

PATENT SPECIFICATION

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(54) COMPACT OPTICAL VIEWER FOR MICROFICHE AND CASSETTE

(71) We, IZON CORPORATION, a Corporation organised under the Laws of the State of Delaware, United States of America, of 45 Research Drive, Stamford, State of Connecticut 06906, United States of America, 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:—

This invention relates to a microfiche reader, and more particularly to a compact microfiche reader wherein the projected microimages of a microfiche are reflected several times prior to striking a viewing screen. The various embodiments of this invention represent an improvement on the device shown in U.S. Patent 3,941,467 issued to Kapany et al, hereby incorporated by reference. As set out in that Patent, a microfiche reader folds a projected, conical beam of light by causing the beam to be successively reflected against a plurality of reflecting surfaces until it strikes at a viewing screen. The plurality of reflecting surfaces is defined by the several exterior faces of a solid of trapezium shape. One of the reflecting surfaces of the trapezium performs a dual function. It forms one of the reflecting surfaces and additionally permits subsequently reflected light to pass through it for final imaging on a viewing screen. The manner chosen by Kapany et al in accomplishing this result resides in the selection of certain angles of the reflecting surfaces so that rays of light initially striking the dual-function surface do so at an angle of incidence greater than a certain critical angle for total internal reflection. The critical angle is, in turn dependent upon the index of refraction of the material from which the trapezium is fashioned. The Kapany et al construction also utilizes a Fresnel lens which is not essential for the operation of the device, but is apparently utilised only to give a brighter and more uniformly illuminated picture, particularly at the edges.

According to the present invention there

is proposed an optical projector, of the type for projecting a cone of light from an illuminated micro-image, including a plurality of reflecting surfaces for intercepting and folding a cone of light and a dual function optical element adapted to reflect or to transmit light according to the angle of incidence of incident light thereon relative to the critical angle of reflection, the said dual function optical element being defined by a transparent prism sheet including a multiplicity of prisms at one surface and the other surface thereof being flat.

Thus it will be seen that a similar action takes place to that of Kapany in that a light cone is effectively folded several times before striking a viewing screen. However, in contradistinction to Kapany, there is no requirement that a solid trapezium or other block of light transmitting material be employed. Instead, a dual-function surface is constituted by a series of prisms which define a prism sheet. The prism sheet performs the same function as a dual-function surface of Kapany, but fulfils the additional function of acting to focus the final image on a viewing screen. One advantage exhibited by this invention over the construction of Kapany et al is that significant weight and cost savings are realised. Thus, in lieu of a relatively heavy and expensive solid plastic block (the trapezium), reflecting surfaces are defined by planar mirrors in sheet or planar form which may be inexpensively fashioned and positioned relative to each other.

Still further, the use of a solid block of transparent material requires a longer light cone throwing distance for the same sized viewing area. Thus, for a solid block of transparent material of index of refraction n , the throwing distance is n times the throwing distance required by the practice of this invention. For example, if a Kapany et al type of viewer has a throwing distance of nine inches, using polymethylethacrylate ($n=1.5$) as the material for the trapezium, the practice of this invention admits of a throwing distance of about six inches. A lesser

throwing distance yields a viewer still more compact for a given size viewing screen.

The invention will now be described further, by way of example only, with reference to the accompanying drawings which illustrate several embodiments thereof and in which:—

Fig. 1 is a view illustrating the device shown in U.S. Patent 3,941,467 issued to Kapany et al;

Fig. 2 is a view similar to Fig. 1 but illustrates a device in accordance with the invention employing a prism sheet which performs a dual function;

Fig. 3 is an enlarged view taken at the indicated portion of Fig. 2;

Fig. 4 is a view illustrating a modified form of prism sheet;

Fig. 5a is a view similar to Fig. 3 and illustrates two prism sheets for use in those circumstances wherein a mirror otherwise follows immediately in the optical path of the first prism sheet;

Fig. 5b is a view similar to Fig. 5a and illustrates the use of a second pair of prism sheets;

Fig. 6 illustrates a complete viewer constructed according to the principles shown at Fig. 2;

Fig. 7 is a partially schematic sectional view taken on line 11—11 of Fig. 6 and illustrates two lenses for projecting microimages based on two parallel tracks located on a Philips cassette film strip;

