June 21, 1966 S. BOUSKY 3,256,767

FIBER OPTICS CODE APPARATUS

Filed Feb. 4, 1963 3 Sheets-Sheet 1

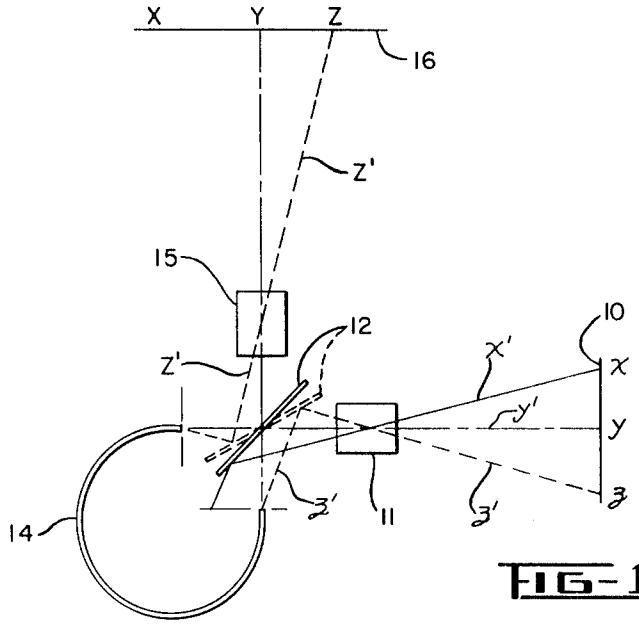


FIG-1

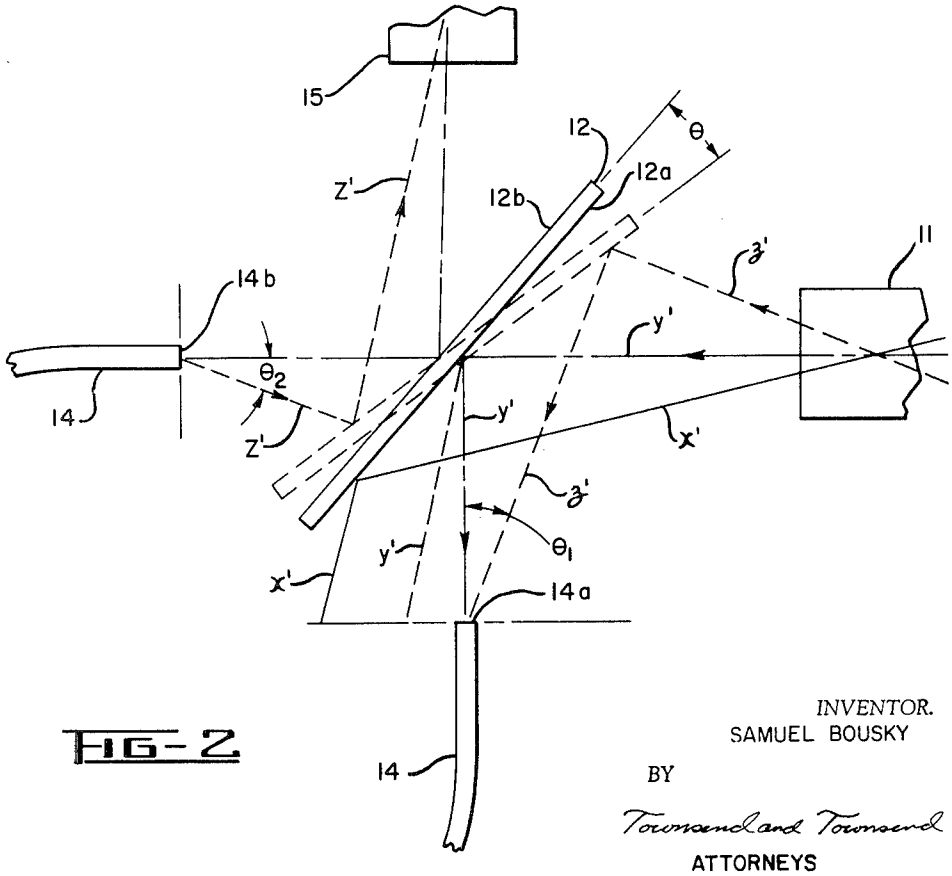


