Dec. 13, 1960

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CATHODE RAY DISPLAY DEVICES

Filed July 20, 1959

2 Sheets-Sheet 1

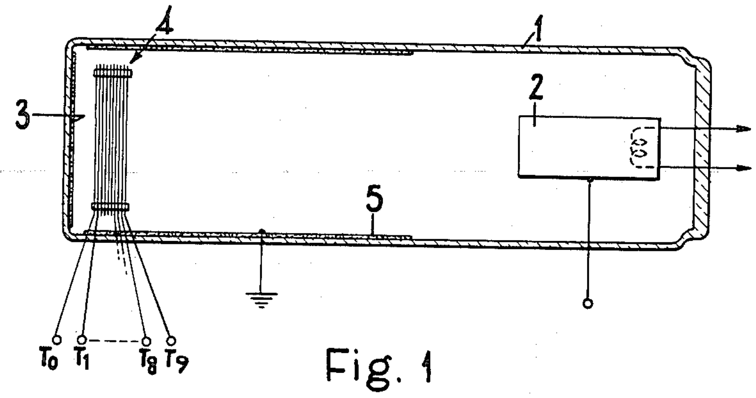

Fig. 1

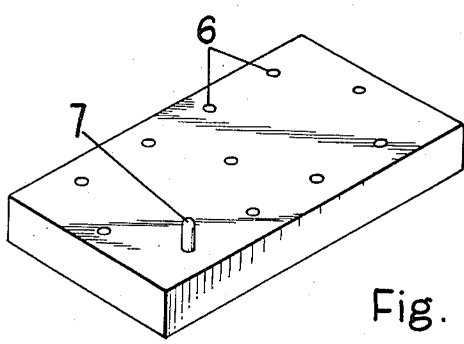

Fig. 2

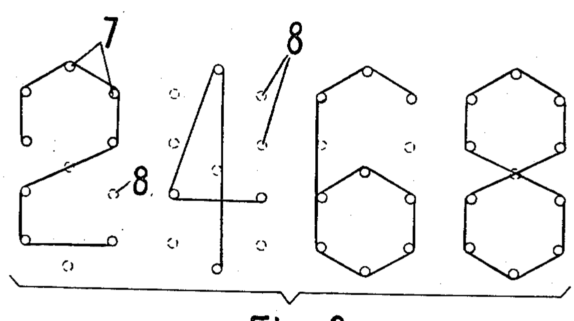

Fig. 3

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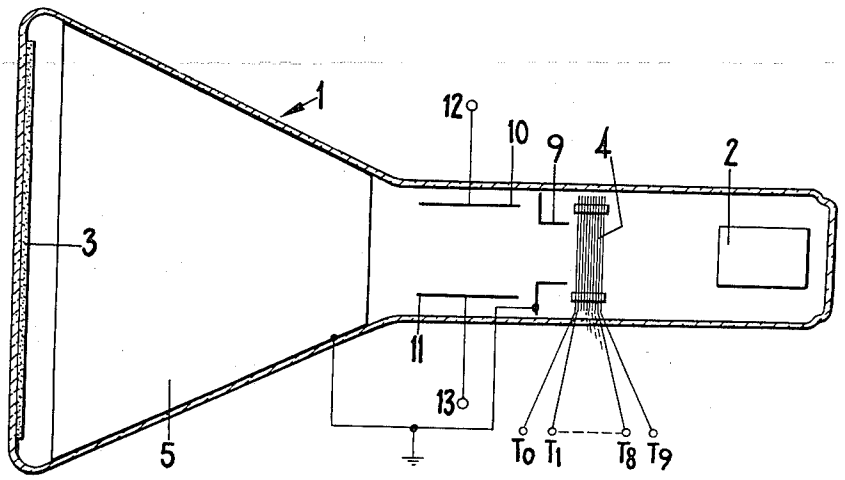

