RADIATION SENSITIVE POSITION ENCODER USING CODED DISCS

Original Filed Dec. 15, 1967 3 Sheets-Sheet 1

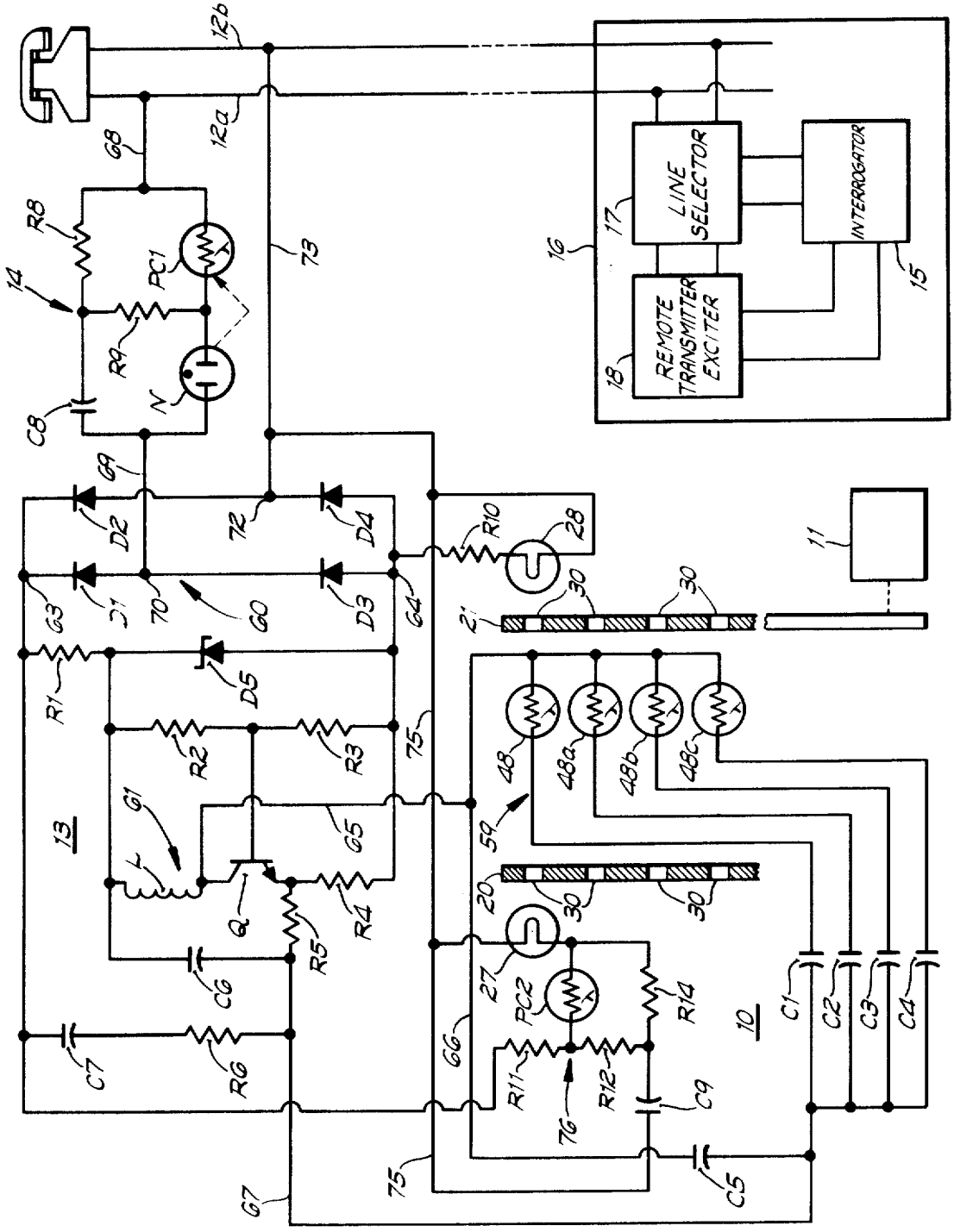


Fig. 1

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RADIATION SENSITIVE POSITION ENCODER USING CODED DISCS

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Fig. 2

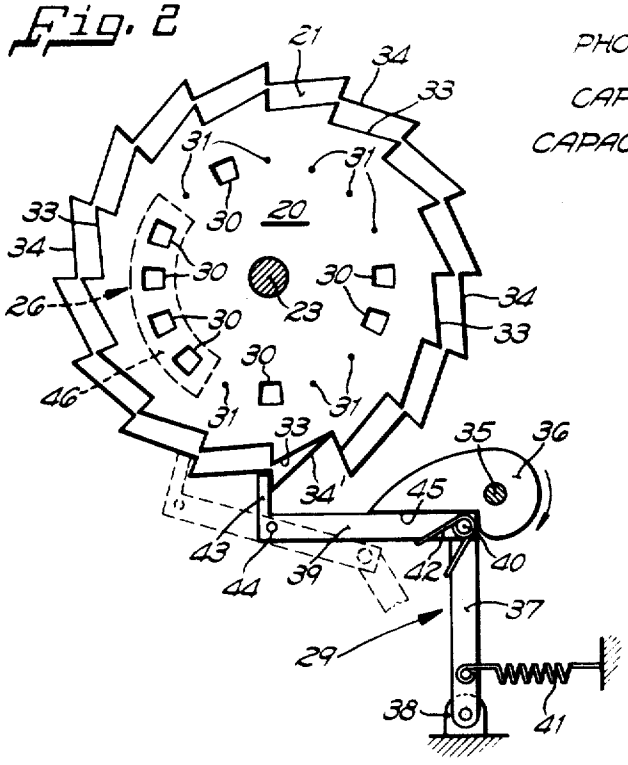


Fig. 7

PHOTOCELL	48c	48b	48a	48	TOTAL CAPACITANCE mf