FIG-2

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FIBER OPTICS CODE APPARATUS

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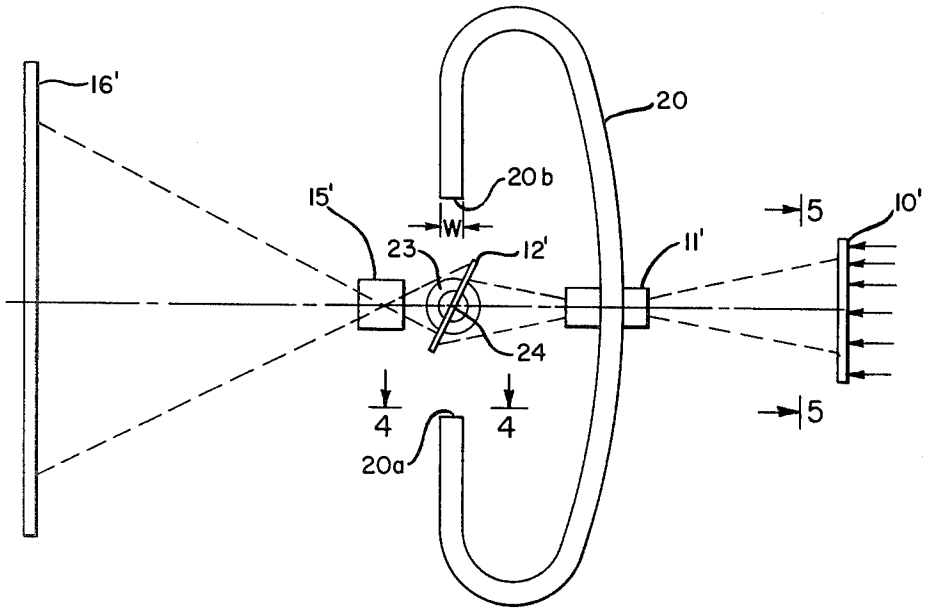