Fig. 4

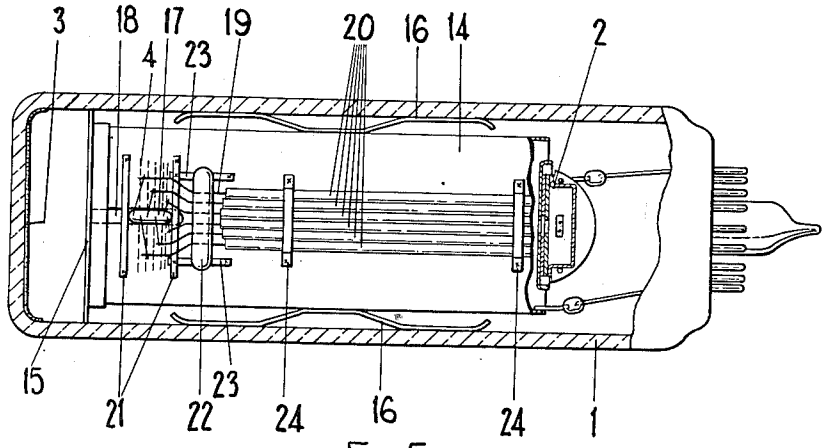

Fig. 5

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CATHODE RAY DISPLAY DEVICES

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11 Claims. (Cl. 315—21)

This invention relates to a display device for displaying characters, which may be letters, numerals, circuit symbols, direction indications, mathematical signs, or the like, either singly or in combination. Devices of this kind have wide-spread applications for use with indicating meters, train describing arrangements, and so on.

One known device of this kind consists of an electric glow discharge tube having the required characters formed from thin wire or sheet metal sealed within a bulb filled with neon or other gas at low pressure, the bulb also containing one or more further electrodes In use, an electric discharge is initiated between the character which it is desired to display and the other electrode or electrodes so that the displayed character forms the cathode and is covered by the negative glow of the discharge, the remaining characters taking no part in the discharge and therefore not being illuminated Such a device suffers from the disadvantage that, owing to the fact that the characters are formed from thin metal, the field strength at the surface is high, and considerable sputtering takes place, blackening the inside of the envelope in which they are contained and forming a conducting coating over the internal insulating components, both of which effects interfere with the operation of the device. Such devices therefore have a very short useful life, and the like cannot, in practice, be greatly extended by running them at a lower curent, as at low currents the discharge is unstable.

An object of the present invention is to provide an alternative form of display device which can be designed to have a relatively long life.

According to one aspect of the present invention a device for use in displaying characters has a sealed evacuated envelope containing a fluorescent screen visible through the envelope, an electron gun arranged in operation to project an electron beam towards the fluorescent screen so as to flood an area of the screen, two or more electrically conducting characters insulated from each other and arranged consecutively along the path of the beam, the characters being individually connected to conductors extending through the envelope by means of which each character can be separately connected to a source of potential, and the arangement being such that the device can be operated so that the characters lie within the cross-section of the electron beam and with the said area of the screen substantially uniformly illuminated when the characters are maintained at suitable potentials, and so that any selected one of the characters can be caused to cast its shadow on the fluorescent screen by a suitable change in the potential applied to that character.

It will be understood that the term "shadow" means an electron shadow formed by regions of the screen which do not receive electrons bounded by regions which are bombarded by electrons so as to be rendered fluorescent. The term "its shadow" also means that the shadow reproduces the form of the character on the screen.

In use of the device the characters not to be displayed are maintained approximately at the potential of the final

anode of the electron gun, or preferably at a few volts positive with respect to this anode, which causes the electrons to spread into the shadow areas after passing the characters, and thereby causes little departure from uniformity in the illuminated area of the screen. The potential of the character to be displayed is, however, made considerably negative with respect to the final anode, which causes this character to repel the electrons approaching it from the cathode and causes a shadow having the form of the character to appear on the fluorescent screen.

Preferably the characters lie in substantially parallel surfaces extending across the path of the electron beam and each is of a web form, parts of the webs of different characters being aligned along the path of the beam, preferably to the full extent possible.

The term "web form" means that each character is delineated by one or more narrow lengths (i.e. webs) of material so that the electrons can pass directly on both sides of each web when the character is mounted in position in the device. The webs can advantageously be formed from metal wire bent so as to outline the characters.

In one preferred method of forming the characters they are formed on one half of a die having holes in which a number of pins may be set. The characters are formed by winding round appropriate pins a wire of a metal which can be work-hardened, and this wire is subsequently flattened and set by compressing it between the halves of the die to form the characters in the desired final form. After the process is completed the characters may be removed and spot-welded to support wires by means of which they are supported within the envelope of the device, the support wires also serving as electrical connections.