CAPACITOR	C4	C3	C2	C1	
CAPACITANCE	.8	.4	.2	.1	
POS.	BINARY CODE				
1	□	□	□	□	1.5
2	□	□	□	•	1.4
3	□	□	•	□	1.3
4	□	•	□	•	1.0
5	•	□	•	•	.4
6	□	•	•	•	.8
7	•	•	•	•	.0
8	•	•	•	□	.1
9	•	•	□	□	.3
10	•	□	□	•	.6
11	□	□	•	•	1.2
12	□	•	•	□	.9
13	•	•	□	•	.2
14	•	□	•	□	.5
15	□	•	□	□	1.1
16	•	□	□	□	.7

Fig. 3

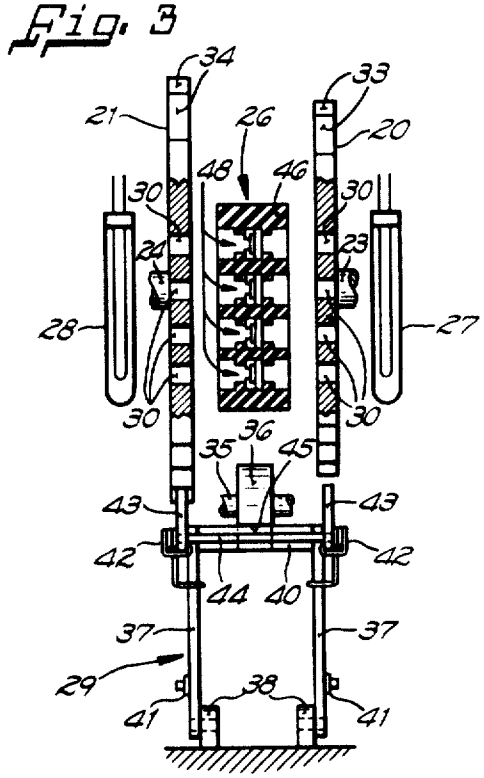
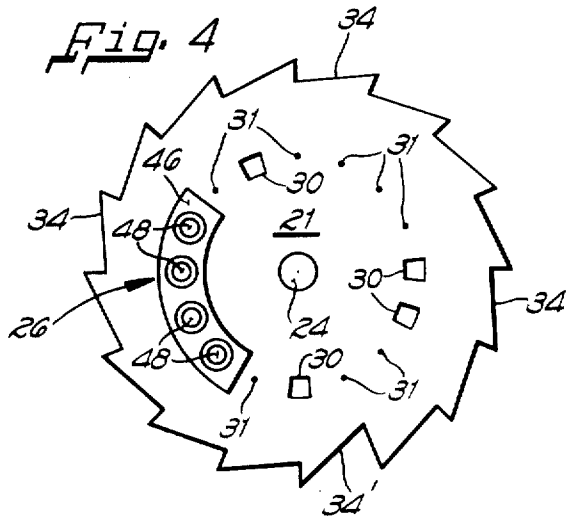


