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Wavelength Multiplexing by H. O. Bartelt (OPTICS communications) Vol. 27, No. 3 December (1978)
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(54) Displacement encoder

(57) In an optical encoder, light from an optical fibre input 10 is encoded by means of the encoding disc 18 and is subsequently collected for transmission via optical fibre 24. At some point in the optical path between the fibres 10 and 24, the light is separated into component form by means of a filtering or dispersive system 14 and each colour component is associated with a respective one of the coding channels of the disc 18. In this way, the significance of each bit of the coded information is represented by a respective colour thereby enabling the components to be re-combined for transmission by the fibre 24 without loss of information.

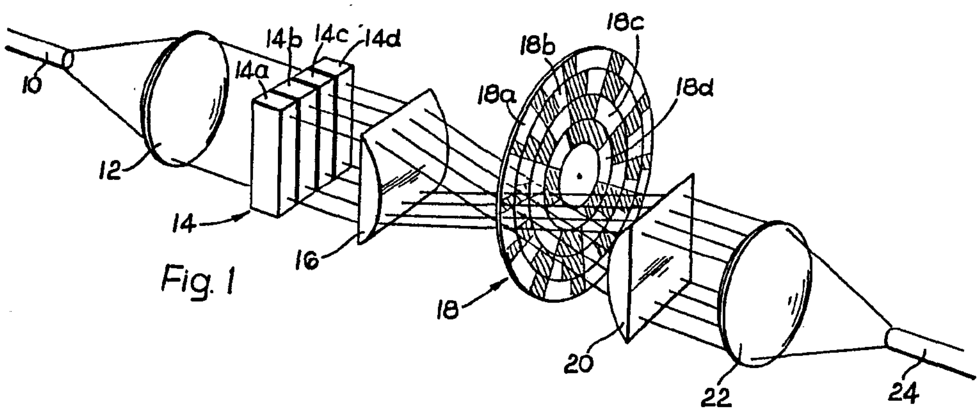

Fig. 1

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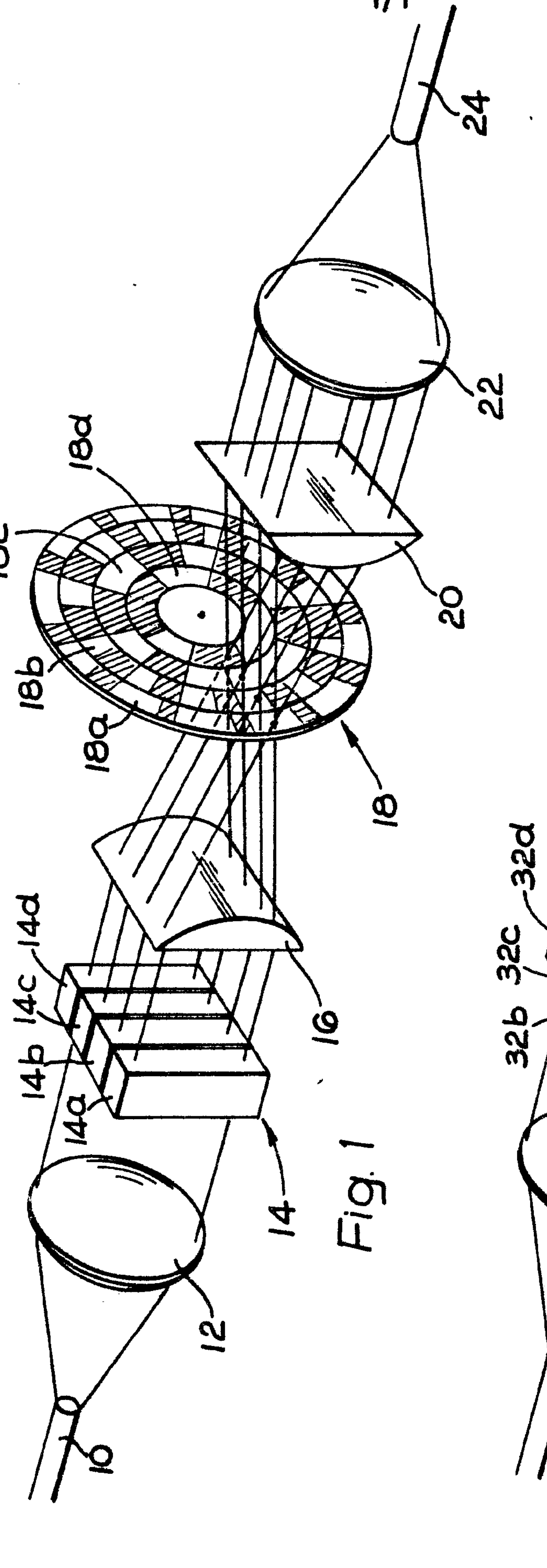

