ABSTRACT: An electrooptical encoding device comprising a moveable member having a characteristic coded pattern of intermixed light reflecting and nonreflecting stripes representative of data to be electrically encoded. An electrooptical monitoring assembly is positioned adjacent the path of movement of the coded moveable member for serially illuminating the coded pattern of light reflecting and nonreflecting stripes with an interrogating light beam as the moveable member moves past the electrooptical monitoring assembly. The electrooptical monitoring assembly also includes an arrangement for serially receiving back pulses of light returned by the coded pattern of light-reflecting stripes and deriving serially coded output signals which are representative of the data encoded on the side of the moveable member. The electrooptical monitoring assembly comprises a source of illumination, a first optical subassembly for directing light from the source of illumination onto the characteristic coded pattern of light-reflecting stripes formed on the sides of the moveable member, a second optical subassembly for receiving light pulses reflected back from the pattern of light-reflecting stripes and for directing the received light pulses to the photosensitive surface of an electro-optic converter such as a photocell for converting the intelligence contained in the received light pulses into coded electrical signals representative of the data encoded on the moveable member.
ELECTROOPTICAL ENCODING DEVICE

BACKGROUND OF INVENTION

1. Field of Invention
This invention relates to a new and improved electro-optical encoding device.

More particularly, the invention relates to a simple, inexpensive and reliable electro-optical encoding device for use with physically moveable members for suitably marking or encoding the moveable members with characteristic markings to identify the fact of movement by a particular moveable member, the extent of movement thereof, etc.

2. Prior Art Problem
There are a wide variety of equipments used and situations encountered in both industry and government where it is either desirable or necessary to develop and use electrical output signals which are indicative of some phenomenon being observed or recorded for measurement and/or data keeping purposes. For example, in the processing, storage and distribution of articles of commerce (such as bags of sugar) which are generally sold by weight, it is desirable to maintain accurate and up-to-date records of the weight of an individual article, as well as the total weight of all of the articles in a particular classification (such as the total weight of a carton of 100 bags of sugar). For this purpose, it would be extremely desirable to have a device which not only weighs the article in question, but derives a coded electrical output signal which then can be supplied to a central data processing computer for storage, and subsequent processing record keeping, etc. Another problem area concerns the generation of characteristic coded electrical output signals which are representative of a characteristic being printed by a conventional office typewriter or desk calculator. Still another example of the need for suitable encoders is with respect to the measurement of the magnitude of motion of a vibrator, test or other moveable member where it is desired to obtain an accurate indication of the extent of movement of the member for design, quality check, or other purposes. These and many other similar problem areas make it abundantly clear that there is a wide-spread need for a good low-cost encoding device that has general utility.

SUMMARY OF INVENTION
It is therefore a primary object of the invention to provide a new and improved electro-optical encoding device which is relatively simple in construction, low cost and reliable in operation, and which easily may be employed in conjunction with a physically moveable member to derive a serially encoded characteristic electro output signal representative of the movement of a particular member, the extent of movement of the member, etc.

In practicing the invention a new and improved electro-optical encoding device is provided which comprises a moveable member having disposed thereon a characteristic coded pattern of internizem light reflecting and nonreflecting stripes representative of the data to be electrically encoded. The pattern of light reflecting and nonreflecting stripes may be permanently formed on the moveable member, or may be formed on a detachable target flag that can be readily secured to the moveable member. Electro-optical monitoring means are positioned adjacent the path of the coded moveable member for serially illuminating the coded pattern of light reflecting stripes with an interrogating light beam as the member moves past the electro-optical monitoring means. The electro-optical monitoring means also includes means for serially receiving back pulses of light returned by the coded pattern of light reflecting stripes, and deriving serially coded electrical output signals therefrom which are representative of the data encoded on the moveable member.

The electro-optical monitoring means may comprise a source of illumination together with a first means for directing light from the source of illumination onto the characteristic coded pattern of light reflecting and nonreflecting stripes formed on the moveable member. A second means is provided for receiving reflected light pulses back from the patterns of light-reflecting stripes and for directing the received light pulses to a desired point. The electro-optical monitoring means is completed by an electro-optic converting device such as a photoelectric cell having the light output from the second light-receiving means directed thereon for converting the intelligence contained in the received light pulses into coded electrical signals representative of the data encoded on the moveable member. The first and second light-transmitting and light-receiving means may comprise a fiber optic bundle having a light-transmitting branch and a light-receiving branch, the light-transmitting branch having one end positioned adjacent the source of illumination and a remaining end positioned adjacent the path of the moveable member for transmitting light from the source and directing an interrogating light beam against the moveable member as the pattern of reflecting stripes is serially moved past the electro-optical monitor. The light-receiving branch has one end positioned adjacent the path of the moveable member in the vicinity of the interrogating light beam produced by the transmitting branch and has a remaining end positioned to direct light pulses received from the pattern of reflecting stripes onto the light sensitive surface of an electro-optic converter such as a photocell.