The characters are preferably mounted together to form a matrix which can be installed as a unit within the device. For the manufacture of a character matrix containing the numerals 0 to 9, the characters can conveniently be formed by the use of a die as described above provided with pins in the form of a symmetrical figure consisting of two equal and approximately symmetrical hexagons joined in such a way as to share a common vertex, holes for the pins being provided at each of the vertices of the figure.

Where the device is designed to produce a beam of electrons which is diverging or converging at the region of the characters, the characters may if desired increase in scale in proportion to their distance from the effective point of divergence or convergence of the beam so that whenever portions of separate characters correspond, they overlie each other along the paths of the electrons, thereby minimising the total shadow area cast on the screen in use when all the characters are maintained at the same potential. With the wire-character-forming method described, each character can be formed in a separate die.

The form of the display device in accordance with the invention as described above is suitable for displaying the characters singly, the electron gun being arranged to produce an electron beam such as to flood and illuminate substantially the whole of the fluorescent screen.

According to a further aspect of the present invention, a device for displaying characters which is in accordance with the said first aspect of the invention is further designed for the display of combinations of two or more of the characters, the electron gun being arranged so as in operation to flood and illuminate only a part of the area of the screen, the characters being spaced from the fluorescent screen, and at least one deflecting means for the electron beam being provided which is arranged to control the path of the beam between the characters and the screen whereby the posi-

tion on the screen of the area illuminated by the beam, and on which the shadow of the selected character is formed, can be changed under the control of the deflecting means.

The deflecting means can conveniently consist of a pair of electrostatic deflecting plates arranged within the sealed envelope between the characters and the screen and connected to external terminals for enabling a beam-deflecting voltage to be applied between the plates.

Alternatively external electromagnetic deflecting coils might be used. Preferably a plate is provided in the path of the beam before the deflecting means, the plate having an aperture through which the beam passes and which is of smaller cross-sectional area than the beam so as to mask the cross-section of the beam to a suitable shape, for example rectangular; this plate may conveniently be connected to, or form, the final anode of the electron gun.

In operation of a device in accordance with this second aspect of the invention the potentials of the characters are so chosen that the first character to be displayed is at a negative potential with respect to the final anode, and the remaining characters are slightly positive with respect to this anode, and at the same time the deflecting means is energised to deflect the electron beam so as to illuminate the region of the screen on which the first character is to be displayed. The second character is then selected by suitable variations of the character potentials, and the deflecting means is adjusted so as to display the second character in the second position on the screen, and similarly the third, fourth, etc. characters can be displayed in successive positions under the control of the deflecting means.

With a single deflecting means a line sequence of the characters can be obtained, and by using two deflecting means arranged to deflect the beam in mutually inclined directions, a two-dimensional display of the characters can be obtained.

By using for the screen a phosphor of suitably long afterglow, or by repeating the sequence of operations at a suitable rate, a continuous or apparently continuous and simutaneous display of all the required characters on the screen can be obtained.

The deflecting means, may for example be automatically controlled by time base circuits and the character potentials controlled by input signals in synchronism with the time bases. By using letters for the characters written messages can be built up on the screen in this way.

Three embodiments of the invention will now be described by way of example with reference to Figures 1 to 5 of the accompanying drawings in which

Figure 1 is a schematic representation of a longitudinal section through one form of number display device according to the present invention,

Figures 2 and 3 represent a preferred manner of forming numerals for the character matrix in the device shown in Figure 1,

Figure 4 is a schematic representation of a longitudinal section through a second form of number display device according to the invention, and

Figure 5 is a view of a third form of number display device according to the invention, with the envelope shown in section and part of the internal arrangement broken away or omitted for clarity.

Corresponding parts of the various embodiments are denoted by corresponding reference numerals.