Fig. 8 is a partially schematic view similar to Fig. 6 and shows a reader exhibiting compatibility for both a Philips cassette and a standard four inch by six inch microfiche;

Fig. 9 is a partially schematic view illustrating another embodiment of the invention;

Fig. 10 is a view illustrating the open position of the device shown in Fig. 9;

Fig. 11 shows a viewer of similar type to that illustrated in Fig. 10 and differing therefrom in the manner of folding of the viewing screen and a mirror;

Fig. 12 represents still another embodiment; and

Fig. 13 is a view of the reader shown at Fig. 12 with the addition of a mirror and folding viewing screen.

Referring now to Fig. 1 of the drawings, the numeral 30 denotes generally the principal optical elements of the Kapany device as disclosed in United States Patent specification No. 3,941,467. The numeral 31 denotes a solid block of transparent material through which a cone of light whose apex is denoted by the numeral 32 is projected. The cone of light represents light from a microimage. The principal ray is denoted by the numeral 33 and strikes first reflecting surface 34.

From thence it strikes, at more than a critical angle with respect to the perpendicular, the surface 35 of the solid and is thence reflected to reflecting surface 37. From surface 37 the light passes normally out through surface 35 for viewing. The reader will observe the extended dash lines adjacent the cone apex 32, such lines illustrating the bending action suffered by the light when it passes from air into transparent material 31.

Referring now to Figs. 2 and 3 of the drawings, a compact optical viewer is illustrated which also employs a dual-function surface, but which is superior from the point of view of both of size and cost. At Fig. 2 the numeral 12 indicates the central ray from a projected cone of light which carries a microimage to be viewed. The ray first strikes reflecting surface 14 and then strikes prism sheet 44. It is then totally internally reflected at the upper surface of the prism sheet, as is the case with the Kapany surface 35, and thence strikes second mirror 16. From thence it exits normally to the prism sheet and thence to viewing screen 46. While shown as passing straight through prism sheet 44, it is to be understood that light from mirror 16 is refracted as it passes through the prism sheet, as is shown in Fig. 3.

Referring now to Fig. 3 of the drawings in greater detail, a magnified portion of the screen and prism sheet of Fig. 2 is shown. Numerals 44, 46, 48 respectively denote the prism sheet, the viewing screen, and an air gap between the sheet and screen. Prism sheet 44 is defined by a plurality of ridges provided on one surface of a sheet, the ridges and the sheet being transparent. Each ridge has two faces, each face being generally straight in transverse cross-section although one of the two faces of any ridge may be curved. The ridges in all of the prism sheets illustrated are straight and are parallel to each other. However, ridges having an elliptical contour, with the axis of the light cone defining one of the two foci of nested ellipses may be employed.

Referring now to Fig. 4 of the drawings, one embodiment of a prism sheet is illustrated. The prism sheet 44 is not to be confused with a Fresnel lens, to which it bears a superficial resemblance. The individual ridges which make up the prism sheet are elliptical in contour, although in transverse cross-section they are similar to the previously described embodiment. The ridges are denoted by the numeral 50, while the numeral 52 indicates the intersection of the principal ray 12 of the cone of light with the prism sheet. It is to be observed that point 52 is one foci of the nested elliptical ridges.

Referring now to Figs. 5a and 5b of the drawings, two and four prism sheets are illustrated. In the event that a single prism sheet only is to be employed in the reader, for example as shown in Figs. 2 and 3, a viewing screen is placed adjacent the flat surface of the prism sheet. However, if light passing through the first prism sheet is to be subsequently reflected, it is necessary to include a second prism sheet so as not to change the direction of the light rays. However, if the thickness of the prism sheet is too great, the image on the rear projection screen becomes badly distorted due to crossing of the light rays in the manner shown in Fig. 5a. But the distortion becomes negligible to the eye if the number of prisms is large, e.g. 200 prisms per inch. The distortion produced will not be resolved by the human eye.

In order to improve the image on the screen, a second pair of prism sheets can be placed immediately next to and in registry with the first two prism sheets, thereby undoing the crossing of rays as is shown in Fig. 5b. It is to be understood that in any of the embodiments shown herein utilizing a pair of prism sheets, the optics can be improved by adding an additional pair as in Fig. 5b.