BRIEF DESCRIPTION OF DRAWINGS

Other objects, features and many of the attendant advantages of this invention will be appreciated more readily as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings, wherein like parts in each of the several figures are identified by the same reference character, and wherein:

FIG. 1 is a partially broken away, perspective view of a weighing apparatus which has been adapted to include an electro-optical encoding device constructed in accordance with the invention;

FIG. 2 is a schematic diagram illustrating the essential parts of a new and improved electrical encoding device constructed in accordance with the invention, and employed with the weighing apparatus shown in FIG. 1;

FIG. 3 is a partial perspective view of a typewriter which has been adapted to include an electrical encoding device according to the invention;

FIG. 4A and 4B illustrate a particular form of target flag construction suitable for use in modifying a conventional typewriter for use with the electro-optical encoding assembly shown in FIG. 3;

FIG. 5 is a detailed sketch of an encoded target flag showing one manner of properly encoding a target flag such as that shown in FIGS. 4A and 4B;

FIG. 6 is a suitable light sensing and amplifying circuit suitable for use in the monitor assembly shown in FIG. 2;

FIGS. 7A and 7B are diagrammatic sketches of suitable alternative optical systems useable in practicing the invention;

FIG. 8 is a diagrammatic sketch of a dual-sided fiber optical interrogating assembly that may be used in practicing the invention;

FIG. 9 is a partially broken away perspective view of a desk calculator, or other similar, special purpose signal generator which has been designed to incorporate an electro-optical encoding device constructed in accordance with the invention;

FIG. 10 is a partially broken away diagrammatic sketch of a spring testing apparatus employing an electro-optical encoding device in accordance with the invention.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENT

FIG. 1 is a partially broken away perspective view of a weighing scale which has been adapted to incorporate the present invention. In FIG. 1, the weighing scale is indicated as
comprising a housing 11 having a weighing platform 12 on which articles to be weighed are disposed. The articles disposed on platform 12 then operate through a suitable weighing mechanism (not shown) to cause a scale 13 to be rotated to an extent determined by the weight of the articles placed on the platform 12. The rotary scale 13 may have suitable visible markers formed thereon which can be read by an operator in order to determine the weight of the article placed on the platform 12. In addition, the scale 13 includes markers 14 which may or may not be visible to the human eye, but which are viewed by an electro-optical monitoring assembly shown at 15 that is positioned to view and serially count and record the markers 14 as they are rotated past the end of the electro-optical monitoring assembly 15.

As best shown in FIG. 2 of the drawings, the electro-optical monitor assembly 15 is comprised by a housing 16 containing a source of illumination 17 and fiber optic bundle 18 having a light-transmitting branch 19 and light-receiving branch 21. The fiber optic bundle has a composite light-transmitting and light receiving end 22 positioned to illuminate and view the markers 14 formed on the rotary scale 13 for serially reading out the number of markers which are caused to scan past the end 22 of fiber optic bundle 18. The light receiving branch 21 of fiber optic bundle 18 is positioned to direct light from the ends 22 onto the photosensitive surface of a photoelectric cell 23, a photo transistor, or some other suitable electro-optical converting device for converting light energy to electric signals. The electric signals produced by the photoelectric cell are shaped and amplified in an amplifying circuit 24 and supplied through an output terminal 25 to a suitable utilization device such as a centrally located, data processing, general purpose digital computer. As will be explained more fully hereinafter, the output signals obtained from the output of amplifier 24 and supplied over output terminal 25 are digital in nature, and hence may be accommodated directly through a dial tone transmitter-receiver link, direct connection, etc. to the input storage of a data processing computer.

The operation of the apparatus shown in FIGS. 1 and 2 as follows. Upon an article to be weighed being placed on the weighing platform 12 of the scales 11, the rotary scale 13 is rotated to an angular position dependent upon the weight of the article placed on the platform 12. The extent of this rotary position may be indicated on a suitable visual scale to a person operating the scale. Simultaneously, the marks 14, the character of which will be described more fully hereinafter, will be scanned past the ends 22 of the fiber optic bundle 18 in monitor assembly 15. The marks 14 may be characteristic coded pattern of light reflecting and nonreflecting stripes such that as the marks 14 are rotated past the end 22 of fiber optic bundle 18, they may be scanned and counted by the monitor assembly. For this purpose, an interrogating light beam is transmitted from the source of illumination 17 that produces a steady state or regulated level of light intensity, through the transmitting fiber optic branch 19 onto the intermixed reflecting and nonreflecting stripes or marks 14. Thus it will be appreciated, that the fiber optic light transmitting branch 19 and the related fiber optic elements in the composite portion of the bundle 18, comprise a first means for directing light from the source of illumination 17 onto the characteristic coded pattern of light reflecting and nonreflecting stripes 14. As the light reflecting stripes 14 pass the end 22 of fiber optic bundle 18, they will reflect pulses of light which are picked up by the receiving end of the light receiving fiber optic branch 21 and transmitted to the photosensitive surface of the photoelectric cell 23 or other light-sensitive, electro-optical converting device. The pulse of light thus transmitted to photoelectric cell 23 will result in producing pulses of electrical current in the output of photocell 23 which are amplified by amplifier 24 and supplied through output terminal 25 to the input of a central data processing computer. Thus, it will be seen that the light receiving branch 21 of the fiber optic bundle functions as a second means for receiving light pulses reflected from the patterns of light reflecting stripes and for directing the received light pulses to the light sensitive surface of an electro-optic converting means comprised by photocell 23. In this manner, the intelligence contained in the coded pattern of intermixed reflecting and nonreflecting stripes or marks 14 is sensed and converted into coded electric output signals representative of the date encoded on the moveable member comprised by rotary scale 13. If desired, the reflecting stripes 14 may be merely counted to arrive at the total weight. Alternatively, the stripes may be arranged in a particular code to form indicia such as binary-coded decimal numbers.