Referring first to Figure 1, the device consists of a cathode ray tube having a generally cylindrical glass envelope **1** containing an electron gun **2** at one end and a fluorescent screen **3** formed on the inner surface of the end wall at the other end of the envelope. The gun **2** is adapted to produce a divergent beam of electrons directed at the screen **3** and arranged to flood substantially the whole area of the screen. In the path of this beam is a character matrix **4** which comprises ten numerals formed from stainless steel wire and provided with leads extending through the envelope to terminals T_0, T_1 . . . T_9 outside to the tube. These terminals will, of course, in general be provided on the end of the envelope opposite the screen, usually on a pressed glass base on which the electron gun is also mounted and through which the leads from the characters and other electrodes are sealed. The final anode of the electron gun is provided by an internal conducting coating **5**.

In normal operation of the device the anode coating **5** is earthed, and the cathode of the electron gun **2** is connected to a negative source of potential of about 1000 volts. When no display is required, the terminals T_0 . . . T_9 are each connected to a source of potential about 20 volts positive with respect to the anode **5**. The electron beam leaving the gun **2** tends to throw a composite shadow of the matrix of characters on the fluorescent screen **3**, but this shadow is rendered very diffuse by reason of the positive potentials applied to the characters and the illumination of the fluorescent screen **3** does not depart greatly from uniformity.

When it is desired to display one of the characters on the screen **3**, the appropriate character in the matrix **4** is connected, via its terminal, to a source of potential at about 100 volts negative with respect to the anode **5**. This causes the appropriate character to repel strongly the electrons of the beam and produce a dark shadow of corresponding form on the screen **3**.

Referring now to Figures 2 and 3, the method of forming the individual characters of the matrix **4** is as follows:

A die is formed consisting of two blocks in the form shown in Figure 2 provided with sets of holes such as **6** at the vertices of a figure consisting of two hexagons sharing a common vertex. Pins, one of which is shown at **7**, are provided to fit into these holes.

Figure 3 shows the manner of forming the even digits 2, 4, 6, 8. Taking first as example the form of the digit 2, pins **7** are inserted in the holes as shown to the left of the figure, the unwanted holes **8** being left empty. The figure is then formed by winding a soft wire of stainless steel 0.005 inch in diameter around the pins, cutting off the surplus length, placing the second die-block on top of the first, and compressing the wire between the die-blocks to flatten and harden it. The second die-block is then removed and the figure removed from the pins, spot-welded at its top and bottom to short lengths of stainless steel wire which serve as support wires, and mounted by means of these support wires on a suitable insulator in register with the other characters to form the matrix. It will be appreciated that, using the arrangement of holes shown, all of the digits 0–9 inclusive can be represented in a satisfactory manner, pins being placed in the appropriate holes as shown by way of example for the further digits 4, 6 and 8 in Figure 3.

For minimising the effect of the divergence of the electron beam at the matrix, the characters can if desired be formed as described on dies of slightly different size so that the sizes of the characters increase progressively in the matrix, from the electron gun side to the screen side, in proportion to their distances from the electron gun.

Referring now to Figure 4, the form of device therein shown comprises a sealed evacuated glass envelope **1** having a conical part continued at its narrower end by a tubular neck containing an electron gun **2**, and carrying a fluorescent screen **3** on the interior of its closed wider end. The gun **2** is designed to produce a divergent beam of electrons directed at the screen **3** and arranged to flood a small, approximately rectangular, area of the screen. In the path of this beam is supported a character matrix **4** which comprises ten numerals formed from stainless steel wire and provided with leads extending through the envelope to external terminals indicated schematically by T_0, T_1 . . . T_9. These terminals will in general, as in

the Figure 1 device, be provided on a pressed glass base closing the end of the neck part of the envelope.

An internal conducting coating **5** is provided on the conical portion of the envelope and a plate **9** having a rectangular aperture rather larger than the overall dimensions of the characters but less than the cross-section of the beam is supported immediately after the character matrix and connected to the coating **5**, these two components together functioning as the final anode of the electron gun. A pair of electrostatic deflecting plates **10** and **11** is provided within the envelope immediately after the plate **9**, and the two deflecting plates are connected to external terminals **12** and **13** for the application of beam deflecting voltages thereto. These terminals will, in general, also be provided on a base at the end of the neck part of the envelope.