Fig. 4



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RADIATION SENSITIVE POSITION ENCODER USING CODED DISCS

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Fig. 5

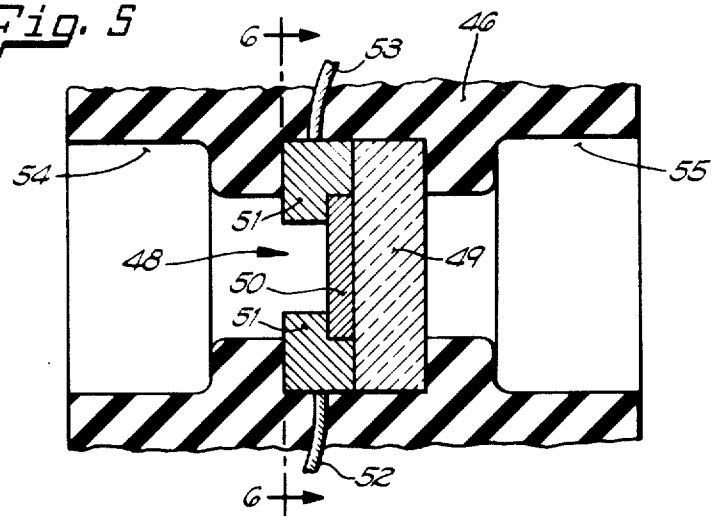
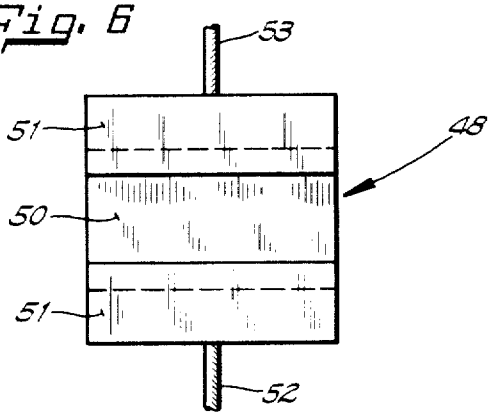


Fig. 6



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RADIATION SENSITIVE POSITION ENCODER USING CODED DISCS

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Int. Cl. G01n *21/30;* H01j *39/12*

U.S. Cl. 250—219 DD 13 Claims

Matter enclosed in heavy brackets [ ] appears in the original patent but forms no part of this reissue specification; matter printed in italics indicates the additions made by reissue.

ABSTRACT OF THE DISCLOSURE

A position encoder for use in an automatic remote meter reading system and including a pair of coded discs disposed in a parallel relation and each having an array of position coding elements. A plurality of photocells are disposed between the discs and are arranged to be selectively energized from their opposite sides by individual illuminating means associated with each disc. The presence or absence of illumination on each photocell is operative to modify the parameters of an oscillating circuit so that a different tone signal will be provided to an interrogator for each position of the coded discs.

BACKGROUND OF THE INVENTION

This invention relates to an encoding device and, more particularly, to a device for converting an analog quantity representing the position of the shaft or other movable member into a digital quantity for transmission to a remote location. The invention has particular, but not exclusive, application to systems for the automatic remote reading of utility meters from a control station.

Utility meters, such as electric, gas and water meters, are generally widely distributed at the customers' points of useage. It is the present practice in the reading of such meters for a meter reader to visit each customer's site and to observe and record the registration on each unit. While there have been a large number of proposals for the automatic reading of such meters from a remote location, they have not been commercially adapted because of their high cost and because they could not meet the limitations imposed by existing utility meters and communication systems. Such limitations include the relatively confined space available for encoding devices in utility metering equipment presently installed.

It is an object of the invention to provide an economical encoding and signal transmitting assembly.

Another object of the invention is to provide an encoding and transmitting device which may be incorporated into relatively confined space.

These and other objects and advantages of the invention will become apparent from the description of the preferred embodiment hereinbelow.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 shows a remote meter reading system incorporating the encoder and transmitter, according to the instant invention;

FIGS. 2, 3 and 4 illustrate the coded disc portion of the encoding device according to the instant invention;

FIG. 5 illustrates a bi-directional, photosensitive device useable in the encoder illustrated in FIGS. 2 and 3;

FIG. 6 is a view taken along lines **6—6** of FIG. 5; and

FIG. 7 is a table illustrating an example of the binary code produced by the coded discs shown in FIGS. 3, 4 and 5.