FIG-3

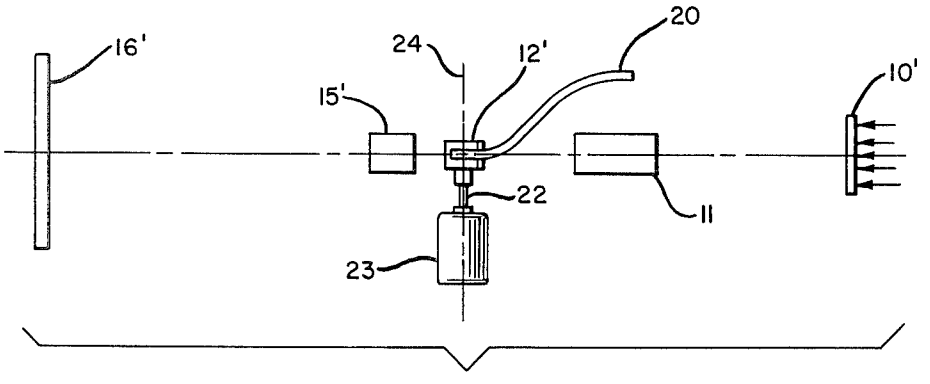


FIG-6

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FIBER OPTICS CODE APPARATUS

Filed Feb. 4, 1963 3 Sheets-Sheet 3

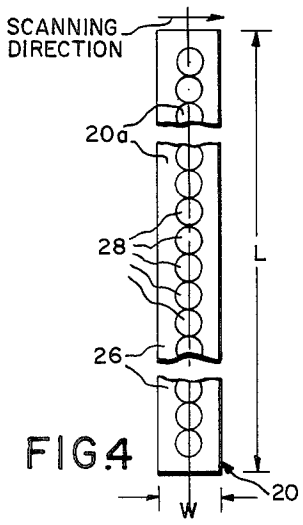


FIG.4

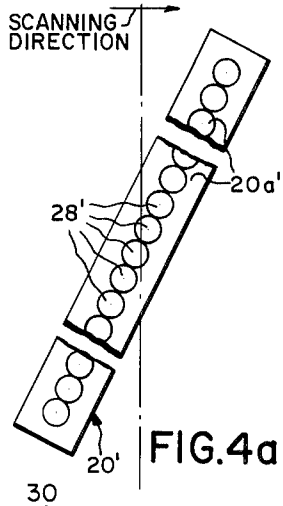


FIG.4a

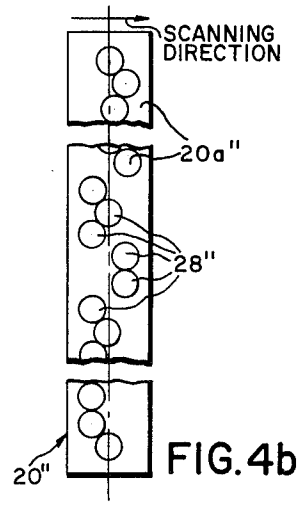


FIG.4b

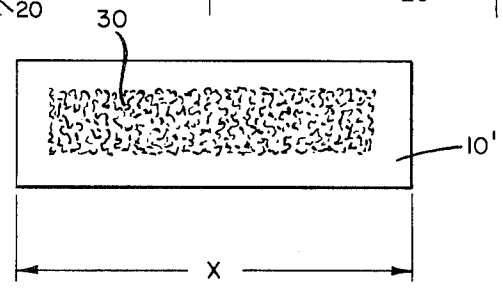


FIG-5

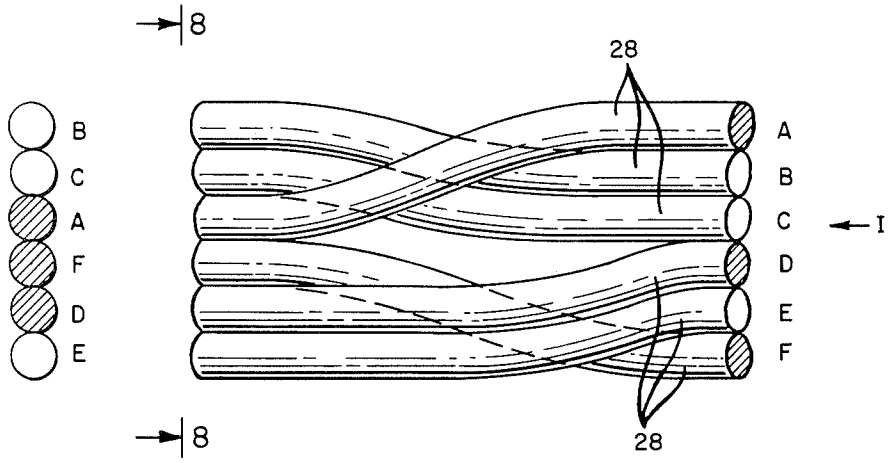


FIG-8

FIG-7

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United States Patent Office 3,256,767 Patented June 21, 1966

3,256,767

FIBRE OPTICS CODE APPARATUS

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Filed Feb. 4, 1963, Ser. No. 255,955
4 Claims. (Cl. 88—1)

This invention relates to coding systems for coding and decoding graphic information and is a continuation-in-part of my copending application United States Serial No. 145,682 filed October 17, 1961, now abandoned.

It is often desirable to record printed, written or photographic information in a coded form which can be rapidly decoded by apparatus which is easily mass produced but which is of sufficient complexity so that it cannot be exactly duplicated by a person attempting to break the code.

