July 4, 1967 A. HEINZ 3,328,945

WRAPPING UNIFORMLY PITCHED WINDINGS ON A STRAND

Filed Sept. 23, 1964 3 Sheets-Sheet 1

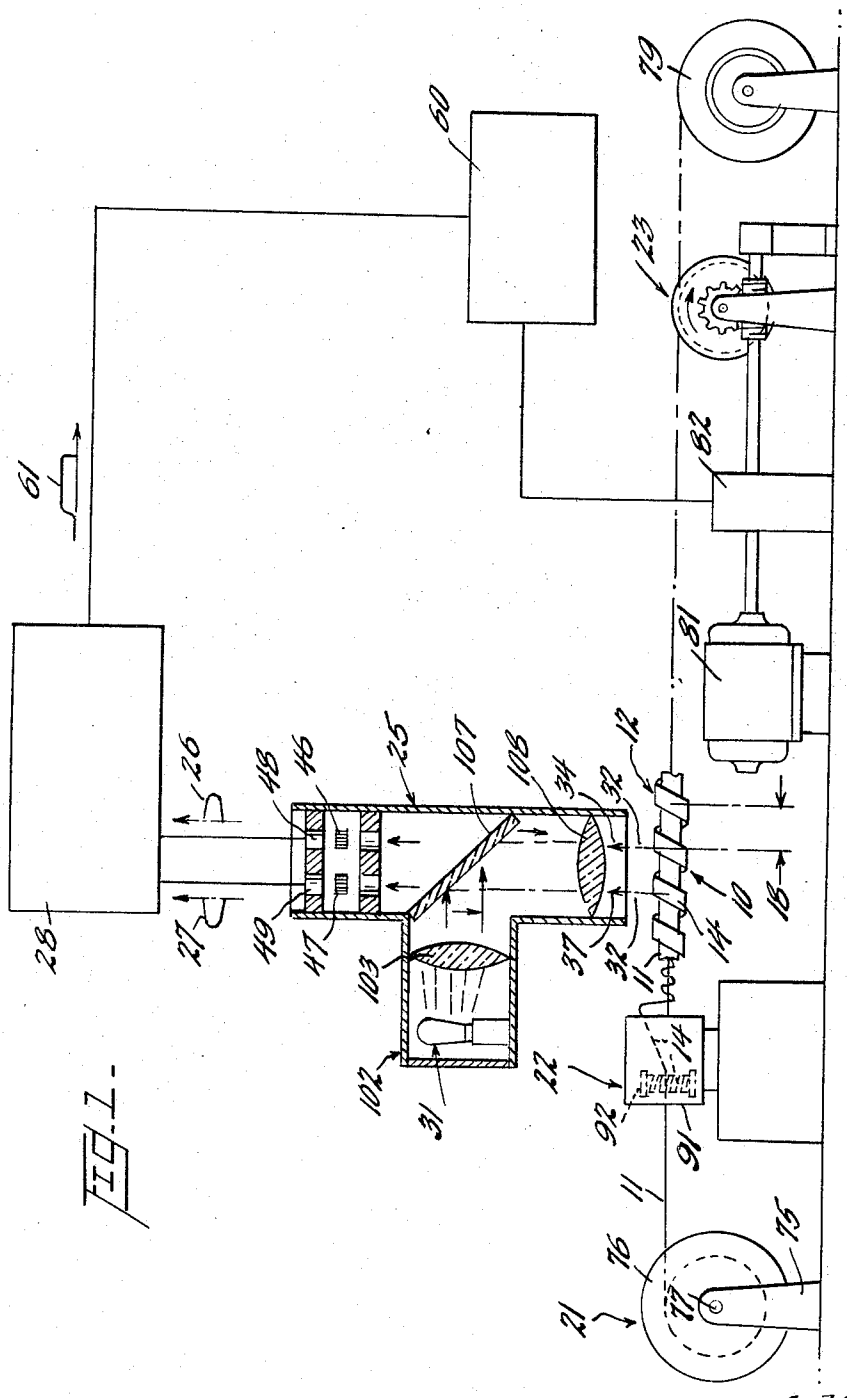



FIG. 1.