FIG. 3 of the drawings is a partial perspective view of another form of the invention and comprises a conventional electric typewriter, such as an IBM Executive typewriter, which is a keyboard actuated apparatus having a plurality of keys (not shown) for actuating respective printing hammers such as that shown at 27. The printing hammers in typing out a message are moved to a common printing position where they form or print desired characters on a piece of paper installed in the machine by pressing the printing hammer and an inked ribbon against the paper which is backed up by a carriage 26 that moves longitudinally with each actuation of the keys of the typewriter in a well-known manner. An electro-optical monitor assembly 15, similar to that shown in FIG. 2 of the drawings, is mounted adjacent the common printing position of the sending characteristic coded markers (to be described more fully hereinafter) formed on the side of the respective key-actuated printing hammers 27 of the typewriter, as the printing hammers move past the electro-optical monitor 15. The arrangement is such that the electro-optical monitor 15 operates to derive a coded electric output signal which is representative of each of the characters being typed by the typist. The coded electric output signals thus derived may be supplied over a conductor to a centrally located data processing computer. For example, a conventional dial tone transmitter made available commercially by the telephone company to its subscribers, may be used for the purpose of communicating with the centrally located data processing computer. Alternatively, direct connection wiring or other means may be provided for communicating with the centrally located data processing computer. It is assumed that this centrally located data processing computer is a general purpose digital computer capable of receiving, storing and processing electric signals in digital form, and which may be coded in any desired manner such as straight binary, binary coded decimal, etc.

For a more detailed description of the construction and operation of a suitable keyboard-actuated apparatus such as that shown in FIG. 3 and incorporating the above features, reference is made to copending U.S. Pat. application Ser. No. 815,247 (docket HD—5010)—Leonard J. Higgins—inventor, entitled—Keyboard Actuated Apparatus and Attachment for Deriving Coded Electrical Output Signals Representative of Characters to Be Recorded—filed Mar. 14, 1969 concurrently with this application, and assigned to Mechanical Technology, Inc.

For the purpose of the present description, it will be assumed that the electro-optical monitor 15 and the necessary, associated markers attached to each of the printing hammers 27 (as will be described more fully hereinafter), are separate attachments to a conventional, existing typewriter where by reason of the attachment of the assembly, the existing conventional typewriter is converted into a computer input terminal. By reason of the attachment of this assembly, and the associated markers, it will be appreciated that the converted typewriter can be operated as a computer input terminal without requiring any special training on the part of the operator other than that normally required of a typist and perhaps the small amount of competence necessary to set up a dial tone transmitter-telephone connection with a centrally located data processing computer. Accordingly, with such a converted typewriter, as a normal office routine, at the time that a secretary or other record clerk types a personnel time
card, an invoice, a receipt, etc. all that needs to be done in order to simultaneously communicate the data being typed to the central data processing computer, is that the typist dial the computer station on the telephone, and upon being assigned an entry line, place the handset of the telephone on the dial tone transmitter, properly address the computer through the dial tone transmitter and proceed to type in the data to be printed out by the typewriter, and to be recorded simultaneously in the central data processing computer.

As is shown in FIG. 3 of the drawings, the electro-optical monitor 15 is mounted in a position adjacent the common printing tone of the conventional typewriter so that the respective key-actuated printing hammers, such as shown at 27, pass closely adjacent the end of the electro-optical monitor 15. As stated earlier, the electro-optical monitor 15 is similar in construction to the monitor assembly shown in FIG. 2 and the printing hammers 27 are modified to include target flags having characteristic coded patterns of reflecting and nonreflecting areas formed on the sides thereof. As a consequence, each respective printing hammer 27 is caused to move past the end 22 of the electro-optical monitor, they will be interrogated by the monitor, and result in the production of characteristic coded electrical output signals representative of the data encoded in the patterns of reflecting and nonreflecting stripes formed on the sides of the hammers.

Figures illustrating the component of the invention and comprises a striped target flag 29 consisting of a surface bearing intermixed light reflecting 32 and nonreflecting or minimally reflecting stripes 31. The stripes are arranged in a characteristic coded pattern with a certain dimensional mark-space ratio such that simple code sequences (typically in a six-bit binary code sequence) can be dimensionally represented to distinguish the target flag of one printing hammer 27 from the target flag of another printing hammer. The target flag may be fabricated as separate attachments that may be readily secured over the end of a respective key-actuated printing hammer 27 to form the overall arrangement shown in FIG. 4B of the drawings. The target flags 29 may be fabricated from small strips or angles of aluminum foil, or the like, and marked with an appropriate six bit code that establishes a binary relationship between the alpha-numeric character indicated at 33 formed on the face of the printing hammers 27 the electrical output signal. The target flags 29 may be in the form of an inverted U-shaped clip as shown in FIG. 4A, or may comprise a simple strip glued or otherwise affixed to the side of the printing hammers 27. With such an arrangement, the target flags 29 will be prefabricated in a separate, low-cost processing step and made available for attachment to the printing hammers 27 of the typewriter. It is also anticipated that the target flags 29 could be formed on the printing hammers permanently at the time of manufacture or the typewriter should such manner of fabrication be desired.

