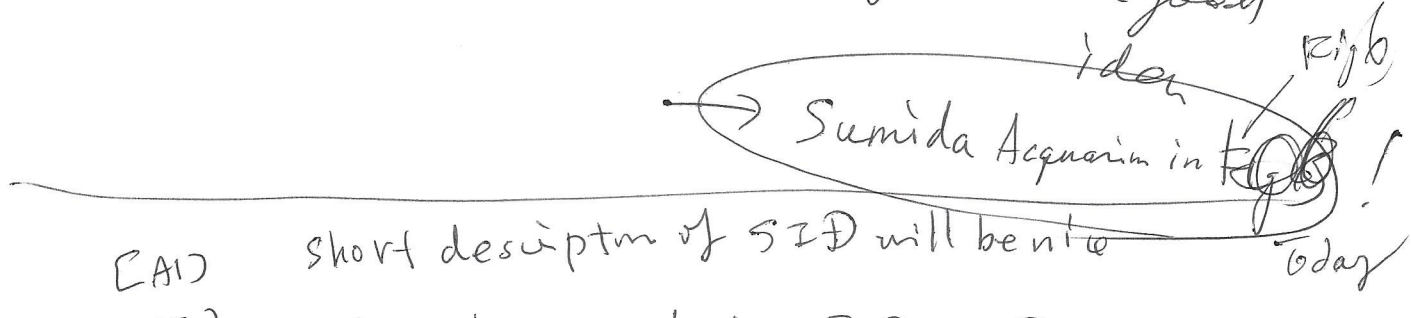
(11)

NHK's development

cite a reference

where are VFDBs used today?

Mentioning them is a good idea



[A1] short description of SID will be nice

[A2] short description of K.F. Bran Prize will be nice.

⑨ pressure ← Incorrect

on the same plane at the same depth

add.

"Life" → "Life span".

"comp~~p~~det-16 ~~(~~

CCS-16 in the main text)

add.

On the same plane ~~~

→ It also has features such as ease of ~~reading~~ reading because ~~each~~ all the digits are shown at the ~~same pla~~ same depth.

Remo

Tegitron → Degitron

(10)

Tesitron → Degitron

this line → this approach

a separate display tube

→ separate display tubes