May 20, 1952 W. E. MUTTER 2,597,363

CATHODE-RAY STORAGE TUBE

Filed June 29, 1951 2 SHEETS—SHEET 1

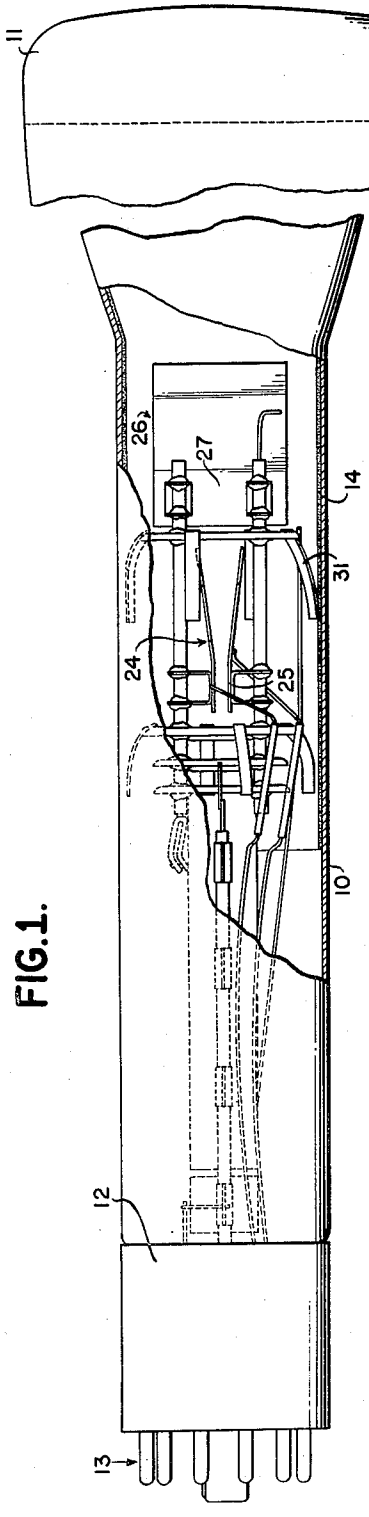


FIG.1.

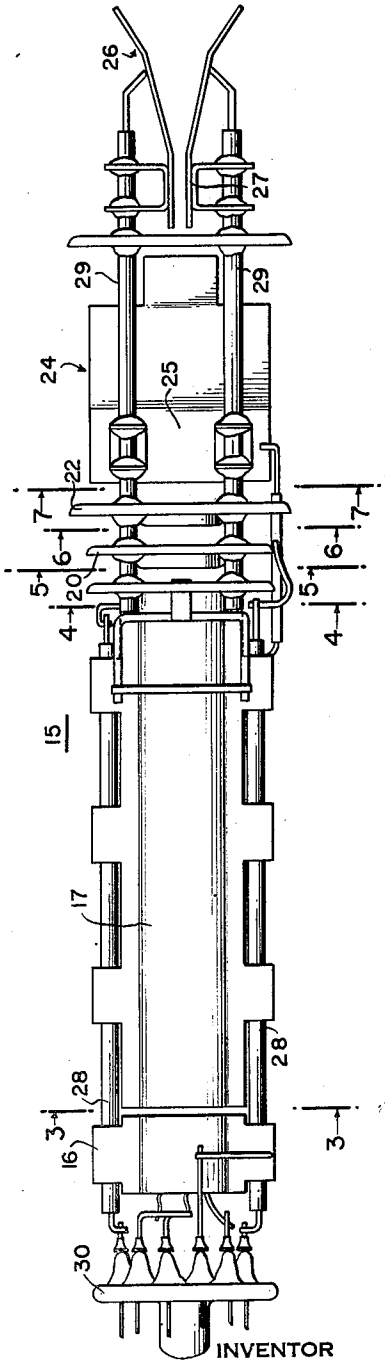


FIG.2.