INVENTOR

BY A. Heinz,
W. M. Kain
ATTORNEY

July 4, 1967 A. HEINZ 3,328,945

WRAPPING UNIFORMLY PITCHED WINDINGS ON A STRAND

Filed Sept. 23, 1964 3 Sheets-Sheet 2

FIG. 2

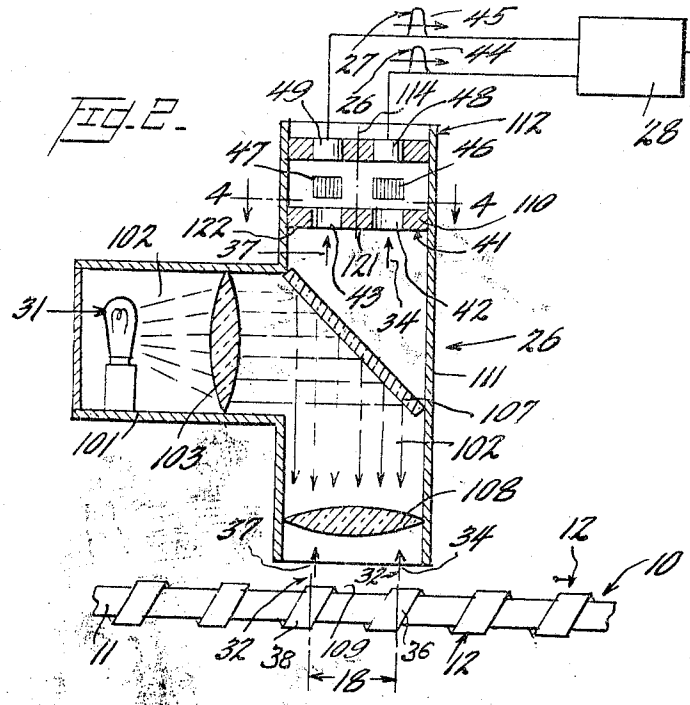



FIG. 3