In operation of the device, the potentials of the characters of the matrix **4** are so chosen that the first character to be displayed is negative with respect to the final anode, the remaining characters being slightly positive with respect to this anode, and at the same time the deflecting plates **10** and **11** are energized to deflect the electron beam so as to illuminate the region of the screen on which the first character is to be displayed. The potentials of the plates **10** and **11** and of the characters of the matrix **4** are then changed so as to display the second character in the second position on the screen, and then in turn the third, fourth, etc. characters in the third and fourth positions. This sequence of operations is repeated at such a speed as to produce an apparently continuous and simultaneous display of all the required characters in line on the screen.

In a modification of this arrangement, a second pair of deflecting plates, arranged to produce deflection at right angles to that produced by the plates **10** and **11**, is added so that characters can be displayed in a two-dimensional array.

The number display device shown in Figure 5 is generally similar to that shown schematically in Figure 1 but differs in details of construction. The device comprises a cylindrical glass envelope **1** having a fluorescent screen **3** applied to the internal surface of the end wall closing one end of the envelope, and closed at the opposite end by a pressed glass base through which are sealed seventeen metal pins, indicated by T, which form terminals for the connection of the tube into the associated circuit. Most of the internal connections to these pins for applying the operating electric current and potentials to the electrodes within the envelope and for supporting the electrodes in position have been omitted from the figure for clarity.

A nickel cylinder **14** fits within the envelope over the greater part of its length, being supported in position at the end nearest the fluorescent screen **3** by a flanged ring **15**, and carrying leaf springs **16** bearing against the internal surface of the glass envelope **1**. The end of this cylinder opposite to the ring **15** is supported from the pins T by stout support wires (only one of which is shown) and is connected to one of them by a metallic connection so that it can serve as a further anode for the electron gun.

A triode electron gun **2** is supported in the mouth of the cylinder **14** at the end opposite the fluorescent screen **3** and its components are metallically connected to certain of the pins T so that suitable potentials may be applied to them in use. This electron gun is of such a design that it can be operated to produce a divergent beam of electrons which causes the whole of the screen **3** on the end wall to fluoresce. This end wall and the rest of the internal surface of the half of the envelope nearest to the screen are coated with a thin transparent layer of conducting tin oxide, to which contact is made by the springs **16** carried by the cylinder **14**, and which therefore also serves in part as an anode for the electron beam.

Just within the open end of the cylinder **14** nearest to the fluorescent screen **3** is supported a character matrix. This matrix comprises the digits 0–9, each formed from stainless steel wire by winding it round suitable projections on one half of a die and then compressing it in the die so that it becomes work-hardened. Each digit is welded to a further stainless steel wire at its top and bottom, these latter wires serving as support means, and for making electrical connection to the digits. Each digit is formed in a separate die and on a slightly different scale, increasing in proportion to its distance from the electron gun **2** in the tube when assembled, so that, whenever portions of the separate digits correspond, they overlie each other along the path of the electrons from the electron gun **2**, thereby minimising the composite shadow effect of the matrix on the fluoroscent screen **3**. The digits are assembled in order in a jig in the proper alignment with the support wires at the top and the bottom of the assembly lying parallel. At the end of the assembly designed to be nearest to the screen **3** a pair of short wire stubs are placed, similar to the other support wires, but without having a digit suspended between them. The support wires, including these stubs, are then sealed together in a parallel arrangement by applying to them an elongated bead of a glass which seals to stainless steel.

The matrix is assembled in the end of the tube **14** by inserting the glass beads **17** into diametrically opposite slots **18** cut in this cylinder with the blank support wires nearest the screen, and the matrix is secured in position by welding small nickel straps **21** to the cylinder across each slot on both sides of each bead. Alternate stainless steel wires from the beads **17** are cut short and the remaining ones are welded to leads **19** which are spaced by a glass supporting bridge **22** attached to the cylinder **14** by nickel straps **23** and are carried through insulating sleeves **20**, secured along the outer side of the cylinder **14** by nickel straps **24**, to terminal pins T at the pressed glass base. The leads from each bead thus make connection to half of the digits in the matrix, and the leads to the different beads are connected to different digits so that each digit is connected to one of the terminal pins T. The envelope is evacuated, sealed, and gettered after assembly, in the manner usual for the manufacture of cathode ray tubes.