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CATHODE-RAY STORAGE TUBE

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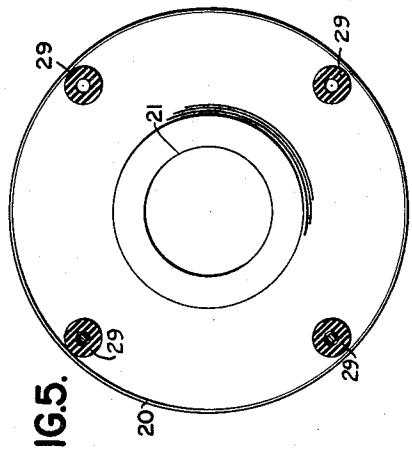


FIG.5.

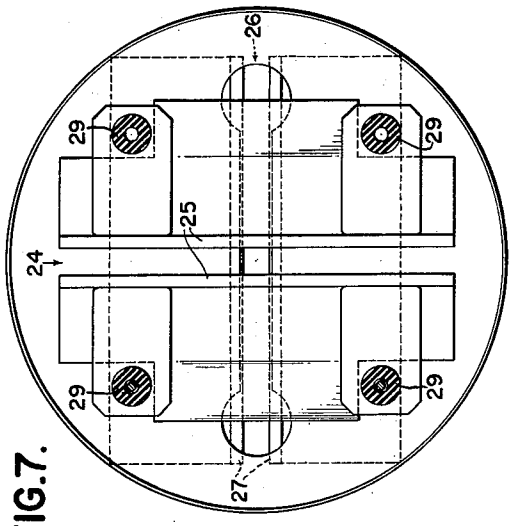


FIG.7.

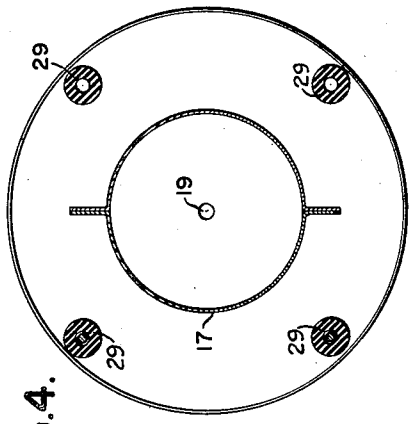


FIG.4.

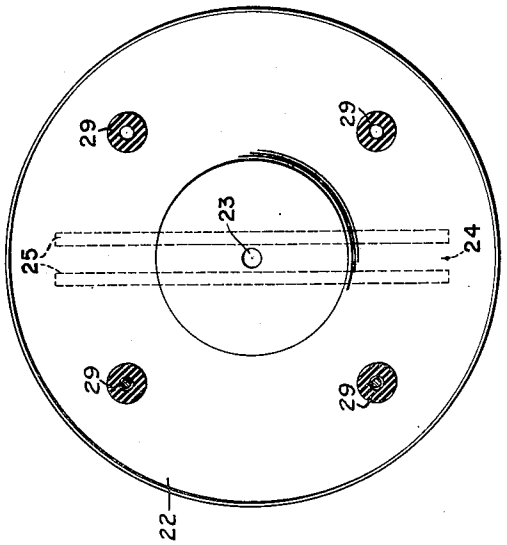


FIG.6.

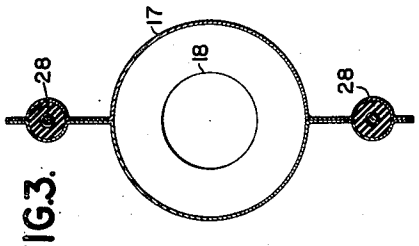


FIG.3.

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UNITED STATES PATENT OFFICE

2,597,363

CATHODE-RAY STORAGE TUBE

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12 Claims. (Cl. 313—75)

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This invention relates to cathode-ray tubes, and more particularly to such tubes for use in electro-static digital data storage systems. A system of this type is described by F. C. Williams and T. Kilburn in their paper entitled "A Storage System for Use with Binary-Digital Computing Machines" which appeared at pages 81–100 of the Proceedings of the Institution of Electrical Engineers for March 1949. In storage tubes of this general type, the capacity for storing bits of digital information for a given size of tube depends not only upon the size or cross-section of the electron beam but also upon the uniformity or freedom from de-focusing of the beam as a function of its deflection. With a given circuit, access time to the stored information is dependent upon the deflection sensitivity of the tube.