From a consideration of FIG. 3 of the drawings taken in connection with FIGS. 4A and 4B, it will be appreciated that as the respective printing hammers 27 of the key-actuated typewriter are caused to move past the common printing position, the alternate or intermixed light reflecting and nonreflecting patterns 32 and 31 formed on the side of the printing hammers will produce characteristic coded, electric output signals in the output of the photocell 23 of the electro-optic assembly. These output signals are then amplified by the amplifier 24 and supplied through output terminal 25 to a central data processing computer facility for storage and processing either directly or over a dial tone transmitter, etc.

FIG. 5 of the drawings illustrates in greater detail the format or layout of the alternately striped target flags which are employed in the characteristic form of the patterns on the respective key-actuated printing hammers 27 of the typewriter. This format may be employed whether the target flags are to be separately prefabricated, or permanently formed on the sides of the printing hammers. As shown in FIGS. 5A and 5B, the flags consist of a surface bearing alternating or intermixed light reflecting and nonreflecting or minimally reflecting stripes. The stripes are arranged with a certain dimensional mark-space ratio to provide a desired output binary code sequence (such as a six bit binary code), within the constraints dictated by the dimensional tolerances of the portions of the key-actuated member 27 where the target flag area is formed.

FIG. 5A shows a typical target flag having a sequence of characteristic light reflecting stripes intermixed with nonreflecting or minimally reflecting areas. For this purpose it is desirable to provide separating spaces marked with a little 5 intermediate area or stripe where the presence or absence of a light reflecting surface indicates either a binary "1" or a binary "0" in the conventionally accepted manner. Thus, if the target flag depicted in FIG. 5A is scanned or otherwise read out in the direction of the arrow, the resultant coded electrical output signal developed by the photocell and supplied to the computer for storage and subsequent processing would be a binary coded electrical signal of the form 100111. FIG. 5B of the drawings illustrates a different target flag providing a signal having the binary form 110100. More elaborate and sophisticated code sequences obviously can be readily provided in the same manner, if desired or required. In a particular embodiment of the invention, an overall target flag area such as that depicted in FIG. 5A would have a typical size of about three-eighths of an inch wide and three sixteenths of an inch with the % of inch dimension being divided into 15 regions to form an eight-bit code. With this format, about three one-twentieths or one-fortieth of an inch was required to form a nonreflecting space (s), a binary "0" or a reflecting binary "1" area or stripe, as the case may be, with all of the stripes or areas being equal in dimension. Variations in this format to provide one or two stripe encoding, etc. are believed obvious to one skilled in the art. Similar encoding formats can be employed to form the reflecting markers 14 on the rotary moveable member 13 of the embodiment of the invention shown in FIGS. 1 and 2. A particularly desirable format would employ a binary coded decimal spacing of the reflecting stripes forming different decimal numerals representing different weight values for articles weighed on the scale.

FIG. 6 is a schematic circuit diagram of a suitable photosensitive readout and amplifying circuit useable in connection with the invention to derive desired coded electrical output signals representative of the respective characters or data formed on the side of the target flags. In the circuit arrangement illustrated in FIGS. 6A and 6B, the target flags are perceived as a photocell, phototransistor, photodiode or some other suitable electro-optic converter, is employed. The device 23 is positioned adjacent the output end of the receiving branch 21 of the fiber optic bundle so that light emanating from the end of the receiving fiber optic elements impinges upon the photosensitive surface of the device 23. The device 23 may comprise a field effect phototransistor having a source electrode connected to a source of positive voltage and a drain electrode connected to the base electrode of an NPN amplifying transistor 35. The gate of the phototransistor 23 is connected through a limiting resistor to the tap point 36 of a resistor voltage divider connected across the source of operating potential. The NPN amplifying transistor 35 has its collector connected directly to the positive terminal of the source of operating potential and its emitter connected through a 560 ohm resistor to the common or ground terminal of the operating potential source. A zener diode 37 is connected in series circuit relationship with a dropping resistor across the source of operating potential in order to stabilize the voltage applied to the circuit to a desired voltage value. Output signals developed by the circuit are applied to the collector of transistor 35 and supplied through the output terminal 25 to the central data processing computer, etc.

In operation, light flux from the end of the receiving branch 21 of the fiber optic bundle impinges on the photosensitive surface of the phototransistor 23 to cause a variation in the
current flowing between the source and drain electrodes thereof. The magnitude of this current variation can be adjusted in accordance with the setting of the tap point 36 on the voltage-dividing resistor and the value of the limiting resistor connected between the tap point and the gate electrode of the device. The variation in light flux (which is pulsed in nature due to the alternate reflecting stripes or surfaces of the coded target flag) produces a corresponding pulsed current flowing through the device 23 that is amplified by the transistor amplifier 35, and supplied as a coded, pulsed digital output signal at the output terminal 25 connected to the emitter of transistor 35. It will be appreciated however that the invention is in no way limited to use with the particular sensing and amplifying circuit shown in FIG. 6, and that the circuit is merely typical of a suitable arrangement for deriving the desired coded electric output signal from any of the optical sensors previously described.