As a typical example, banks and similar organizations must verify the signatures of their customers hundreds of times a day. The usual practice is to compare the present signature with one on a customer's signature card. This practice requires bulky storage files in the working area near the bank tellers' windows and further entails repeated time consuming reference to such files to the annoyance of both customers and teller. The problem becomes even more complex in a large bank system which has a number of branch offices. Under such circumstances it is impossible for each branch office to have a signature sample for all the depositors of the system. Banks have long recognised the need for a practical coding system of signature verification but none has been devised which meets the requirements fo coding capacity, speed of operation and low cost.

One structure that has been suggested for coding a signature is a bundle of optical fibers formed at each end into a matrix the same size as the area to be coded with the orientation of the fibers changed from one end of the fiber bundle to the other whereby the image at the output end of the fiber bundle is a "scrambled" version of the image at the input end. However, in order to produce adequate resolution fibers with an extremely small diameter such as. for example, 0.001 to 0.005 inch must be used. A matrix large enough to reproduce a coded signature would typically have to be several hundred fibers on a side which necessitates the use of anywhere from one hundred thousand to a quarter of a million fibers. Obviously, it is impractical to provide every banking teller in a large banking system with an identical coded fiber bundle containing such an enormous number of fibers.

The principal object of the present invention is the provision of an optical coding system for coding and encoding graphic information and in which a coded sequence of elongated optical fibers is scanned across a target image.

One feature and advantage of the present invention lies in the fact that the system has an exceedingly large capacity for different codes.

Another feature and advantage of this invention lies in the fact that a large area of information can be coded with a minimum number of optical fibers.

According to another object of the present invention, provision is made for changing the angle between the axis of the coded sequence of optical fibers and the direction in which the sequence is scanned.

Another feature and advantage of such a coding device lies in the fact that a great many codes can be produced with combinations of different coded sequences and different angles.

Still another object of the present invention is the provision of a scrambled sequence of elongated optical fibers which are scanned across the target image and in which the ends of certain of the optical fibers are offset

from the axis of the sequence thereby providing still a further coding key by which the image can be coded.

The accomplishment of the foregoing and other objects of the invention will appear from the following description of a preferred embodiment thereof, reference being made to the accompanying drawings in which similar characters of reference represent corresponding parts in each of the several views.

FIG. 1 is a schematic diagram of an optical system for transmitting an image in accordance with this invention.

FIG. 2 is an enlarged view of a portion of FIG. 1.

FIG. 3 is a plan view of an optical decoding apparatus embodying this invention.

FIG. 4 is an enlarged end view of the optical fiber sequence as viewed along line 4—4 of FIG. 3.

FIG. 4*a* is a view similar to FIG. 4 but showing an alternative arrangement of the fiber sequence.

FIG. 4*b* is a view similar ot FIG. 4 of an alternative structure of the fiber sequence.

FIG. 5 is a front view of a coded signature plate viewed along line 5—5 of FIG. 3.

FIG. 6 is a side elevational view of the apparatus shown in FIG. 3.

FIG. 7 is a perspective view of a layer of optical fibers (magnified many times) illustrating the manner of changing the fiber positions to provide a coding key, and,

FIG. 8 is an end view of the row of fibers viewed along the line 8—8 of FIG. 7.

This invention is based on the use of a sequence of light-conducting fibers and means arranged between a target image to be transmitted and a terminal screen for effectively scanning this sequence across the target.

While the invention is obviously useful for encoding and decoding graphic information, it will be described with reference to a target image which is an individual signature coded in a manner according to the present invention.

Referring now to the drawings, FIGS. 1 and 2 depict diagrammatically an image transmission system comprising a single line target image **10**, a lens **11**, a mirror **12**, both sides, **12***a* and **12***b* of which are light reflective, a single light conducting fiber **14** bent into a 270° loop, another lens **15** and a terminal screen **16**. As an introduction to the multifiber apparatus according to this invention, the system is described with respect to FIGS. 1 and 2 showing a single fiber loop **14**.