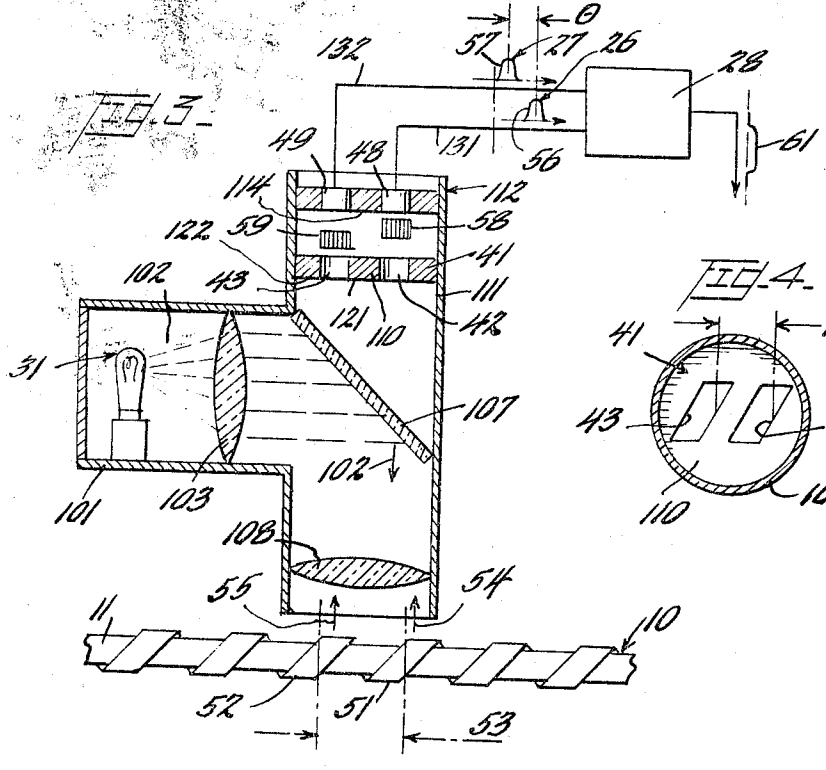



FIG. 4

July 4, 1967 A. HEINZ 3,328,945

WRAPPING UNIFORMLY PITCHED WINDINGS ON A STRAND

Filed Sept. 23, 1964 3 Sheets-Sheet 3

FIG. 5

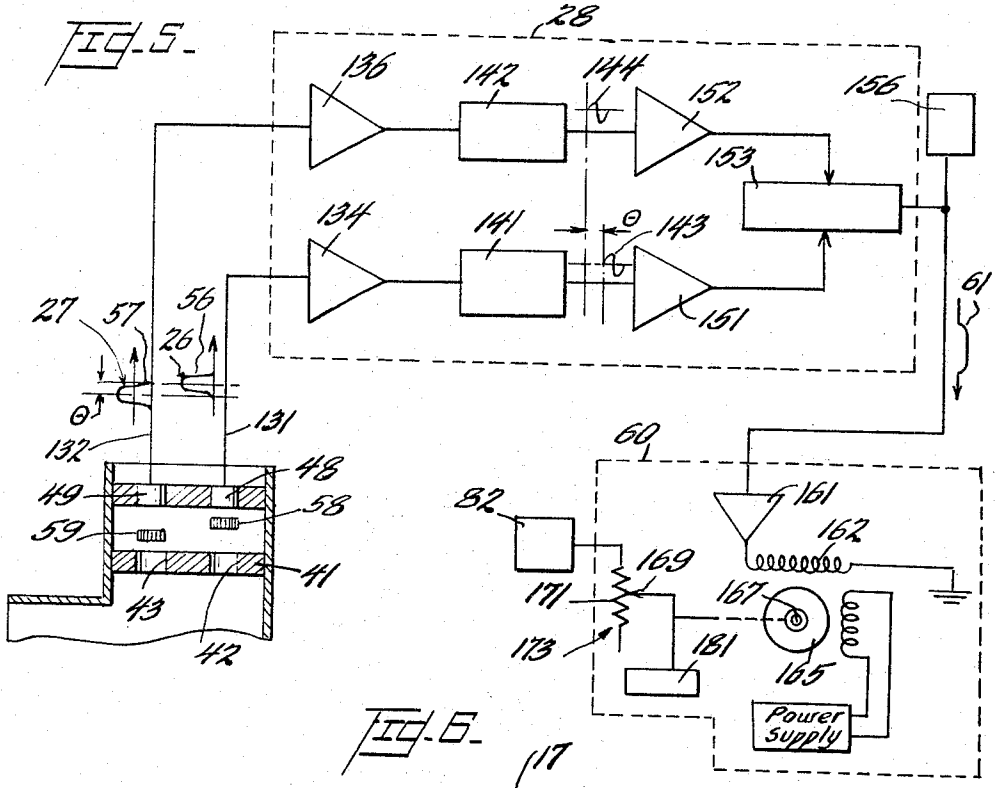
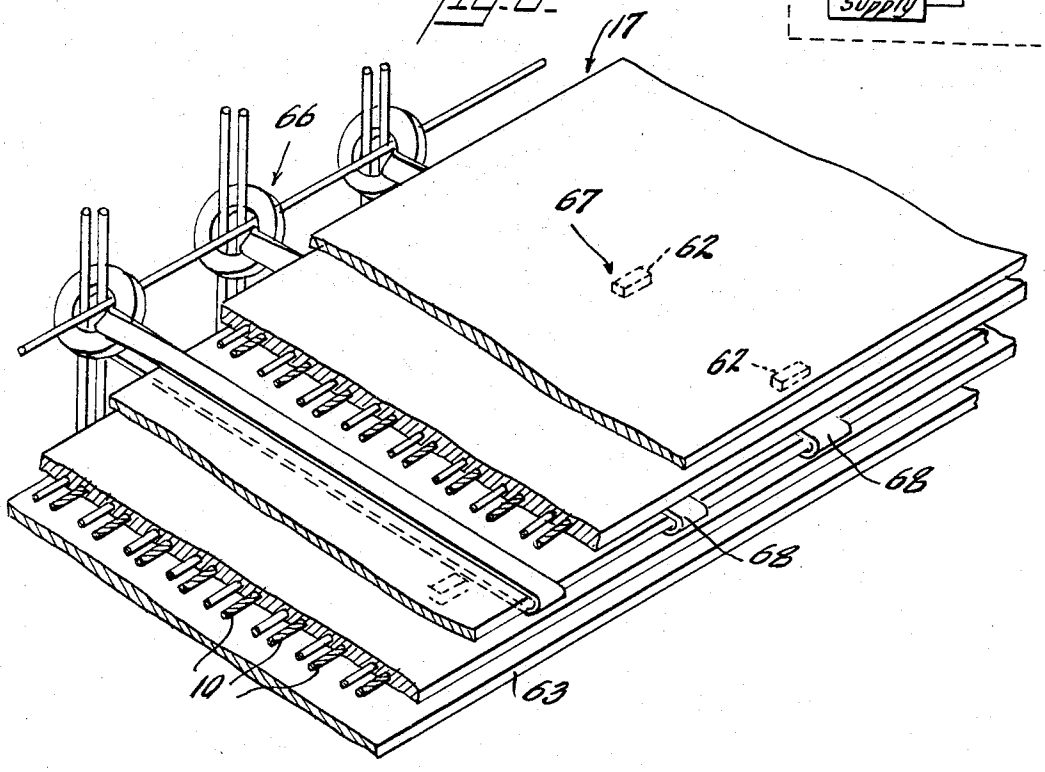