While it is anticipated that the photoelectric cells, semiconductor phototransistors, photodiodes, or other suitable light sensitive devices such as 23 will be designed to respond to visible light, the invention is in no way restricted to the use of visible light. For certain applications, it may be desirable to employ either infrared or ultraviolet light in sensing and reading out the characteristic coded patterns on the target flags in accordance with the invention. Accordingly, appropriate modification of the electrical monitoring circuitry would be made to adapt the device to different forms of radiant energy, is believed obvious to those skilled in the art. Should it be desired, a fluorescent substance could be printed or painted on the sides of the moveable members 27 to form the coded target flags or patterns. The patterns thus encoded could then be illuminated and read out from an ultraviolet light source. While this technique would not necessarily be superior to the techniques previously described employing visible light, such an arrangement would be appropriate where it is desired to keep the encoding on the respective moveable members secret as in cyphering applications. Such a readout arrangement when employed in conjunction with readily removable or detachable target flags or patterns such as those described with relation to FIGS. 4A and 4B whereby the target flags are readily replaceable, makes possible the application of the invention in encrypting operations involving the transmission and processing of secret messages or records.

FIG. 7 of the drawings illustrates two diagrammatic views of alternative optical systems for use in reading out the coded patterns of alternate light reflecting and nonreflecting stripes on the target flags that are attached to the moveable members being monitored. In FIG. 7A the alternating reflecting stripes 32 are illuminated from a source of illumination either directly or through a suitable fiber optic bundle and suitable focusing lens arrangement 41 for producing a finely focused spot of interrogating light as shown at 42 that can be contained within the width of the reflecting stripes 32 and/or the width of the non or minimally reflecting binary "0" or "1" stripes. The spot 42 illuminated by the light-transmitting lens 41 is viewed by the end of a fiber optic readout bundle 21 whose output end is directed onto the photosensitive surface of a photoelectric cell 23 in the previously described manner. The dotted outline circle shown at 43 illustrates the general area viewed by the fiber optical readout branch 21. This circle 73 also depicts the general area of illumination that would be produced by a fiber optical transmitting branch, such as that shown at 19 in FIG. 2, should such a fiber optic light transmitting branch be employed in place of the focusing lens arrangement 41.

As a result of the use of the focusing lens arrangement 41, an improved output signal can be obtained from the photoelectric cell 23 having a greatly improved signal to noise ratio. This improved signal to noise ratio is depicted in FIG. 7C of the drawings wherein the solid waveform signal (shown at 44) depicts the nature of the coded electric output signal obtained from photoelectric cell 23 where both fiber optic light-transmitting and fiber optic light-receiving branches are employed in a monitor assembly such as that shown in FIG. 2. The signal waveform depicted by the dotted line graph 45 illustrates the comparable output signal obtained if the optical system shown in FIG. 7A is used in employing a focusing lens 41. This improved output signal is obtained by reason of the fact that substantially all of the light will be reflected into the end of the fiber optic receiving branch 21. From a comparison of the finely focused, interrogating light spot 42 to the more diffused, enlarged spot 43 (which would be produced by a complete interrogating fiber optic light system using a fiber optic light-transmitting branch) it will be appreciated that considerably more light will be reflected into the end of the light-receiving branch 21 from the finely focused spot 42 than would be the case with the more diffused spot 43. This increased reflected light flux results in more sharply defined and intense received light pulses that in turn produce the improved output signal pulses such as those shown at 45 having a greatly improved signal to noise ratio.

FIG. 7B is a schematic diagram of the modifications of the electro-optical readout monitor assembly using a source of illumination 17, a focusing lens 41 for focusing light from source 17 into a finely focused interrogating light spot 42 that is then read out by a light-receiving lens assembly shown generally at 46 for focusing received, reflected light pulses from spots such as 42. The light from the photoelectric cell 23 either directly or through a fiber optic bundle. With an optical system such as shown in FIG. 7B, substantially the same or perhaps better signal-to-noise ratios can be obtained than those obtained with the arrangement of FIG. 7A.

FIG. 8 is a schematic diagram of a double-sided, fiber optic monitor or sensor that may be used with advantage in connection with apparatus such as the embodiment of the invention shown in FIGS. 3-7. The dual sided, fiber optic monitor shown in FIG. 8 is designed to position composite transmit-interrogate and light-receiving branches 22A and 22B on both sides of a moveable member 27 (such as the printing hammer of a typewriter) and on which suitable coded target flags are formed on at least two sides thereof in the manner described with relation to FIGS. 4 and 5. Each of the fiber optic branches 22A and 22B comprise a part of the fiber optic bundle 18 having a pair of parallel light-transmitting branches 19A and 19B, and a pair of parallel light-receiving branches 21A and 21B.