With mirror **12** in the solid line position, a ray *y'* of light from the mid-point *y* on the line image **10** passes through the lens **11** and is reflected from side **12***a* of mirror **12** into the input end **14***a* of fiber **14**. This ray is transmitted by the fiber in accordance with well-known principles of fiber optics around the loop to fiber output end **14***b* and projects therefrom to side **12***b* of the mirror **12** for reflection through lens **15** to mid-point Y on terminal screen **16**.

However, with the mirror **12** in the solid line position, other points on the image **10** such as, for example, points *x* and *y* at the ends of the target line image **10** are not projected on screen **16** because their rays, *x'* and *z'* are not reflected into the fiber **14** by the mirror. However, when the mirror is pivoted about its axis normal to the plane of paper through angle θ to the broken line position, shown clearly in FIG. 2, ray *y'* is deflected out of alignment with the fiber input end **14***a* and ray *z'* is directed into the fiber so that it is transmitted to the opposite end **14***b* and is reflected by side **12***b* of the mirror to screen **16** where it appears at point Z. Thus,, as the mirror rotates in this manner, it effectively "scans" the end **14***a* of fiber **14** along the length of the line image **10** so that the points *x*, *y* and *z* are successively

transmitted through the fiber for projection on the screen **16**.

The foregoing description of loop **14** made of a single optical fiber used in conjunction with the optical scanning and projecting system illustrates how a single fiber can be used and scanned across a line image. By providing a sequence of such fibers arranged in a single row to form a band **20**, see FIGS. 3 and 4, a two-dimensional image containing coded or uncoded information can be scanned to produce, respectively, uncoded or coded information in a two-dimentional area. By orienting the positions of the fibers in the sequence differently at opposite ends **20***a* and **20***b* of the band a coding key is provided. This positional transposition of fibers will be explained below in detail with reference to FIGS. 7 and 8. This coding key has an extremely large coding capacity and, while independent, can be combined with other coding keys described in greater detail below to produce a system having an extremely large code capacity.

Referring now to FIGS. 3, 4, 5 and 6, apparatus comprising a decoding optical transmission system comprises a coded target **10'**, which for purposes of explanation may be a coded translucent signature card, a lens **11'**, a plain mirror **12'** with both of its sides being light reflective, a 360° band **20** of optical fibers, lens **15'** and read-out screen **16'**. Mirror **12'** is mounted on a shaft of motor **23** for rotary movement about axis **24**. The axes of lenses **11'** and **15'** lie in a common plane. Band **20** comprises a sequence of optical fibers **28** arranged in a single row at opposite ends **20***a* and **20***b* of the band. The band **20** is a 360° loop so that the ends **20***a* and **20***b* face each other with mirror **12'** interposed therebetween.

Fibers **28** may each be drawn in a special furnace from a thick rod of high refractive index glass encased in a tube of lower refractive index glass. The emerging filament is wound in substantially a single layer or row on a revolving drum but this winding is accomplished in such a manner that the axial position of the fiber is shifted differently on successive revolutions of the drum. The result is that the fiber loops are crossed over each other in a predetermined pattern in the direction of the drum axis. The row of fibers is then cut parallel to the drum axis, is removed from the drum and is encased in a protective sheaf of plastic **26**, see FIG. 4. The continously wound single fiber is thus divided into a plurality of separate fibers **28**, each of which extends between ends **20***a* and **20***b* of band **20**. The number of separate fibers **28** in a band determine the length L and may be typically **100** or more depending upon coding requirements. Each fiber may be drawn to a diameter of 0.005 to 0.001 inch or less with substantial diametric uniformity over the length.