Previously known cathode-ray tubes have not proved entirely satisfactory for use in such storage systems because the amount of digital information which could be stored in a given tube was seriously limited by the minimum size of the electron beam which could be obtained and by the fact that the beam size varied substantially as a function of the degree of deflection of the beam. Furthermore, the deflection sensitivity of previously available tubes was insufficient to permit fast enough access to the stored information.

It is a principal object of the present invention, therefore, to provide improved beam-shaping and -deflecting means for cathode-ray tubes.

Another object of the present invention is to provide, in a cathode-ray tube, means for forming an electron beam having a substantially smaller cross-section than could previously be obtained.

A further object of the present invention is to provide, in a cathode-ray tube, means for minimizing the de-focusing or change in the cross-section of the electron beam with deflection.

An additional object of the present invention is to provide a cathode-ray tube having substantially improved deflection sensitivity.

In accordance with the present invention, the above objects are achieved by utilizing carefully selected proportions between the elements of the electron gun and the deflection elements, these proportions involving both the axial spacings of the several elements and the diameters of the apertures therethrough, as well as the transverse spacing between the deflecting elements. It has been found that the actual dimensions of the elements are not critical, but that the proportionality of each of several pairs of dimensions is relatively critical to achieve the improved result which is characteristic of the present invention.

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In accordance with the present invention there is provided, in a cathode-ray tube having a source of an electron beam and a fluorescent screen, beam-shaping means axially disposed between the source and the screen. These means comprise in succession a first electrode having first and second apertures, a second electrode having a third aperture, and a third electrode having a fourth aperture. The diameters of the first, second, third and fourth apertures and the axial spacing between the first and third apertures vary by not more than 25% from proportionality to the ratios of the numbers 100, 16, 130, 20 and 1200, respectively.

In accordance with a further feature of the present invention, beam-deflecting means are also provided, these means comprising a pair of deflecting plates, a portion of which are parallel. The axial spacing between the first and third apertures, the spacing between the parallel portions of the deflecting plates and the axial dimension of the deflecting plates vary by not more than 25% from proportionality to the ratios of the numbers 120, 3 and 50, respectively.

Other objects and features of the present invention will be pointed out in the following description and claims and illustrated in the accompanying drawings, which disclose, by way of example, the principle of the invention and the best mode, which has been contemplated, of applying that principle.

In the drawings, in which like reference numerals designate like components:

Fig. 1 is a plan view, partly cut away, of a cathode-ray tube incorporating beam-shaping and -deflecting means in accordance with the present invention;

Fig. 2 is an elevation of the beam-shaping and -deflecting means of the cathode-ray tube of Fig. 1; and

Figs. 3–7 are sections taken respectively on the lines 3—3, 4—4, 5—5, 6—6 and 7—7 of Fig. 2.

Referring to Fig. 1 of the drawings, there is shown a cathode-ray tube comprising an envelope 10 having at its enlarged end a fluorescent screen 11 and at the opposite end a base 12 provided with suitable connecting prongs 13. A portion of the interior wall of envelope 10 near its enlarged end is provided with a conductive coating 14.

Mounted within envelope 10 is a beam-forming, -shaping and -deflecting means designated generally by the reference numeral 15 and illus-

trated more clearly in Figs. 2–7. Assembly **15** comprises a control grid **16** within which is mounted the usual cathode and heater assembly (not shown) comprising a source of an electron beam, a first electrode **17** having a first aperture **18** and a second aperture **19**, a second electrode **20** having a third aperture **21**, a third electrode **22** having a fourth aperture **23**, and a pair of deflecting plates **24**, portions **25** thereof being parallel to each other. The remaining portions of the plates preferably occupy two or more pairs of non-parallel planes, as illustrated. This configuration minimizes de-focusing with deflection. There may also be provided a second pair of deflecting plates **26**, likewise having parallel portions **27**. In use, deflecting plates **24** may be employed to provide horizontal deflection of the electron beam and deflecting plates **26** to provide vertical deflection of the electron beam.

As is well known to those skilled in the art, the several electrodes and the deflecting plates are suitably supported by insulating members **28** and **29**, which in turn are suitably mounted within and supported by insulating member **30** mounted within and supported by base **12**. Contact to conductive coating **14** is readily made by a plurality of conductive spring-like fingers **31**.