In Fig. 5a the first prism sheet is denoted by the number 54 and includes surfaces 56 and 58 on a typical ridge. Air gap 60 is interposed between the flat surface of the prism sheet 54 and the flat surface of a second prism sheet 62. Faces 64 and 66 on a typical ridge of prism sheet 62 correspond with surfaces 56 and 58 of prism sheet 54. It is to be noted that surface 58 is parallel to surface 64, while surface 56 is parallel to surface 66. Further, any one or both of homologous surfaces 58, 64 may be curved, effectively to define a lens. Similarly, any one or both of homologous surfaces 56, 66 may also be curved similarly effectively to define a lens.

Figs. 6 and 7 of the drawings illustrate an embodiment employing two projection lenses. In Fig. 7 the numerals 12 and 12' indicate the principle axes of two projected light cones, each light cone corresponding to a respective part of two parallel tracks carried by an optical film on a Philips cassette. The reader is denoted generally by numeral 28' while numeral 26 represents, generally, the indicated auxiliary devices in a typical reader.

Fig. 8 illustrates another embodiment wherein the compact reader can accommodate either a microfiche, such as a standard four inch by six inch microfiche or a Philips cassette. The microfiche is denoted by numeral 70 and employs projection lens 10, while the cassette is denoted by numeral 72

and employs projection lens 10'. It is to be understood that mirror 11 is pivoted out of the optical path when cassette 72 is employed. Thus, either the microfiche or the cassette may be used for projection.

Referring now to Figs. 9 and 10, another compact viewer is illustrated. Numeral 76 denotes a first mirror for receiving a cone of light projected from a cassette or other carrier of optical information on a reduced scale, whilst numerals 78, 80 respectively indicate second and third mirrors. As before, numeral 44 denotes a prism sheet while numeral 46 indicated a viewing screen. The principal light ray is indicated by numeral 12. The action of the device is similar to that previously described with respect to other embodiments. Here, however, the reflecting surfaces, particularly the first and second reflecting surfaces, are substantially parallel. As before, light striking prism sheet 44 at more than the critical angle is reflected, while light rays substantially normal to the prism sheets are transmitted through for viewing on screen 46.

The embodiment of Fig. 10 differs from that of Fig. 9 in that the Fig. 10 embodiment includes pivots 86 and 88 as well as additional mirror 82 coupled to viewing screen 84. The screen, when not in use, is folded clockwise about pivot 88 until it attains parallelism with mirror 82, whereupon these two elements are folded clockwise about pivot 86.

Furthermore, a pair of parallel and spaced prism sheets denoted by numerals 54 and 62 are employed, their action and disposition being the same as that described with respect to Fig. 5 of the drawings.

Another embodiment is shown in Fig. 11, and comprises first, second, third and fourth mirrors identified by the respective numerals 90, 92, 93 and 94. Numeral 96 indicates a viewing screen, while numeral 12 again indicates the principal ray of a cone of light projected from a cassette or other information storage device. The viewing screen 96 is provided with a pivot 98 whereby such screen is connected to the top of mirror 94, while the bottom of screen 96 is pivotally mounted for motion about an axis 100. Numeral 102 indicates the lower edge of mirror 94, whilst numerals 54, 62 indicate two dual purpose prism sheets. The optical operation of the device will be readily apparent from a consideration of the drawing. In order to fold the device when not in viewing usage, mirror 94 is moved to the right so that its bottom edge slides along the top of the viewer, viewing screen 96 thus swinging about axis 100 in clockwise direction.

Referring now to Fig. 12 which illustrates another embodiment of the invention,

numeral 110 denotes a first reflecting surface, (neglecting any small mirrors near the apex of the projected light cone) and numeral 112 a second reflecting surface, while numeral 44 again represents a prism sheet having an associated spaced viewing screen 46. Numeral 113 indicates a slot for the reception of a microfiche, although it will be understood that elements 26 may be modified so as to include a Philips cassette which carries optical information instead of the microfiche. A light cone projected from the stored micro information has a principal ray denoted by numeral 12, as before, and strikes surfaces 110 and 112 as indicated. Reflecting surface 114 is positioned as shown, extending upward to the left as viewed at Fig. 12 until adjacent the left end of prism sheet 44. The dual-function action of prism 44 is the same as that previously described.