Fig. 1

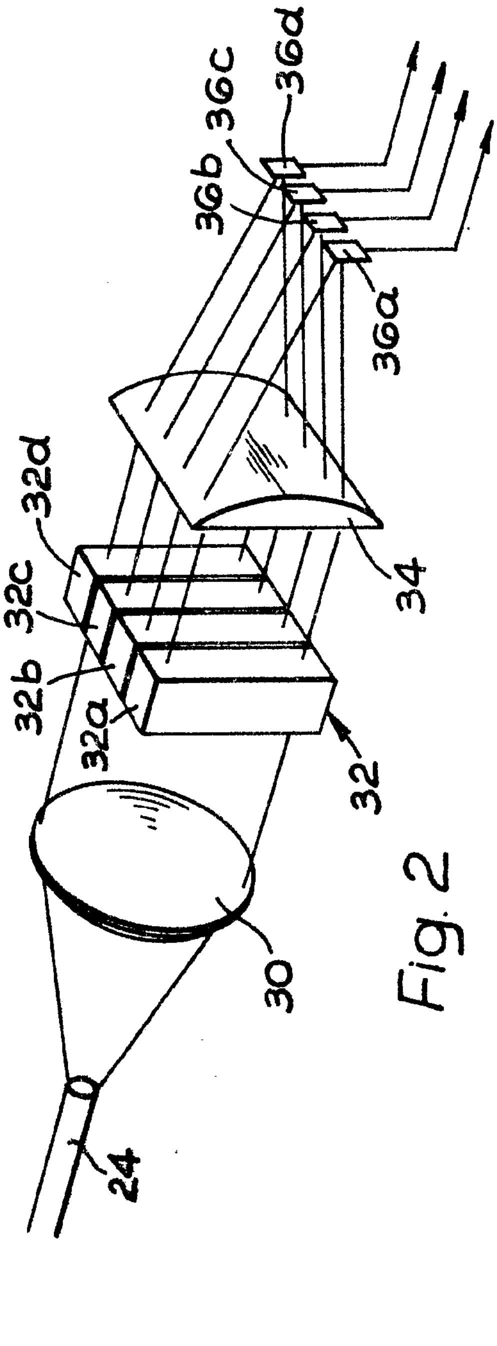

Fig. 2

SPECIFICATION

Displacement encoder

This invention relates to displacement encoders by means of which an absolute or incremental angular or linear displacement can be represented digitally.

In certain environments, it can be undesirable to employ an electrically powered encoder. This applies to for instance environments where the level of electrical noise is high, where the presence of electrical energy could lead to hazards (e.g. an explosive atmosphere) or where electrical/electronic equipment is likely to malfunction (e.g. nuclear reactors).

The object of the present invention is to provide an displacement encoder (and in particular an optical encoder) which is so adapted as to be capable of use in such environments.

According to a broad aspect thereof, the present invention provides a displacement encoder provided with means for distinguishing the bits of coded information from one another according to their significance.

According to a more specific aspect thereof, the present invention provides an optical encoder provided with means for representing each bit of the coded information in a different colour. By "colour" we mean a particular wavelength or range of wavelengths.

Typically the encoder will comprise an optical system for directing light along a predetermined path, a movable encoder member disposed in said light path and having a plurality of coding channels on portions of which the light impinges dependent upon the position of the encoder member and, in order to distinguish the bits of the coded information according to their significance, means for separating the light into a plurality of discrete components having mutually distinct spectral bands, each component being associated with a respective coding channel such that the output (and hence bit significance) derived from each coding channel is additionally governed by the associated spectral band.