The ends of the parallel light-transmitting branches 19A and 19B are positioned opposite a source of illumination 17 for transmitting light from this source through the several light-transmitting branches through the source through the several light-transmitting fiber optic elements that comprise the respective branches 19A and 19B as well as the branches 22A and 22B to illuminate the target flag on both sides of the moveable member 27. Light reflected from the coded pattern of light-reflecting stripes is gathered by the light-receiving fiber optic elements comprising part of the branches 22A, 22B and the light-receiving branches 21A and 21B, and transmitted through the respective light-receiving fiber optic elements to the photosensitive surface of the photoelectric cell 23. From a consideration of FIG. 8, it will be appreciated that both sides of the coded patterns of reflecting stripes on the moveable member 27 are read out in parallel, but that each individual side is read out serially. As a result, a considerably improved signal to noise ratio is obtained, and any variation in signal level due to lateral misalignment of the moveable member 27 is minimized. This latter feature is due to the fact that if the moveable member 27 due to lateral misalignment moves further away from one of the branches such as 22A thereby weakening its pulses light output, it will come closer to the remaining branch 22B thereby strengthening its light output so that the composite effect on the output signal developed by the photocell tend to compensate each other.

FIG. 9 of the drawings is a partially broken away, perspective view of an auxiliary signal generator for generating aux-
iliary instruction signals that can be used in a variety of situations. For example, such an auxiliary signal generator could comprise a low cost desk calculator or it could be employed with a typewriter that has been adapted in accordance with the embodiment of the invention shown in FIG. 3 to provide auxiliary instructions to a central data processing computer such as end of message characters, block instructions, end of record characters, start of paragraph, end of paragraph, and the like. This can be accomplished with the auxiliary signal generator shown in FIG. 9 without the need for an operator to memorize special code character sequences. The auxiliary signal generator is controlled by a plurality of push buttons or keys 51 supported on a housing 52 by means of return springs 53 and suitable bearing supports (not shown). The respective keys 51 are connected through a reciprocally moveable shaft member 54 to a target flag 55 having a characteristic coded pattern of intermixed light reflecting and non-reflecting or minimally reflecting stripes formed thereon by any of the previously described techniques. The reciprocally moveable target flags 55 are illuminated with an interrogating light beam and viewed by a fiber optic branch 56 having transmit and receive subbranches 56A and 56B, respectively. If desired, the fiber optic branch 56 and its associated transmit and receive subbranches may comprise an auxiliary branch of a main fiber optic bundle employed with a monitor of the type shown in FIG. 3 of the drawings. Each of the respective auxiliary function signal generator push buttons or keys 51 will be provided with similar optical readout arrangements for reading out the particular auxiliary instruction message encoded thereon.

If the auxiliary signal generator shown in FIG. 9 is employed as an auxiliary instruction signal generator to be used in conjunction with a typewriter modified in the manner shown in FIG. 3 of the drawings, it is possible for a typist as he or she is typing a message on a conventional typewriter modified in accordance with the invention merely to depress an appropriate push button or key 51 that is properly identified as the beginning of a new paragraph, end of a paragraph, etc. wherever such auxiliary instructions are desired. Upon the depression of the appropriate push button 51, its associated target flag 55 will be scanned by its respective fiber optic readout branch 56, and will generate the desired characteristic coded message that can be supplied to a centrally located data processing computer along with the message being typed to indicate any of the above-mentioned auxiliary instructions.

It should be noted that with respect to the auxiliary signal generator shown in FIG. 9, or an apparatus having a reciprocally moveable member such as the modified or adapted typewriter shown in FIG. 3, the encoded electrical output signal can be derived and transmitted either at the time that the key is depressed, or upon its release, or on both occasions (i.e. either or both forward and return reading is possible). In the event that electrical signal encoding is desired in only one direction, the encoding may be provided in either the forward or return direction, with the message being blanked in the opposite direction of movement. A certain improvement in operation may be achieved by incorporating blanking into a monitor amplifier such as shown in FIG. 6, or alternatively by appropriately programming the central data processing computer such that the encoded output signal pulses are gated through only the moveable member, such as the typewriter printing hammer 27, or target flag 55, or other monitored part travelling in the "go" or "printing" direction. The arrangement would be such that transmission of the encoded output signal with the member travelling in the "return" direction is suppressed. Although the "return" transmission of the encoded signal is suppressed, it may be desirable to provide a local control unit incorporating a bit counter (not shown) or some other equivalent known comparison means for coded signal bit character comparison purposes. With such arrangement, the bit characters generated by the moveable member or other monitored part travelling in the "go" or "printing" direction can be compared to the bit characters read in the reverse or "return" direction for read verification or parity check purposes.