Fig. 13 illustrates a modification of the device shown at Fig. 12, and differs therefrom by the addition of another mirror 115 and a viewing screen 116 attached to the top of mirror 115 by means of a pivot 120, mirror 115 in turn carrying a lower pivot 122. The optical action of the embodiment of Fig. 13 is believed to be self-evident. To fold the device, screen 116 is pivoted about axis 120 in a clockwise direction until it is in parallelism with mirror 115, whereupon the two elements are folded in a clockwise direction about pivot 122 to the top of the device.

The prism sheets, such as 44 at Fig. 3 and 54, 62 of Fig. 5, employed in the embodiments hereinbefore described may be formed in the manner similar to that described with respect to Figs. 10 and 11 of the published specification of copending German Patent Application No. 2 736 486, entitled Light Channeling Devices, and U.S. Patent 3,728,422 both incorporated by reference. A stack of generally rectangular shims of metal, are distorted so that the shims slide relative to each other. One set of edges of the shims thus assumes the staggered relation shown at Fig. 11 of the above noted copending German application, except that the edges are not biased as shown by the numeral 72, but are still rectangular, as shown at Fig. 10. The edges are, further, not as distant from each other as shown at Fig. 11, and instead are displaced an amount to produce an edge cross-section the same as that of prism sheet 44 of Fig. 3 of this application. Again, the shim edges are mirror polished. The resultant shim assembly may now be employed either as a mould or as a master for electro-forming. The mirror polished shim ends yield the desired optically flat surfaces of the individual ridges of the prism sheet, such as flat surfaces or faces 56, 58 of prism

sheet 54 of Fig. 5a of this Application.

It should be noted that the prism sheet or prism sheets should be as thin as possible. Care should also be taken to ensure that the prism sheets are supported or arranged in such a way that they will not curve or bend with variation of environmental conditions.

WHAT WE CLAIM IS:—

1. An optical projector, of the type for projecting a cone of light from an illuminated micro-image, including a plurality of reflecting surfaces for intersecting and folding a cone of light and a dual function optical element adapted to reflect or to transmit light according to the angle of incidence of incident light thereon relative to the critical angle of reflection, the said dual function optical element being defined by a transparent prism sheet including a multiplicity of prisms at one surface and the other surface thereof being flat.

2. An optical projector as claimed in claim 1, wherein the prisms are each straight and parallel to each other.

3. An optical projector as claimed in claim 1, wherein the prisms are each elliptical in contour when viewed orthogonally to the said sheet, the elliptical prisms being nested and having a common focus.

4. An optical projector as claimed in claim 2 or 3, wherein the prisms are of isosceles triangular transverse cross-section.

5. An optical projector as claimed in any one of the preceding claims wherein the sides of the prisms are mutually perpendicular.

6. An optical projector as claimed in any one of the preceding claims, wherein the mirror surface reflecting light onto the prism sheet for total reflection by such sheet and the mirror surface reflecting light onto the prism sheet for passage through such sheet are disposed at an acute angle to the base of the prism sheet.

7. An optical projector as claimed in any one of the preceding claims, further including a second prism sheet arranged in opposed disposition relative to the first prism sheet to constitute therewith a co-operating pair of prism sheets.

8. An optical projector as claimed in claim 7, wherein the individual prism sheets of the co-operating pair are arranged in parallel disposition.

9. An optical projector as claimed in claim 7 or 8, further including third and fourth prism sheets identical with the first and second prism sheets respectively, the first and second prism sheets defining a first pair of prism sheets and the third and fourth prism sheets defining a second co-operating pair of prism sheets of which the individual prism



numeral 110 denotes a first reflecting surface, (neglecting any small mirrors near the apex of the projected light cone) and numeral 112 a second reflecting surface, while numeral 44 again represents a prism sheet having an associated spaced viewing screen 46. Numeral 113 indicates a slot for the reception of a microfiche, although it will be understood that elements 26 may be modified so as to include a Philips cassette which carries optical information instead of the microfiche. A light cone projected from the stored micro information has a principal ray denoted by numeral 12, as before, and strikes surfaces 110 and 112 as indicated. Reflecting surface 114 is positioned as shown, extending upward to the left as viewed at Fig. 12 until adjacent the left end of prism sheet 44. The dual-function action of prism 44 is the same as that previously described.