The separating means may be disposed in the path of the light beam upstream or downstream of the encoding member or alternatively may be embodied in the encoding member itself. Such means may be implanted by for example thin film multi-dielectric interference filters or by dispersive elements (such as prism trains, diffraction gratings) or a combination of such filters and dispersive elements. Thus, for example, of the transparent and opaque zones constituting the coding channels of the encoding member, the transparent zones may be associated with or consist of thin film optical interference filters.

A further optical system will be provided downstream of the encoding member in order to recombine the various colour components for optical transmission to a remote point, e.g. via an optical fibre, for subsequent electrical processing.

It will be observed that the encoder may be entirely optically powered and need only employ a single input and single output optical fibre. Separation of the light into different colour components is effected non-electrically and since the individual bits are identifiable, in terms of their significance, by the colour used to represent them, the outputs from the encoding member can be combined for transmission by a single optical fibre without loss of information. Thus, the encoder is particularly suitable for use in environments where the use of electrical power is undesirable.

If as mentioned above the separating means, such as filters, are embodied in the encoding member itself, it will be appreciated that the optical systems on either side of the encoding member may be identical which may be advantageous especially since the roles of the input and output optical fibres may be readily interchanged.

In order to retrieve the coded information, means is preferably provided for chromatically analysing the output of the encoder and assigning to each bit a significance dependent upon the colour used to represent it. The analysing means may comprise filters and/or dispersive elements in order to separate the re-combined light output into different colour components and opto-electrically transform the components into an electrical digital output wherein the significance of the bits are determined by colour.

To promote further understanding of the invention, an embodiment of the invention will now be described by way of example only with reference to the accompanying drawings in which:

Figure 1 is a diagrammatic perspective view of an optical encoder in accordance with the invention; and

Figure 2 is a similar perspective view showing a decoder for use in conjunction with the encoder.

Referring now to Figure 1, light from a suitable source is transmitted from an input optical fibre 10 to a lens 12 which expands the light into a parallel beam for transmission through a system 14 for separating the light into a plurality of components having mutually distinct spectral widths, i.e. centred on different wavelengths. For the purpose of illustration only, the system 14 is shown as comprising four elements 14a—14d which serve to produce four different colour components. These are individually focussed by lens 16 onto respective circumferential coding channels 18a—d of an optical angular displacement encoding disc 18.

Each channel 18a—d has opaque and transmissive zones so that a digital word is formed, made up of bits provided one from each channel. The digital coding of the disc 18 may be any of the conventional codes employed, e.g. BCD, Gray code etc. Thus, as in conventional encoders, the significance of each bit is determined by the channel from which it is derived, e.g. the most significant bit of each digital word may be represented by the output from the innermost channel 18d and the least significant bit may be represented by the output of channel 18a.

The output from the encoding disc 18 is

thereafter collected and combined by means of lenses 20 and 22 and focussed into the optical fibre 24 for onward transmission. It will be understood that even though the outputs from the channels 18a—d are recombined, the significance of each bit of information is preserved by virtue of the fact that the channels are associated with different colour components. As shown, separation into different colour components is effected upstream of the disc 18 but it may equally be achieved at the disc or downstream thereof, e.g. the system 14 may be disposed between the lenses 20 and 22 or may actually be embodied within the structure of the disc.

The system 14 may, as previously mentioned, be implemented by interference filters or dispersive elements or a combination of both. The light source will be one which provides the required wavelengths for the different channels of the disc 18 with adequate spectral separation therebetween. Thus, for example, the light source may be the high temperature black body (Q.I. lamp) or line source (each line corresponding to a respective filter/channel) or several light emitting diodes with the light outputs thereof optically combined. Conveniently, as a safeguard against fibre breakage and other malfunctioning, the encoding disc 18 may include a channel (not shown) which transmits a respective colour at all positions of the disc so that the absence of that colour in the output of the encoder is indicative of a malfunction.