FIG. 6



United States Patent Office 3,328,945
Patented July 4, 1967



3,328,945

# WRAPPING UNIFORMLY PITCHED WINDINGS ON A STRAND

Alfred Heinz, Raritan Township, Hunterdon County, N.J., assignor to Western Electric Company Incorporated, New York, N.Y., a corporation of New York

Filed Sept. 23, 1964, Ser. No. 398,556
8 Claims. (Cl. 57—6)

This invention relates to apparatus for winding a strand onto an elongated member, and more particularly, to apparatus for controlling the pitch of coils of tape wrapped around an advancing wire.

In manufacturing operations, it is often necessary to accurately control the relative position of various elements. When the elements are applied to a member in rapid succession and are positioned in closely spaced relationship, problems inherent in visually performed position sensing operations become critical and render necessary the use of high speed sensing facilities.

More particularly, in the manufacture of transparent ribbon cable used in permanent magnet memory array devices, numerous pairs (45 pairs, for example) of generally parallel, opaque conductors, such as wires, are embedded in laminated polyethylene sheets. The wire of one pair may be a twistor wire having magnetic twistor tape coiled or helically wrapped thereon. The memory properties of the array devices are dependent upon maintenance of a predetermined spacing or pitch between adjacent coils of the helically wrapped tape. Because the pitch of the coils is small, and because relatively high wrapping speeds are employed, visual inspection of the spacing of the coils is ineffective to insure conformity of the twistor wire with manufacturing specifications.

It is an object of the present invention to provide new and improved apparatus for winding a strand onto an elongated member.

Another object of the present invention resides in the provision of facilities for controlling the pitch of coils of tape wrapped around an advancing wire.

Still another object of the present invention resides in the provision of facilities for illuminating an elongated member having coils of strand thereon to project light beams from the coils through a mask for sensing the spacing of coils.

A further object of the present invention is to provide a mask having a pair of spaced apertures for successively passing bands of light projected from adjacent coils wrapped on an elongated member.

A still further object of the present invention resides in the provision of facilities for advancing a carrier wire relative to coil wrapping head, including instrumentalities responsive to the pitch of wrapped coils for controlling the relative speed of the advancing facilities and the wrapping head and thereby control the pitch of the coils.

A still further object of the present invention resides in the provision of masking facilities having a pair of apertures spaced along a given direction of advancement of a wire, in conjunction with facilities for illuminating the wire to reflect light from adjacent coils of ribbon wrapped around the wire through the apertures for controlling the pitch of the coils.

With these and other objects in view, the present invention contemplates provision of facilities for advancing an elongated member, such as a carrier wire, at a selected rate along a path extending past a wrapping head which wraps a strand, such as a tape onto the advancing carrier wire to form coils having a nominal pitch which is proportional to the selected rate of advancement. Adjacent coils of the tape are illuminated to produce bands of light having a spacing indicative of the pitch of the adjacent coils. Bands of light produced by the illumination of adjacent coils having an undesired pitch, pass in succession through apertures provided in a mask to successively render photoelectric sensing facilities effective to generate an error signal indicative of the difference between the nominal pitch and the undesired pitch. Control instrumentalities are responsive to the error signal for regulating the relative speeds of the advancing facilities and the wrapping head to form the coils having the nominal pitch.



These and other objects of the present invention will become apparent upon reference to the following description and to the accompanying drawings illustrating a preferred embodiment thereof in which:

FIG. 1 is a schematic view of an apparatus constructed in accordance with the principles of the present invention for wrapping coils of strand, such as tape, along an elongated member, such as a carrier wire, illustrating a source of illumination for reflecting a light beam from each of the coils wrapped on the carrier wire;

FIG. 2 is an enlarged, partially sectioned, elevational view of the apparatus shown in FIG. 1, illustrating light beams reflected from adjacent coils having a nominal pitch;

FIG. 3 is an enlarged, partially sectioned, elevational view similar to FIG. 2 showing light beams reflected from adjacent coils having an unacceptable pitch;

FIG. 4 is a plan view taken along line 4—4 of FIG. 2 showing a mask which is effective to successively pass the light beams reflected from the adjacent coils having the unacceptable pitch;

FIG. 5 is a schematic diagram of a circuit including a pair of photosensitive elements which respond to the successive light beams passed through the mask for rendering a monitoring circuit effective to generate an error signal which initiates adjustment of the rate of advancement of the carrier wire;

FIG. 6 is a perspective view of a permanent magnet memory array utilizing the carrier wire having the coils of tape wrapped thereon.