FIG. 10 of the drawings illustrates the novel electro-optical encoding arrangement applied to a measuring instrument for measuring the strength of compression springs such as are shown at 61 in FIG. 10. Springs 61 to be tested and classified after manufacture may be injected into one branch 62 of a housing 63 by means of an automatic spring conveying or feeding mechanism (not shown) which may be arranged on the output of a spring forming machine. Following introduction of a spring 61 to be tested into the Y-branch 62, the spring will drop down into the bottom portion 64 of the housing 63 due to gravity where it will be retained by a slideable closure member 65. A reciprocally moveable compression member 66 is supported in a second branch 67 of housing 63 so that it is linearly aligned with the bottom portion 64 of the housing into which the spring 61 to be tested drops. The compression member 66 is reciprocally moveable to the dotted line position by a suitable fixed force drive mechanism (not shown) and includes a longitudinally arranged pattern of characteristic markers 67 formed along its length. The markers 67 may be formed on the compression member 66 by any of the techniques previously described, and may include an interrogated pattern of light reflecting and nonreflecting surface areas or stripes. The characteristic pattern of light reflecting stripes is viewed by an electro-optical monitor assembly 15 similar to that shown in FIG. 2 of the drawings through a window 68 formed in the side of the housing 63.

In operation, following the introduction of a compression spring 61 into the housing 63, the compression member 66 is caused to be moved downward to the dotted line position shown in FIG. 10 with a known force. Upon this occasion, it will compress the spring 61 being tested to a degree determined by the strength of the spring. The strength of the spring hence will determine the extent to which a longitudinally extending pattern of light reflecting markers is scanned past an interrogating end of the electro-optical monitor assembly 15. As a consequence, the electro-optical monitor will derive at its output terminal, encoded electrical output signals representative of the strength of the spring as determined by the number of characteristic markers read out from the coded pattern 67. During the return movement of the compression member 66 to its raised position shown in FIG. 10, the bottom slide 65 is open, drop out a spring 61 previously tested, and then close to adapt the housing to receive the next spring to be tested. It will be appreciated, however, that by appropriately serially encoding the marks longitudinally formed on the compression member 66, a characteristic, serially coded electric output signal will be derived which is representative of the compression strength of a particular spring under test. The encoded output signal thus derived through the use of appropriate logic circuitry can be employed to actuate suitable handling equipment subsequent to the measuring instrument shown in FIG. 10 to appropriately classify, package, label, etc. each of the respective compression springs.

From the foregoing description, it will be appreciated that all of the embodiments of the invention disclosed use the basic scheme of a moveable member appropriately encoded with a characteristic pattern of intermixed light reflecting and non-reflecting surface areas or stripes which is interrogated and electrically read out serially by means of an electro-optical assembly. All of the arrangements are such that the alignment of the interrogating electro-optical readout assembly with the respective moveable member is not critical, but nevertheless provides reliable electrical encoding of the identity, extent of movement, etc. of a moveable member being monitored. The invention may be designed so that it is easily attached to and detached from an apparatus to be adapted for electrical encoding, or it may be permanently incorporated into the equipment at the time of original manufacture. The novel encoding device herein proposed is superior in the manner of positional tolerance, the ability to interrogate from one side or the other of a moveable member, or from both sides of the member.
the use of appropriately encoded reflecting surface areas, the need for piercing of the moveable member which would result in structurally weakening such member, is avoided. By the use of a fiber optic bundle in the fabrication of the electro-optical monitoring assembly, the monitor assembly may be more readily accommodated into existing equipment, and reflector signal encoding can be accomplished with less complexity of apparatus. Further, the characteristic marking target flags employed in conjunction with the fiber optical monitor assembly can be made precisely and at low cost using known photographic and etching, printing or plating techniques. Additionally, the use of the fiber optic sensor allows the associated light source, photoelectric cell, amplifier, and other signal processing circuitry all to be located remotely from the generally critical monitoring or readout position for a moveable member to be monitored. This is achieved without any substantial sacrifice in performance since the fiber optic bundle may be easily intertwined into and around obstacles in being led from the locality of the critical readout or monitoring position to a less critical area where the other components of the signal processing circuitry can be mounted.

It will be appreciated therefore that various combinations of the above-described encoding and electro-optical monitoring arrangements may be used economically to gather a wide variety of data using any desired data code system for deriving a serially encoded electrical output signal representative of the movement of a particular member, the extent of movement of the member, etc. where appropriately coded target flags or surface areas are affixed or otherwise formed on the moveable member at a location where it can be easily monitored. It should be kept in mind that the invention is not limited to the modification of existing equipment, but that an important aspect of the invention is the original inclusion in such equipment of a series of printed, embossed, plated, etched or otherwise formed stripes coded in a pattern to comprise a target flag on the side of a moveable member which then readily can be read out in the manner described. Additionally, it should be noted that for best performance the use of an interrogating light beam is preferred. However, under certain circumstances, the ambient lighting conditions may permit the use of a "receiving only" encoding arrangement wherein the area of the target flag is generally illuminated by the ambient lighting conditions. Such a "receiving only" arrangement will have a poorer signal to noise ratio than the preferred embodiment; however, for certain applications it may be adequate.

From the foregoing description it will be appreciated that the invention provides a new and improved electro-optical encoding device which is relatively simple in construction, low cost, reliable in operation, and which easily may be employed in conjunction with a physically moveable member to derive a serially encoded characteristic electric output signal representative of the fact of movement of a particular member, the extent of movement of the member, etc.

Having described several embodiments of a new and improved electro-optical encoding device constructed in accordance with the invention, it is believed obvious that other modifications and variations of the invention are possible in the light of the above teachings. It is therefore to be understood that changes may be made in the particular embodiments of the invention described which are within the full intended scope of the invention as defined by the appended claims.