The relative positions of fibers **28** are different at opposite ends of the band. This transpositon of fibers, which constitutes a basic coding key in this system, will be better understood by reference to the simplified fiber diagram of FIGS. 7 and 8. The six fibers identified by letters A through F, inclusive, are arranged with their opposite ends in a row. Each fiber conducts an element of the image to be transmitted. Assume that the image I falls on the ends of the fibers to the right of the figure so that fibers A, D and E conduct dark spots as indicated by shading, and the remaining fibers conduct lighter spots. The transposition of the fibers in the row over the length of the band changes the pattern of light and dark spots at the left end of the figure so that the dark spots are adjacent to rather than spaced from each other. A total image I transmitted by these "scrambled" fibers is therefore "coded" in the process of transmission. The many fibers **28** in band **20** are similarly transposed in a predetermined manner to provide a code key.

Referring to FIGS. 3, 4, 5, 6 and 7, assume target **10'** is a translucent rectilinear plate on which a coded signature **30** appears. Further assume that this signature code is keyed to the code of the apparatus. Light behind target **10'** illuminates the signature **30** and lens **11'** focuses a portion the image via mirror **12'** onto the end **20***a* of band **20**. When target **10'** is properly positioned relative to the mirror **12'** and fiber sequence at the end of the band **20**, the reflected image from the mirror is picked up by the fibers at the band end **20***a* and transmitted to the opposite end **20***b*. During this transmission, the transpositioned fibers in the band accomplished the decoding function so that the image projected from band end **20***b* to the mirror is the decoded signature. The mirror **12'** is rotated by motor **23** through a scanning sector defined by the width X of the target **10'** so that the end **20***a* of the band **20** is effectively scanned the length of the target **10'**, each fiber **28** at the end **20***a* of the band **20** being scanned along a line the length of the target **10'**. The projection of this scanned image on large screen **16'** permits the viewer to read the signature as it was originally written. The scanning rate of 12 to 20 oscillations per second is selected to permit visual image retention by the reader of the projected decoded image. Alternatively, the screen **16'** can be made up of phosphorescent particles which retain the projected image after only one scan of the fiber sequence across the target **10'**.

The apparatus may be used with equal facility to code a signature by the reverse procedure. Assume that a specimen of a signature to be coded is written on screen **16'** which is illuminated from either the front or rear. The target **10'** is replaced with a photographic film. The elements of the signature image are "scrambled" in the transmission through band **20** and are recorded in permanent coded form on the film. A rapid photographic processing system is preferably used to speed the entire coding process which may be accomplished in a matter of a few minutes.

The entire system contemplates a series of decoding or "read-out" machines into each of which a target plate **10'** may be placed, properly oriented relative to the scanning plane of the mirror **12** and fiber sequence **20** and read on a screen **16'** in the machine. These machines would include the light sources, mirror, motor drive and a sufficient control to properly key the decoding apparatus to the plate **10'**.

Other coding keys are possible with this apparatus. Referring now to FIG. 4*a*, according to the coding key illustrated there, the angle between the longitudinal axis of the fiber sequence **20***a'* at the end of the fiber band and the direction of scan is changed from 90° so that the bits of information are not picked up on a line drawn across the width target **10'** but on a line at an angle with respect to the width of the target. One way of changing the angle between the line sequence and the direction of scan is to tilt the axis of the fiber sequence. Various different codes can be achieved by varying the angles of either or both ends **20***a* and **20***b* with respect to the perpendicular to the direction of scan. Another way of achieving this coding key is by changing the angle between the plane of the mirror reflecting surface and the pivotal axis **24** of the mirror.

Referring now to FIG. 4*b*, in the additional coding key illustrated there, the ends of individual fibers **28''** at the band end **20***a''* are spaced in different positions with respect to the longitudinal axis of the band **20''**. According to this embodiment of the invention, the bits of information are picked up from the target along a segmented line across the width of the target with the different line segments spaced in different positions with respect to the width of the target **10**. As a further coding feature, the relative lateral position of the fibers can be arranged differently at opposite ends of the band **20''**. Then, by changing the angle between the axis of the band end and the direction of scan, as described with respect to FIG. 4*a*, a great many different codes are possible.