Fig. 13 illustrates a modification of the device shown at Fig. 12, and differs therefrom by the addition of another mirror 115 and a viewing screen 116 attached to the top of mirror 115 by means of a pivot 120, mirror 115 in turn carrying a lower pivot 122. The optical action of the embodiment of Fig. 13 is believed to be self-evident. To fold the device, screen 116 is pivoted about axis 120 in a clockwise direction until it is in parallelism with mirror 115, whereupon the two elements are folded in a clockwise direction about pivot 122 to the top of the device.

The prism sheets, such as 44 at Fig. 3 and 54, 62 of Fig. 5, employed in the embodiments hereinbefore described may be formed in the manner similar to that described with respect to Figs. 10 and 11 of the published specification of copending German Patent Application No. 2 736 486, entitled Light Channeling Devices, and U.S. Patent 3,728,422 both incorporated by reference. A stack of generally rectangular shims of metal, are distorted so that the shims slide relative to each other. One set of edges of the shims thus assumes the staggered relation shown at Fig. 11 of the above noted copending German application, except that the edges are not biased as shown by the numeral 72, but are still rectangular, as shown at Fig. 10. The edges are, further, not as distant from each other as shown at Fig. 11, and instead are displaced an amount to produce an edge cross-section the same as that of prism sheet 44 of Fig. 3 of this application. Again, the shim edges are mirror polished. The resultant shim assembly may now be employed either as a mould or as a master for electroforming. The mirror polished shim ends yield the desired optically flat surfaces of the individual ridges of the prism sheet, such as flat surfaces or faces 56, 58 of prism

sheet 54 of Fig. 5a of this Application.

It should be noted that the prism sheet or prism sheets should be as thin as possible. Care should also be taken to ensure that the prism sheets are supported or arranged in such a way that they will not curve or bend with variation of environmental conditions.

WHAT WE CLAIM IS:—

1. An optical projector, of the type for projecting a cone of light from an illuminated micro-image, including a plurality of reflecting surfaces for intersecting and folding a cone of light and a dual function optical element adapted to reflect or to transmit light according to the angle of incidence of incident light thereon relative to the critical angle of reflection, the said dual function optical element being defined by a transparent prism sheet including a multiplicity of prisms at one surface and the other surface thereof being flat.
2. An optical projector as claimed in claim 1, wherein the prisms are each straight and parallel to each other.
3. An optical projector as claimed in claim 1, wherein the prisms are each elliptical in contour when viewed orthogonally to the said sheet, the elliptical prisms being nested and having a common focus.
4. An optical projector as claimed in claim 2 or 3, wherein the prisms are of isosceles triangular transverse cross-section.
5. An optical projector as claimed in any one of the preceding claims wherein the sides of the prisms are mutually perpendicular.
6. An optical projector as claimed in any one of the preceding claims, wherein the mirror surface reflecting light onto the prism sheet for total reflection by such sheet and the mirror surface reflecting light onto the prism sheet for passage through such sheet are disposed at an acute angle to the base of the prism sheet.
7. An optical projector as claimed in any one of the preceding claims, further including a second prism sheet arranged in opposed disposition relative to the first prism sheet to constitute therewith a co-operating pair of prism sheets.
8. An optical projector as claimed in claim 7, wherein the individual prism sheets of the co-operating pair are arranged in parallel disposition.
9. An optical projector as claimed in claim 7 or 8, further including third and fourth prism sheets identical with the first and second prism sheets respectively, the first and second prism sheets defining a first pair of prism sheets and the third and fourth prism sheets defining a second co-operating pair of prism sheets of which the individual prism



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5 sheets are disposed in like manner to the individual prism sheets of the said first pair.

5 10. An optical projector as claimed in any one of claims 1 to 6, further including a screen and wherein the prism sheet is disposed in the vicinity of the screen.

10 11. An optical projector as claimed in any one of claims 1 to 6, including first and second substantially parallel mirrors, a third mirror positioned with an edge adjacent the edge of the second mirror, the first and third mirrors making an obtuse angle with each other, a prism sheet positioned in the plane of the second mirror and adjacent thereto, the prism sheet being positioned opposite to the third mirror, and adapted to reflect at least a portion of the light received from the third mirror.