What is claimed is:

1. A new and improved electro-optical encoding device comprising a plurality of individually moveable members each having disposed thereon a characteristic coded pattern of intermittent light reflecting and nonreflecting stripes representative of data to be electrically encoded, electro-optical monitoring means positioned adjacent the coded moveable members for serially illuminating the coded patterns of light reflecting and nonreflecting stripes with an interrogating light beam as the member moves past the electro-optical monitoring means, and for serially receiving back pulses of light returned by the coded patterns of light-reflecting stripes are deriving serially coded electrical output signals therefrom representative of the data encoded on the moveable members, said electro-optical monitoring means comprising a common source of illumination, fibert optical light transmitting means having multiple branch paths for directing light from said common source of illumination onto the characteristic coded patterns of light reflecting and nonreflecting stripes of the respective moveable members, second fiber optic light receiving means having multiple branch paths for receiving light pulses reflected from the patterns of light reflecting stripes on the respective members and directing the received light pulses to a common readout source and a single electro-optic converting element located at the common readout point and having the light output from the second fiber optic light receiving means directed thereon for converting the intelligence contained in the received pulses of reflected light into coded electrical signals representative of the data encoded on the moveable members.

2. An encoding device according to claim 1 further including focusing lens means for focusing light directed upon or emanating from the patterns of light-reflecting stripes into finely focused intense light beams.

3. An encoding device according to claim 1 wherein the first fiber optic light transmitting means comprises a plurality of light-transmitting fiber optic branches having one end positioned adjacent the common source of illumination and a remaining end positioned adjacent the path of a respective moveable member for transmitting light from the source and directing an interrogating light beam against the moveable member as the pattern of reflecting stripes is serially moved past, and wherein the second fiber optic light transmitting means comprises a plurality of light receiving branches having one end positioned adjacent the path of a respective moveable member in the vicinity of the interrogating light beam produced by the associated light transmitting fiber optic branch and having a remaining end positioned to direct light pulses received from the pattern of reflecting stripes onto the light sensitive surface of the single common electro-optic converting element.

4. An encoding device according to claim 3 wherein the moveable member moves past the electro-optical converting element twice in a forward and return motion whereby the coded electrical output signal derived during the forward motion may be compared to the coded electrical output signal derived during the return motion for parity check purposes.

5. An encoding device according to claim 4 further including focusing lens means for focusing light directed upon or emanating from the patterns of light-reflecting stripes into finely focused intense light beams.

6. An encoding device according to claim 1 wherein the moveable members have similar coded patterns of reflecting stripes formed on at least two sides thereof and the fiber optic branches comprise dual fiber optic light-transmitting branches and dual fiber optic light-receiving branches for illuminating and receiving back reflected light pulses from each of the sides of the moveable members, the light-receiving branches being directed in common to the light sensitive surface of the single common electro-optic converting element.

7. An encoding device according to claim 1 wherein the moveable members move past the electro-optical monitoring means twice in a forward and return motion whereby the coded electrical output signal derived during the forward motion may be compared to the coded electrical output signal derived during the return motion for parity check purposes.

8. An encoding device according to claim 1 wherein the pattern of light reflecting and nonreflecting stripes is permanently formed on the moveable members.

9. An encoding device according to claim 1 wherein the pattern of light reflecting and nonreflecting stripes is formed on a detachable target flag that may be readily secured to the moveable members for encoding and readout purposes.
10. A keyboard-actuated apparatus for deriving coded electrical output signals characteristic of the individual characters and markings represented by the several keys of the apparatus and including a plurality of keys for causing physical movement of respective key actuated members past respective readout zones associated with each key actuated member upon the respective keys thereof being actuated, characteristic coded patterns of light reflecting and nonreflecting stripes formed on portions of each key actuated member that moves past the readout zone, a common source of illumination, first fiber optic light transmitting means having multiple branch paths for directing light from said common source of illumination to the respective readout zones for illuminating the characteristic coded patterns of light reflecting and nonreflecting stripes, second fiber optic light receiving means having multiple branch paths for receiving light pulses from the patterns of light-reflecting strips on the respective key actuated members and directing the received light pulses to a common readout point, and common electro-optic converting means located at the common readout point and having the light output from the second fiber optic light receiving means directed thereon for converting the intelligence contained in the received pulses of reflected light into coded electrical signals representative of the individual characters and markings represented by the several keys of the apparatus.

11. An encoding device according to claim 10 further including focusing lens means for focusing light directed upon or emanating from the patterns of light reflecting stripes into finely focused intense light beams.

12. An encoding device according to claim 10 wherein the moveable members move past the electro-optical monitoring means twice in a forward and return motion whereby the coded electrical output signal derived during the forward motion may be compared to coded electrical output signal derived during the return motion for parity check purposes.

13. An encoding device according to claim 10 wherein the pattern of light reflecting and nonreflecting stripes is permanently formed on the moveable members.

14. An encoding device according to claim 10 wherein the pattern of light reflecting and nonreflecting stripes is formed on a detachable target flat that may be readily secured to the moveable members for encoding and readout purposes.