Although in the illustrated embodiment, the encoding member is in the form of a rotatable disc for measurement of angular displacement, it will be understood that the encoding member may be linearly displaceable for the measurement of translational displacement. If desired, the encoding member may form part of a system for measuring other parameters, such as pressure or temperature, which are converted into a linear or angular displacement. For instance, the encoding member may be linked to a movable diaphragm in a pressure sensing arrangement. The invention also includes within its scope, an incremental encoder employing two optical fibres and a three channel encoding member, the construction of the system being substantially as disclosed above except for the use of an incremental coding disc.

Referring now to Figure 2, a decoding system for retrieving the coded information from the light transmitted via optical fibre 24 comprises a length 30 for expanding the light into a parallel beam which is transmitted by the separation system 32 and then focussed by lens 34 onto photo-electric detectors 35a—d. The system 32 may comprise interference filters and/or dispersive elements for the purpose of separating the light into the same components as the system 14 so that the different components are brought to focus on respective ones of the detectors 36a—d. Thus, if for example the element 14a in the encoding system transmits red light and if the disc 18 is in a position in which the red light is transmitted by one of its transmissive zones, then the bit of information represented thereby is retrieved by means of the corresponding element 32a and detector 36a. The detectors 36a—d may provide electrical outputs in response to detection of the associated colour components so that the digitally encoded word formed by the disc 18 can be represented electrically.

The photo-electric detection can be either solid state (P.I.N. diode, A.P.D., transistor etc) or photo-electronic (photo-cell, photomultiplier etc). One novel technique is to use a multi-element scanning photodetector e.g. self-scanned line photo array (solid state) or TV type pickup (Vidicon, Image Iconoscope, Image Dissector, etc). In this case, the photoelements may be such that one or more of the scanned elements correspond to each channel and the scanned serial waveform contains the decoded information from the encoder.

CLAIMS

1. A displacement encoder provided with means for distinguishing the bits of the coded information from one another according to their significance.

2. An optical encoder provided with means for representing each bit of the coded information in a different colour.

3. An encoder as claimed in Claim 2 in which the light inputted to the encoder is separated into the different colour components prior to encoding and each component is applied to a respective coding channel of the encoding member.

4. An encoder as claimed in Claim 2 in which the encoding member is arranged to produce outputs from its coding channels which differ in colour from one another.

5. An encoder as claimed in Claim 2 in which the outputs from the coding channels of the encoding member are each processed subsequent to encoding such that the bit represented thereby is coloured differently from the remaining bits of the coded information.

6. An encoder as claimed in any one of Claims 2 to 5 in which the coded information is transmitted from the encoder by means of a single optical fibre.

7. An encoder as claimed in any one of Claims 2 to 6 in which the light is inputted to the encoder by means of a single optical fibre.

8. An encoder as claimed in any one of Claims 2 to 7 in which "colouring" of each code bit is effected by non-electrical means.

9. An encoder as claimed in Claim 8 in which "colouring" of each code bit is effected by filter means and/or dispersive means.

10. An encoder as claimed in any one of Claims 2 to 9 including means for chromatically analysing the output of the encoder and assigning to each bit a significance dependent upon the colour used to represent it.

11. An encoder as claimed in Claim 10 wherein said analysing means is arranged to produce an electrical output corresponding to each decoded bit.

12. An encoder as claimed in any one of Claims 2 to 11 including a light source in the form of a black body radiator.

13. An encoder as claimed in any one of Claims 2 to 11 including a light source in the form of a line source, each line corresponding to a respective one of the colours used to represent bits of coded information.

14. An encoder as claimed in any one of Claims 2 to 11 including a light source comprising a plurality of electro-optical semi-conductor elements emitting light within mutually distinct wavelength bands, and means for optically combining the outputs of said elements.

15. An encoder as claimed in any one of Claims 1 to 14 in which the encoder member is angularly movable.

16. An encoder as claimed in any one of Claims 1 to 14 in which the encoder member is linearly movable.

17. An encoder as claimed in any one of Claims 2 to 16 in which the encoding member includes one channel which provides continuity of light transmission at all positions of the encoding member so as to afford security against optical fibre breakage.

18. An optical encoder substantially as hereinbefore described with reference to, and as shown in, the accompanying drawings.

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