DESCRIPTION OF THE PREFERRED EMBODIMENT

FIG. 1 shows an automatic remote meter reading system in which an encoder **10**, according to the instant invention, may be employed. The encoder **10** may be suitably coupled to the meter **11** which is to be read and to the customers' telephone lines **12a** and **12b** through a transponder **13** and a line coupler **14**. An interrogator **15** at the telephone exchange **16** is coupled to the lines **12a** and **12b** through a line selector **17**, a remote transmitter exciter **18** and the telephone network, not shown.

The details of the meter **11**, the interrogator **15**, the line selector **17** and the remote transmitter exciter **18** form no part of the instant invention and, accordingly, will not be discussed in detail. It is sufficent for purposes of understanding the instant invention to note that when it is desired to read the meter **11**, the interrogater **15** is actuated and in turn actuates the line selector **17** and the remote transmitter exciter **18**. The line selector **17** couples the interrogator **15** and the remote transmitter exciter **18** to the particular customer's lines **12a** and **12b**. The remote transmitter exciter **18** then sends a signal through the lines **12a** and **12b** which actuates the line coupler **14** whereby the encoder **10** and the transponder **13** are actuated and coupled to the lines **12a** and **12b**. The encoder **10** provides the coded information corresponding to the registration of meter **11** to the transponder **13** which, in turn, transmits the information to the interrogator **15**. The transponder **13** may take the form of an oscillator, and the encoder may change the parameters of the oscillating circuit as a function of the meter registration, whereby tone signals will be placed on the line **12a** and **12b** in accordance with the reading of meter **11**.

FIGS. 2 and 3 show the encoding device **10** in greater detail to include a pair of coded discs **20** and **21** which are respectively mounted for rotation about central shafts **23** and **24**, a sensor assembly **26**, a pair of lamps **27** and **28** and a drive assembly **29** for coupling the discs **20** and **21** to the meter being read.

The discs **20** and **21** are provided with an array of coding units, one coding unit being provided for each disc position. In the illustrated embodiment, wherein each of the discs **20** and **21** has sixteen positions, sixteen coding units are provided on each disc. Also, where the sensor assembly **26** is photosensitive, the coding units comprise transparent positions or holes **30** and opaque or unperforated positions **31**. As seen in FIG. 2, the coding units **30** and **31** are arranged on the disc **20** in a substantially equally spaced circular array. A similar array of coding units **30** and **31** are arranged on the disc **21**. As will be pointed out more fully hereinbelow, the arrangement of holes **30** and unperforated positions **31** are such that, when used with at least a four-unit sensor assembly **26**, an unambiguous code will be provided for each of the sixteen positions of the discs **20** and **21**.

In addition, the outer periphery of each of the discs **20** and **21** may be provided with sixteen teeth **33** and **34**, respectively, which are cooperatively engageable by the drive assembly **29**. One of the teeth **33** and **34** may be disposed adjacent each of the coding units **30** and **31** on their respective discs **20** and **21**.

The drive assembly **29** includes a scroll cam member **36** which is fixed to a shaft **35** coupled to the meter being read.

The cam **36** cooperatively engages a pawl assembly for stepping the discs **20** and **21** and which comprises a first pair of parallel links **37** having one end pinned at fixed pivot point **38** and a second pair of links **39** pivotally

coupled to the other end of links **38** by knee pin **40**. Springs **41** hold pin **40** in resilient engagement with the cam **36** and sprangs **42** tend to produce clockwise rotation of links **39** to urge fingers **43** carried by their free ends into engagement with the teeth **33** and **34** on discs **20** and **21**.

The diameter of the disc **21** is sufficiently greater than that of the disc **20** so that the radially outward extremity of disc **20** does not extend to the innermost portion of the teeth **34**. As a result, one of the fingers **43** will engage the teeth **34** on disc **21** but the other finger **43** will normally be held out of engagement with the teeth **33** of disc **20** by a pin **45** which couples the ends of links **39**. However, one of the teeth **34** and the disc **21**, and designated **34'**, is deeper than the remaining teeth so that the teeth **33** on disc **20** will extend past its inner extremity.