In use current is supplied to the cathode heater of the electron gun **2**, and suitable potentials are applied to the electrodes of this gun and the anode cylinder **14** through the terminal pins T, so as to produce a divergent beam of electrons illuminating the whole of the screen **3**. Potentionals are also applied to all the digits of the matrix **4** to maintain them normally slightly positive with respect to the cylinder **14**. When it is desired to display any digit of the matrix, the potential of that digit is changed so as to make it substantially negative with respect to the cylinder **14**, and this digit thereupon casts a dark shadow on the screen **3** which reproduces the form of the digit.

The two stubs at the end of the matrix nearest the screen are always maintained positive with respect to the cylinder **14** thus eliminating or reducing the shadow which might otherwise be cast by the support wires of the characters selected for reproduction.

I claim:

1. A device for use in displaying characters, having a sealed evacuated envelope containing a fluorescent screen visible through the envelope, an electron gun arranged in operation to project an electron beam towards the fluorescent screen so as to flood an area of the screen, two or more electrically conducting characters insulated from each other and arranged consecutively along the path of the beam, the characters being individually connected to condutors extending through the envelope by means of which each character can be separately connected to a source of potential, and the arrangement being such that the device can be operated so that the characters lie within the cross-section of the electron beam and with the said area of the screen substantially uniformly illuminated when the characters are maintained

at suitable potentials, and so that any selected one of the characters can be caused to cast its shadow on the fluorescent screen by a suitable change in the potential applied to that character.

2. A display device according to claim 1 in which the characters lie in substantially parallel surfaces extending across the electron beam path and each is of a web form, parts of the webs of different characters being alinged along the path of the beam.

3. A display device according to claim 2 in which the characters are formed from metal wire bent so as to outline the characters.

4. A display device according to claim 1 in which the characters are mounted together on insulating support means to form a character matrix incorporated as a unit within the envelope of the device.

5. A display device according to claim 1 designed for the display of combinations of two or more characters in which the electron gun is arranged so as in operation to flood and illuminate only a part of the area of the screen, the characters are spaced from the fluorescent screen, and at least one deflecting means for the electron beam is provided which is arranged to control the path of the beam between the characters and the screen whereby the position on the screen of the area illuminated by the beam, and on which the shadow of the selected character is formed, can be changed under the control of the deflecting means.

6. A display device according to claim 5 in which a plate is provided in the path of the beam before the deflecting means, the plate having an aperture through which the beam passes and which is of smaller cross-sectional area than the beam so as to mask the cross-section of the beam to a corresponding shape.

7. A display device according claim 1 in which in normal operation the electron beam is arranged to diverge or converge at the region of the characters and wherein the characters increase in scale in proportion to their distance from the point of divergence or convergence, respectively, so that wherever portions of separate characters correspond they overlie each other along the path of the electrons, thereby minimising the total shadow area cast on the screen in use when all these characters are maintained at the same potential.

8. A circuit arrangement arranged for the display of characters, comprising a display device according claim 1, means for applying to the electron gun and the anode of the display device the requisite potentials for generating an electron beam which will flood an area of the screen in use of the device, means for applying to the characters within the tube the potentials at which in use of the device the said area of the screen will appear substantially uniformly illuminated, and means for changing the potential applied to any selected character to a value at which in use a shadow of that character will be produced on the fluorescent screen.

9. A circuit arrangement arranged for the display of characters comprising a display device according to claim 5 together with means for applying to the electron gun and the anode of the display device the requisite potentials for generating an electron beam which will flood an area of the screen in use of the device, means for applying to the characters within the tube potentials at which, in use of the device, the said area of the screen will appear substantially uniformly illuminated, means for changing the potential applied to any selected character to a value at which in use a shadow of that character will be produced on the fluorescent screen, and means for supplying to the deflecting means of the device deflecting potentials suitable for changing the position of the displayed characters in sequential steps along a line on the screen.

10. A circuit arrangement according to claim 9 wherein the display device includes two deflecting means for deflecting the electron beam in two inclined directions, and including means for applying to each of two deflecting means the deflecting potentials required to deflect the beam in sequential steps in two different directions to obtain a two-dimensional display of characters on the screen.

11. A method of forming characters for a display device according to claim 1 in which the characters are formed on one half of a die having holes in which a number of pins may be set, by winding round pins set in appropriate holes a wire of a metal which can be work-hardened, and subsequently flattening and setting the wire by compressing it between the halves of the die to form the characters in the desired final form.

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