In accordance with the present invention, the cross-section of the beam and hence the spot size on fluorescent screen **11** is decreased by substantially increasing the axial spacing between apertures **18** and **21**. This axial spacing may be approximately 12 times the diameter of aperture **18**, for example. In previously known tubes, this ratio was approximately 7.65. The spot size on the fluorescent screen is further reduced by increasing the axial spacing between the third aperture and the screen. This spacing may, for example, closely approximate 2.67 times the axial spacing between the first and third apertures.

Further reduction in the beam cross-section with resultant reduction in de-focusing with deflection is secured, in accordance with the present invention, by reducing the diameter of aperture **19**. The axial spacing between apertures **18** and **21** may be approximately 76 times the diameter of aperture **19**, compared with a previously employed ratio of approximately 48. Furthermore, the diameter of aperture **23** is preferably approximately 1.25 times that of aperture **19**, whereas in previously known tubes these apertures were of equal diameter. This is an important feature of the present invention, in that all the masking of the electron beam takes place at aperture **19**, the secondary electrons generated at the edge of this aperture being suppressed by relatively negative electrode **20**. This prevents these electrons from reaching screen **11** where they would deteriorate the stored charge pattern.

In accordance with the present invention, deflection sensitivity is improved by substantially lengthening deflecting plates **24** and decreasing their transverse spacing. The axial dimension of the deflecting plates is approximately 31 times the diameter of aperture **19**, compared with 12.5 times in previously known tubes. The spacing between the parallel portions of the deflecting plates is reduced to such an extent that the axial spacing between apertures **18** and **21** is approximately 40 times the plate spacing. In previously known tubes, this ratio was approximately 20.

In one particular embodiment of the present invention comprising a cathode-ray tube having a screen diameter of approximately 3 inches the following dimensions were employed:

	Inches
Diameter of aperture **18**	0.250
Diameter of aperture **19**	0.040
Diameter of aperture **21**	0.325
Diameter of aperture **23**	0.050
Axial spacing between apertures **18** and **21**	3.04
Axial length of deflecting plates **24**	1.25
Spacing between parallel portions of plates **24**	0.075

With 2500 volts between the cathode and electrode **22**, and 925 volts between the cathode and electrode **20**, the deflection sensitivity of deflecting plates **24** was approximately 80 volts per inch.

The storage capacity of tubes of the type herein contemplated depends upon the number of references made to a given spot before adjacent spots are regenerated. The following capacity was realized with the particular embodiment of the invention above described:

References per regeneration	Storage capacity in bits
16	1,460
64	1,360
256	1,093
400	1,024
1,020	824

This performance is approximately twice as good as that achieved with previously known tubes.

While there have been shown and described and pointed out the fundamental novel features of the invention as applied to a preferred embodiment, it will be understood that various omissions and substitutions and changes in the form and details of the device illustrated and in its operation may be made by those skilled in the art, without departing from the spirit of the invention. It is the intention, therefore, to be limited only as indicated by the scope of the following claims.

What is claimed is:

1. In a cathode-ray tube having a source of an electron beam and a fluorescent screen, beam-shaping means axially disposed between said source and said screen, comprising in succession: a first electrode having first and second apertures; a second electrode having a third aperture; and a third electrode having a fourth aperture; the axial spacing between said third aperture and said screen closely approximating 2.67 times the axial spacing between said first and third apertures.

2. In a cathode-ray tube having a source of an electron beam and a fluorescent screen, beam-shaping means axially disposed between said source and said screen, comprising in succession: a first electrode having first and second apertures; a second electrode having a third aperture; and a third electrode having a fourth aperture; the axial spacing between said first and third apertures closely approximating 76 times the diameter of said second aperture.

3. In a cathode-ray tube having a source of an electron beam and a fluorescent screen, beam-shaping means axially disposed between said source and said screen, comprising in succession: a first electrode having first and second apertures; a second electrode having a third aperture; and a third electrode having a fourth

aperture; the axial spacing between said first and third apertures closely approximating 12 times the diameter of said first aperture and 76 times the diameter of said second aperture, and the diameter of said fourth aperture closely approximating 1.25 times the diameter of said second aperture.