As those skilled in the art will appreciate, the cam member **36** may be coupled to the meter **11** by a gear drive (not shown) in such a manner that the cam member **36** will make one revolution for each of a predetermined number of revolutions in the meter assembly (not shown). As the cam member **36** rotates clockwise, as seen in FIG. 2, the links **37** and **39** are moved from their full to their phantom position wherein the finger **43** will move into engagement with the succeeding ones of the teeth **34** on disc **21**. As the cam member **36** completes one revolution, wherein its flat portion **45** is moved into engagement with the pin **40**, the spring **41** will rapidly return links **37** and **39** to their full position, thereby moving the disc **21** one position in the counterclockwise direction. The disc **20** will remain stationary, however, because the other finger **43** will be held out of engagement with its teeth **33** by the larger outer periphery of the disc **21** and the pin **44**.

After the disc **21** has completed one revolution wherein the tooth **34'** is in a position to be engaged by the one finger **43**, the greater depth of tooth **34'** will allow engagement between the other finger **43** and one of the teeth of the disc **20**. In this manner, the disc **20** will be moved one position for each complete revolution of the disc **21**.

As seen in FIGS. 2, 3 and 4, the sensor assembly **26** may comprise an opaque arcuate head **46** which is disposed between the discs **20** and **21** and in close parallelism thereto. When sixteen-position discs are provided, the sensor assembly **26** includes at least four sensor units **48**, **48**a, **48**b and **48**c, which may be spaced along the arcuate head **46** at the same distance as that between the coding units **30** and **31**.

Because each of the sensor units **48**, **48**a, **48**b and **48**c are identical, only unit **48** will be discussed in detail. As seen more particularly in FIG. 5, sensor unit **48** is shown to include a substrate **49** of a transparent material, such as glass, and a photosensitive layer **50**, such as cadmium sulphide deposited on one side of the glass substrate **49**. As those skilled in the art will appreciate, cadmium sulfide is a material normally having a high resistance and which changes to a low resistance state upon being illuminated. The photosensitive layer **50** may be disposed on a central portion of the glass substrate **49**, and the upper and lower ends thereof are connected to conductive electrode members **51** for placing the photosensitive material **50** in circuit with conductors **52** and **53**. The opposite sides of the sensor unit **48** are exposed through a pair of apertures **54** and **55** provided in the sensor head **49**.

Because the sensor units **48**–**48**c comprise a photosensitive material **50** deposited on a transparent substrate **49**, they can be illuminated from either direction and, accordingly, a single sensor assembly **26** may be disposed between the discs **20** for sensing the position of each.

Each of the sensor units **48**–**48**c is arranged so that for each position of the discs **20** and **21** one of the sensor units will face one of the coding units **30** or **31** in each

of the discs **20** and **21**. The lamps **27** and **28** are disposed adjacent the outer surfaces of each of the discs **20** and **21** and in an opposed relation to the sensor assembly **26**. As will be pointed out more fully hereinbelow, the lamps **27** and **28** are connected to be sequentially energized so that the sensor units **48**–**48**c will be selectively energized through the holes **30** in the disc **20** by light emitted from the lamp **27** and then from the opposite side through holes **30** in the disc **21** by light emitted from the lamp **28**. The position code for the disc **20** will be determined by which ones of the sensor units **48**–**48**c are energized when the lamp **27** is lit and, similarly, the position code for the disc **21** will be determined by which ones of the sensor units **48**–**48**c are illuminated when the lamp **28** is lit. It will be understood that only those sensor units **48**–**48**c which are opposite a hole **30** in the appropriate one of the discs **20** or **21** will be illuminated, while those adjacent an unperforated position will remain unenergized.

The holes **30** are shown in FIGS. 2 and 4 to be configured with sides that are generally parallel to those of any immediately adjacent hole. This provides greater optical isolation between adjacent ones of the sensor units **48**–**48**c than would be possible with circular holes of substantially the same area.

If the position of the discs **20**, as shown in FIGS. 2, 3 and 4 is taken as a first position, each of the photosensitive units **48**–**48***c* will be illuminated when the lamps **27** and **28** are lit. As the discs **20** and **21** are stepped counterclockwise through each of their sixteen positions, a different arrangement of photosensitive units **48**–**48**c will be illuminated to provide the sixteen position unambiguous code shown in FIG. 7.