Although the present invention has been described in some detail by way of illustration and example, for purposes of clarity of understanding, it is understood that

certain changes and modifications might be practised within the spirit of the invention as limited only to the scope of the claims appended hereto.

What is claimed:

1. Code apparatus comprising a first optical lens having an axis, a second optical lens having an axis lying in a plane containing the axis of the first lens, a mirror located at the intersection of the axes of the lenses, disposed between said lenses and having reflective surfaces on opposite sides normal to and intersecting said plane, a band of elongated light-transmitting fibers having respective axes aligned in a row at each of the opposite ends of the band, the relative positions of the fibers in the rows at opposite ends of the band being different, said band being disposed with its ends facing opposite sides of said mirror transmitting light reflected by one side of said mirror from said first lens to the other side of the mirror for reflection into said second lens, a target image plate facing the first lens opposite from said mirror, the location of said target image plate, said first lens, and said one side of said mirror being such as to focus the image of the target plate on a plane containing one end of said band, a screen facing the second lens opposite from said mirror, the location of said screen, said second lens and said other side of said mirror being such as to focus the image of the other end of said band on said screen, and means for rotating said mirror about an axis normal to the plane of the lens axes so that said one side of said mirror scans the entire image of the target image plate across said one end of said band and said other side of said mirror simultaneously reflects light transmitted from said other end of said band onto said screen, each of the rows at the opposite end of the band being positioned at an angle with respect to the plane of the lens axes.

2. Code apparatus comprising a first optical lens having an axis, a second optical lens having an axis, a mirror located at the intersection of the axes of the lenses and having reflective surfaces on opposite sides traversing said lens axes, a band of elongated light-transmitting fibers having respective axes aligned in a row at each of the opposite ends of the band, the relative positions of the fibers in the rows at opposite ends of the band being different, said band being disposed with its ends facing opposite sides of said mirror for transmitting light reflected by one side of said mirror from said first lens to the other side of the mirror for reflection into said second lens, a target image plate facing the first lens opposite from said mirror, the location of said target image plate, said first lens, and said one side of said mirror being such as to focus the image of the target plate on a plane containing one end of said band, a screen facing the second lens opposite from said mirror, and means for rotating said mirror about an axis transverse to the lens axes, the location of said screen, said second lens and said other side of said mirror being such as to focus the image of the other end of said band on said screen, each of the fiber rows at the opposite ends of the band being positioned at an angle with respect to a plane perpendicular to the rotational axis of the mirror.

3. Code apparatus comprising an optical lens having an axis, a mirror traversing the axis of the lens and having reflective surfaces on opposite sides, a band of elongated light-transmitting fibers having respective axes aligned in a row at each of the opposite ends of the band, the relative positions of the fibers in the rows at opposite ends of the band being different, said band being disposed with its ends facing opposite sides of said mirror for transmitting light reflected by one side of said mirror from said lens to the other side of the mirror, a target image plate facing said lens opposite from said mirror, the location of said target image plate, said lens, and said one side of said mirror being such as to focus the image of the target plate on a plane containing one end of said band, a screen facing said other side of said mirror to receive the image of the other end of said band and means for rotating said mirror about an axis transverse to the lens axis so that said one side of said mirror scans the entire image of the target image plate across said one end of said band and said other side of said mirror simultaneously reflects light transmitted from said other end of said band onto said screen.

4. Code apparatus comprising a mirror having reflective surfaces on opposite sides, a band of elongated light-transmitting fibers having respective axes grouped together in a single row at each of the opposite ends of the band, the relative positions of the fibers at opposite ends of the band being different, said band being disposed with its ends facing opposite sides of said mirror for transmitting light reflected by one side of said mirror to the other side of the mirror, a target image plate facing one side of said mirror, a screen facing the other side of said mirror, and means for rotating said mirror so that one side of said mirror scans the entire image of the target image plate across one end of said band and said other side of said mirror simultaneously reflects light transmitted from the other end of said band onto said screen, each of the fiber rows being positioned at an angle with respect to the direction of scan.

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