4. In a cathode-ray tube having a source of an electron beam and a fluorescent screen, beam-shaping means axially disposed between said source and said screen, comprising in succession: a first electrode having first and second apertures; a second electrode having a third aperture; and a third electrode having a fourth aperture; the diameter of said first, second, third and fourth apertures and the axial spacing between said first and third apertures varying by not more than 25% from proportionality to the ratios of the numbers 100, 16, 130, 20 and 1200, respectively.

5. In a cathode-ray tube having a source of an electron beam and a fluorescent screen, beam-shaping means axially disposed between said source and said screen, comprising in succession: a first electrode having first and second apertures; a second electrode having a third aperture; and a third electrode having a fourth aperture; the diameter of said first, second, third and fourth apertures, the axial spacing between said first and third apertures and the axial spacing between said third aperture and said screen varying by not more than 25% from proportionality to the ratios of the numbers 100, 16, 130, 20, 1200 and 3250, respectively.

6. In a cathode-ray tube having a source of an electron beam and a fluorescent screen, beam-shaping and deflecting means axially disposed between said source and said screen, comprising in succession: a first electrode having first and second apertures; a second electrode having a third aperture; a third electrode having a fourth aperture; and a pair of deflecting plates; the axial dimension of said plates closely approximating 31 times the diameter of said second aperture.

7. In a cathode-ray tube having a source of an electron beam and a fluorescent screen, beam-shaping and -deflecting means axially disposed between said source and said screen, comprising in succession: a first electrode having first and second apertures; a second electrode having a third aperture; a third electrode having a fourth aperture; and a pair of deflecting plates, a portion of said plates being parallel; the axial spacing between said first and third apertures closely approximating 40 times the spacing between the parallel portions of said plates.

8. In a cathode-ray tube having a source of an electron beam and a fluorescent screen, beam-shaping and -deflecting means axially disposed between said source and said screen, comprising in succession: a first electrode having first and second apertures; a second electrode having a third aperture; a third electrode having a fourth aperture; and a pair of deflecting plates, a portion of said plates occupying a pair of parallel planes and the remaining portion occupying at least two pairs of non-parallel planes; the axial spacing between said first and third apertures closely approximating 40 times the spacing between the parallel portions of said plates.

9. In a cathode-ray tube having a source of an electron beam and a fluorescent screen, beam-shaping and -deflecting means axially disposed between said source and said screen, comprising

in succession: a first electrode having first and second apertures: a second electrode having a third aperture; a third electrode having a fourth aperture; and a pair of deflecting plates, a portion of said plates occupying a first pair of parallel planes and the remaining portion occupying second and third pairs of non-parallel planes; the axial spacing between said first and third apertures closely approximating 40 times the spacing between the parallel portions of said plates.

10. In a cathode-ray tube having a source of an electron beam and a fluorescent screen, beam-shaping and -deflecting means axially disposed between said source and said screen, comprising in succession: a first electrode having first and second apertures; a second electrode having a third aperture; a third electrode having a fourth aperture; and a pair of deflecting plates, a portion of said plates being parallel; the axial spacing between said first and third apertures closely approximating 40 times the spacing between the parallel portions of said plates and the axial dimension of said plates closely approximating 31 times the diameter of said second aperture.

11. In a cathode-ray tube having a source of an electron beam and a fluorescent screen, beam-shaping and -deflecting means axially disposed between said source and said screen, comprising in succession: a first electrode having first and second apertures; a second electrode having a third aperture; a third electrode having a fourth aperture; and a pair of deflecting plates, a portion of said plates being parallel; the axial spacing between said first and third apertures, the spacing between the parallel portions of said plates and the axial dimension of said plates varying by not more than 25% from proportionality to the ratios of the numbers 120, 3 and 50, respectively.

12. In a cathode-ray tube having a source of an electron beam and a fluorescent screen, beam-shaping and -deflecting means axially disposed between said source and said screen, comprising in succession: a first electrode having first and second apertures; a second electrode having a third aperture; a third electrode having a fourth aperture; and a pair of deflecting plates, a portion of said plates being parallel; the diameters of said first, second, third and fourth apertures, the axial spacing between said first and third apertures, the spacing between the parallel portions of said plates and the axial dimension of said plates varying by not more than 25% from proportionality to the ratios of the numbers 100, 16, 130, 20, 1200, 30 and 500, respectively.

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