Reference is again made to FIG. 1 which illustrates how the sensor units are coupled to the transponder **13**. More specifically, the sensor units **48**, **48**a, **48**b and **48**c are respectively connected in series with capacitors **C1**, **C2**, **C3** and **C4**, and the series combinations are connected in parallel with each other and with a capacitor **C5**. As will become more apparent hereinbelow, the sensor units **48**–**48**c and the capacitors C1–C4 comprise a capacitive incrementing circuit **59** with respect to capacitor **C5**.

The transponder **13** may include a diode bridge **60** and an oscillator circuit **61**. The diode bridge consists of diodes **D1**, **D2**, **D3** and **D4** which are connected between the oscillating circuit **61** and the encoder **10** on the one hand, and the coupling circuit **14** on the other. When the coupling circuit **14** is active, a D.C. voltage will be supplied to the output terminals **63** and **64** of the diode bridge **60**. A Zener diode **D5** and a resistor **R1** may be connected in series across the conductors **63** and **64** for providing a voltage source for the oscillator **61**.

Oscillator **61** includes an amplifier comprising a transistor Q and a first pair of resistors **R2** and **R3** which are connected in series across Zener diode **D5** and their junction connected to the base of transistor Q and a third resistor **R4** which is connected between the emitter of Q and terminal **64**. Oscillator **61** also includes a Colpitts feedback circuit consisting of an inductance L connected between the collector of Q and the other terminal of resistor **R2**, and a first capacitor **C6** connected between the other terminal of inductor L and by resistor **R5** to the emitter of transistor Q. Capacitor **C5** constitutes a second capacitance in the Colpitts feedback circuit and is connected by conductors **65**, **66** and **67** and resistor **R4** between the emitter and collector of transistor Q.

The transponder **13** also includes a resistor **R6** and a capacitor **C7** which are connected in series between the terminal **63** and resistor **R4**. Capacitor **C7** functions to decouple the emitter of Q from terminal **63**, and **R6** desensitizes the oscillator output frequency to changes in the impedance of the lines **12**a and **12**b.

The coupling circuit **14** includes a photocell **PC1** and a neon lamp N which are connected in series with each

other and by conductors **68** and **69** between one of the customer lines **12a** and one input terminal **70** of the diode bridge **60**. The coupling circuit also includes a resistor **R8** and a capacitor **C8** which are connected in series with each other between conductors **68** and **69**. A second resistor **R9** connects the junction between resistor **R7** and capacitor **C8** and that between photocell **PC1** and the neon lamp N. The other terminal **72** of the diode bridge **60** is connected by conductor **73** to the other one of the customer lines **12b**.

The normal telephone central office battery voltage applied to the lines **12a** and **12b**, which is in the order of 48 volts, D.C., is insufficient to fire the neon lamp N so that the coupling circuit **14** is normally inactive and conductors **68** and **69** are effectively open circuited. High dialing and ringing peak voltages, which may be in the order of 400 volts, are of insufficient duration to cause operation of the coupling circuit **14**.

When the remote transmitter exciter **18** is actuated, however, a voltage of approximately 200 volts is applied between the lines **12a** and **12b**. As a result, sufficient charge will accumulate in capacitor **C8** to break down neon lamp N, causing the latter to illuminate the photocell **PC1**. This, in turn, causes the photocell **PC1** to go from a high impedance state to a low impedance state, thereby connecting the conductors **68** and **69**. As long as the input voltage signal is greater than the lamp breakdown voltage, lamp N will remain illuminated so that coupling circuit **14** will, in effect, remain latched in its conductive, or active, state.

The lamps **27** and **28** have a common terminal connected by conductor **75** to conductor **73**. In addition, the other terminal of lamp **28** is connected to bridge output terminal **64** by resistor **R10**, and the other terminal of lamp **27** is connected to bridge output terminal **63** through an RC time delay circuit **76**. The latter circuit includes resistors **R11** and **R12** and capacitor **C9** which are connected in series between diode bridge terminal **63** and conductor **75**. In addition, resistor **R14** and photoresistor **PC2** are connected to the other terminal of lamp **27** and to the junctions between resistors **R11** and **R12** and between resistor **R12** and capacitor **C9**, respectively.