20 12. An optical projector as claimed in claim 11, further including a viewing screen parallel, contiguous to, but spaced from the prism sheet.

25 13. An optical projector as claimed in claim 11, further including a second prism sheet adjacent and parallel to but spaced from the first prism sheet and arranged in opposed disposition relative thereto, a fourth mirror to receive light transmitted by the first and second prism sheets and a viewing screen positioned to receive light reflected by the fourth mirror, the fourth mirror and viewing screen being pivotally connected together and collectively pivotable about respective parallel pivot axes arranged perpendicular to the axis of the light cone.

35 14. An optical projector as claimed in claim 13, wherein the fourth mirror is pivotally mounted at a first edge thereof and pivotally supports the viewing screen at a second edge parallel and opposite to said first edge, the viewing screen being pivotable to a position parallel and adjacent to the fourth mirror on folding of the projector.

45 15. An optical projector as claimed in claim 13, wherein the screen is pivotally mounted at a first edge thereof and pivotally supports the fourth mirror at a second edge parallel and opposite to said first edge.

50 16. An optical projector as claimed in any one of claims 1 to 6, including first and second mirrors arranged substantially orthogonally to each other, a prism sheet generally orthogonal to the second mirror, and a third mirror so arranged that the plane thereof makes an acute angle with the plane containing the prism sheet, the plane of the third mirror passing substantially through the intersection of the first and second mirrors.

60 17. An optical projector as claimed in claim 16, further including a viewing screen arranged parallel and adjacent to, but spaced from, the prism sheet.

18. An optical projector as claimed in

claim 16, further including a second prism sheet arranged in closely spaced parallel disposition relative to the said prism sheet, a fourth mirror of which one edge is pivoted adjacent the intersection of the planes of the third mirror and prism sheets, and a viewing screen pivoted to the fourth mirror at an edge of the fourth mirror opposite said one edge, the pivot axes of the fourth mirror and screen being parallel.

75 19. An optical projector as claimed in any one of claims 1 to 6, including a second prism sheet adjacent and parallel to but spaced from the first prism sheet and arranged in opposed disposition relative thereto to define therewith a co-operating pair of prism sheets, a final reflecting surface to receive light transmitted by the first and second prism sheets and a viewing screen positioned to receive light reflected by the final reflecting surface, said final reflecting surface and viewing screen being pivotally connected together and collectively pivotal about respective parallel pivot axes perpendicular to the axis of the light cone.

90 20. An optical projector as claimed in claim 19, wherein the final reflecting surface is pivoted at an edge thereof about an axis perpendicular to the axis of the light cone and the viewing screen is pivotally mounted on the said final reflecting surface at an edge thereof parallel to the said edge.

95 21. An optical projector as claimed in claim 19 or 20, further including third and fourth prism sheets identical with the first and second prism sheets respectively and together defining a second pair of co-operating prism sheets corresponding to that pair defined by the said first and second prism sheets, the said second pair being positioned between the second prism sheet and the final reflecting surface.

100 22. An optical projector as claimed in claim 21, wherein the two pairs of prism sheets are arranged in parallel disposition.

105 23. An optical projector as claimed in claim 21 or 22, wherein the two pairs of prism sheets are arranged in closely spaced disposition.

24. An optical projector as claimed in any one of the preceding claims, including means for simultaneously projecting cones of light from different illuminated micro-images.

25. An optical projector as claimed in claim 24, including a plurality of nests of elliptical prisms according to claim 3, the common focus of each nest being coincident with the respective main ray of incident light core.

26. An optical projector substantially as hereinbefore described with reference to and as illustrated in Figs. 2 to 5, Figs. 6 and 7, Fig. 8, Fig. 9, Fig. 10, Fig. 11, or Figs. 12 and 13 of the accompanying drawings.



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By a direction given under Section 17 (1) of the Patents Act 1949 this application proceeded in the name of **GENERAL OPTICAL COMMUNICATIONS INCORPORATED**, a Corporation organized and existing under the laws of the State of Delaware, United States of America of P. O. Box S, Leonia, State of New Jersey, 07605, United States of America.

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