When the photocells **48**, **48a**, **48b** and **48c** are not illuminated, they are in a high impedance state so that the capacitor **C1**, **C2**, **C3** and **C4** are effectively open circuited, and the oscillator **61** sees merely the capacitance of **C5**. When either of the lamps **27** or **28** is energized, only those photocells which are opposite holes **30** will be illuminated and thereby go from a high impedance state to a low impedance state. Thus, those capacitors connected in series with an illuminated photocell will be effectively connected in parallel with capacitor **C5** so that the oscillator **61** sees a higher value of total capacitance.

Preferably, capacitors **C1**, **C2**, **C3** and **C4** each have a different predetermined capacitance which are related so as to provide a different parallel capacitance with respect to capacitor **C5** for each position of the discs **20** and **21**. For example, capacitors **C1**, **C2**, **C3** and **C4** may be 1 nf., 2 nf., 4 nf. and 8 nf., respectively, as shown in FIG. 7, so as to provide the indicated parallel capacitance for each disc position.

As those skilled in the art will appreciate, the frequency of the oscillator **61** will be given by the expression:

$$f \cong \frac{1}{2\pi\sqrt{LC}}$$

where

$$C \cong \left(\frac{1}{C6} + \frac{1}{C5 + C_n}\right)^{-1}$$

and C_n is the sum of the capacitances **C1**, **C2**, **C3** and **C4** that are connected in parallel with capacitance **C5** as the result of their respective photocells **48**, **48a**, **48b** and/or **48c** being illuminated through the holes **30** in discs **20** or **21**. As a result, the oscillator **61** will have a different output signal for each position of the discs **20** and **21**.

Assume that a reading of the meter **11** is to be taken. The interrogator **15** is actuated, and this, in turn, actuates the remote transmitter exciter and the line selector which selects the customer lines **12a** and **12b**. The remote transmitter exciter places a positive potential signal on the line **12a** and a negative potential signal on line **12b**. Capacitor **C8** will charge to a sufficiently high voltage to break down the neon lamp N. This illuminates the photocell **PC1** which then changes from a high impedance state to a low impedance state, whereby current may continue to flow to lamp N. With the photocell **PC1** in its low impedance state, the lamp N will remain illuminated as long as the voltage signals appear in the customer lines **12a** and **12b**.

When the coupling circuit becomes active, a voltage appears across the diode bridge output terminals **63** and **64** which energizes the oscillator **61**. In addition, this voltage, less the small drop across diode **D4**, appears across the lamp **27** time delay circuit **76**, which momentarily prevents lamp **27** from illuminating. The voltage across lamp **28** will be that across the diode **D1** and this will be insufficient to break the lamp down. Initially, therefore, only capacitors **C5** and **C6** will be in the oscillator **61** circuit and, accordingly, a reference frequency signal will be placed on the lines **12*a*** and **12*b*** and received by the interrogator **15**. After a time delay determined by the values of resistance and capacitance in the time delay circuit **76** and the lamp **27** breakdown voltage, the lamp **27** is illuminated and preedtermined ones of the photocels **48**, **48a**, **48b** and **48c** will be illuminated in accordance with the position of the disc **20**. This will modify the capacitance seen by the oscillator **61** and, accordingly, a second freqeuncy signal will be applied to the lines **12a** and **12b** to indicate the position of the disc **20**.

It will be appreciated that the freqeuncy of the second signal will be some increment below that of the first or reference freqeuncy signal. By thus reading the disc position as a predetermined variation or percentage of the reference frequency rather than as a discrete frequency, variations in capacitive values as the result of ageing, for example, will not prevent unambiguous readings.

After the disc **20** reading has been received, the remote transmitter exciter will reverse the polarity of the customer lines **12a** and **12b** so that lamp **28** will be energized through conductor **75**, resistor **R10** and diode **D3**. Diode **D2**, however, will prevent energization of the lamp **27**. As a result, a reading may be taken on the position of the disc **21**. Here again, certain of the photocells **48**, **48a**, **48b** and **48c** may be illuminated in accordance with the position of the disc **21** so that certain ones of the capacitors **C1**, **C2**, **C3** and **C4** may be connected in parallel with the capacitor **C5**. This will again provide a tone signal in accordance with the reading of the disc **21** to the customer lines **12a** and **12b** which is received by the interrogator **15**.

The diode bridge **60** performs the function of signal receiving and mode selection. More specifically, the bridge **60** receives the actuating signals from the remote transmitter exciter **16** and selects which of the lamps **27** and **28** will be energized so that the discs **20** and **21** may be selectively read.

Because the disc **21** makes sixteen steps for each step of the disc **20**, a total of 256 steps of the meter **11** is possible for each encoder register cycle. If meter readings of a greater number of steps per cycle are desired, the discs **20** and **21** may be made with a greater number of code units **30** and **31** and sensor units **48**, or an additional set of discs, lamps and sensor units may be provided.

It will be appreciated that the encoder unit according to the invention provides a compact and economical structure which is suitable for a remote meter reading in-

stallation wherein space and installation costs are extremely important. For example, the device according to the invention, requires only a single sensor assembly for reading a pair of discs **20** and **21**.

Further miniaturization is possible because of the use of the capactive incrementing circuit **59** which allows the positions of both discs **20** and **21** to be read through a single pair of conductors **65** and **67**. It will also be appreciated that additional discs could also be read through conductors **65** and **67** by providing further selectively operable lamps and/or additional photocells or capacitive incrementing circuits **59**, having different capacitive values so that different tone signals will be produced.

Also, the use of the capacitor incrementing circuit **59**, consisting of capacitors C1, C2, C3 and C4 which are switched through photocells **48**, **48**a, **48**b and **48**c, respectively allows the addition and subtraction of discrete values of capacitance without the use of expensive switching devices. This further facilitates the compactness and economics of the encoder **10**.

In addition, the combination of the capacitance incrementing circuit with the oscillator permits the use of a single tone signal to represent a plurality of information bits rather than a different tone signal for each information bit as in some prior art devices.

While only a single embodiment of the invention has been shown and described, it is not intended to be limited thereby, but only by the scope of the appended claims.

I claim:

1. A device for indicating the position of a movable member and including at least a pair of [adjacently disposed] carriage members, a code track disposed on each carriage member for defining a plurality of positions, sensing bit means disposed [between] *adjacent at least one of* said members and in an operative association with each of said code tracks, said carriage members being coupled to said movable member for being moved into said positions of said code tracks relative to said sensing bit means, *and* normally inactive means associated with said carriage members and operative when active to selectively actuate said sensing bit means in a predetermined different manner for each position of carriage members.

2. The device set forth in claim **1** wherein each of said carriage members is rotatable and said code track is disposed in a circular array thereon.

3. The device set forth in claim **1** wherein said code track comprises transparent and opaque positions and said sensing bit means includes photosensitive means arranged in registry with different predetermined ones of said positions when said carriage members are in each of their positions, and said normal inactive means comprises a source of illumination.

4. The device set forth in claim **1** wherein said normally inactive means includes a first and second element *respectively* associated with said [first and second] carriage [means] *members* [respectively], and first means for selectively actuating said normally inactive [elements] *means* and second means for simultaneously interrogating said sensing bit means.

5. The device set forth in claim **1** wherein drive means couples a first one of said carriage members to said movable member for sequential advancement through said positions, said drive means also coupling said carriage members for movement of said second carriage member through one position for each cycle of said first carriage member.

6. The device set forth in claim [**4**] *3* wherein said [photosensitive] *sensing bit* means comprises a plurality of photocells constructed and arranged to be actuated by illumination [from each of a pair of opposite directions].

7. The device set forth in claim **5** wherein said code track comprises transparent and opaque positions on said [discs] *carriage members* and said sensing bit means includes photosensitive means arranged in registry with different predetermined ones of said positions when said [discs] *carriage members* are in certain of their positions, *and wherein* said normally inactive means comprises first and second lamp means disposed *respectively* adjacent [the outer surfaces of] said carriage members, first means for selectively energizing said [lamps] *lamp means*, and second means for simultaneously interrogating said sensing bit means.

8. The device set forth in claim **7** wherein said photosensitive means comprises a plurality of photocells constructed and arranged to be actuated by illumination [from each of a pair of opposite directions].

9. The device set forth in claim **8** wherein said carriage [member comprises] *members each comprise* a disc and said code [track is] *tracks are* disposed in a circular array [thereon].

10. The device set forth in claim **8** wherein said transparent [portions] *positions* comprise apertures defined by generally radial sides.

11. The device set forth in claim **10** wherein each of said photocells comprises a photosensitive material deposited on a transparent substrate.

12. The device set forth in claim 1 wherein said carriage members are adjacently disposed to each other.

13. The device set forth in claim 12 wherein said sensing bit means are disposed between said carriage members.

References Cited

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