Referring now to the drawings, there is shown in FIGS. 1 and 2 an article **10** including a member, such as an elongated electrical conductor or carrier wire **11**, provided with coils **12—12** of strand **14** wrapped thereon. The article **10** may be a twistor wire which is used in a twistor or ribbon type cable of a permanent magnet matrix memory device **17** shown in FIG. 6. The carrier wire **11** may be a 3 mil copper wire, for example, and the strand **14** may be a flat, magnetic twistor tape wrapped helically onto the carrier wire **11** with a given or nominal pitch **18**.

Referring in general to the apparatus shown in FIG. 1, a supply stand **21** is shown for feeding the carrier wire **11** relative to a wrapping device **22** which wraps the spaced coils **12—12** of the twistor tape **14** onto the advancing carrier wire **11** at a given rate to form the twistor wire **10**. A take-up mechanism including a capstan **23** is provided for taking up the twistor wire **10** at a nominal rate of advancement which is designed to render the wrapping device **22**, operating at a given rate, effective to provide the nominal pitch **18** between the coils **12—12** of twistor tape.

An optical sensing unit **25** is provided for monitoring the pitch **18** of the coils **12—12** and for applying input signals **26** and **27** to a monitoring circuit **28** which controls the rate of advancement of the carrier wire **11** relative to the wrapping mechanism **22**. The optical sensing unit **25** includes a light source **31** for illuminating the twistor wire **10** so that a light beam **32** is reflected from each of the coils **12—12** of the twistor tape. Referring to FIG. 2, when the nominal pitch **18** is provided between a leading coil **36** and a subsequent coil **38** of the

coils 12—12, first and second light beams 34 and 37 are reflected simultaneously from the respective coils 36 and 38.

A masking facility 41 (sees also FIG. 4) is provided with apertures 42 and 43 for simultaneously passing the respective light beams 34 and 37 reflected from the respective adjacent coils 36 and 38 so that simultaneous light pulses 46 and 47 are applied to respective photosensitive detectors 48 and 49. The simultaneously applied pulses 46 and 47 render the respective detectors 48 and 49 effective to generate the respective signals 26 and 27 in the form of respective simultaneous signals 44 and 45 which cause the monitoring circuit 28 to produce a zero output, indicating that the rate of advancement of the carrier wire 11 past the wrapping mechanism 22 is effective to produce the nominal pitch 18.

However, when the coils 12—12 are spaced incorrectly, as illustrated in FIG. 3 wherein the adjacent coils 51 and 52 have an unacceptable pitch 53 which deviates from the nominal pitch 18, light beams 54 and 55 reflected from the coils 51 and 52 will be spaced further apart than the apertures 42 and 43 of the mask 41. Accordingly, light pulses 58 and 59, representing the maximum amount of light passed by the respective apertures 42 and 43 from the coils 51 and 52, will be spaced by an interval of time. The interval between passage of the successive beams 54 and 55 through the respective apertures 42 and 43 is proportional to the amount that the pitch 53 varies from the nominal pitch 18. The photosensitive detectors 48 and 49 generate the signals 26 and 27 in the form of respective signals 56 and 57 having the peak values thereof spaced in time by an amount indicative of the error of the pitch 53. The signals 56 and 57 cause the monitoring circuit 28 to generate an error signal 61 having a value indicative of the error of the pitch 53 and a sign indicative of the direction of the error relative to the nominal pitch 18.

Referring to FIGS. 1 and 5, a capstan control circuit 60 is responsive to the error signal 61 for selectively adjusting the speed of the capstan 23 to regulate the rate of carrier wire advancement, and thereby render the wrapping mechanism 22 effective to provide the nominal pitch 18 between the coils 12—12 of the tape 14 wrapped onto the carrier wire 11.

The significance of providing the nominal pitch 18 between the coils 12—12 may be appreciated upon considering the structural elements of the twistor matrix memory device 17 shown in FIG. 6. The twistor matrix memory device 17 may be of the general type described in an article entitled "A Twistor Matrix Memory for Semipermanent Information" by Duncan H. Looney, published in the Proceedings Western Joint Computer Conference, 1959. Referring to FIG. 6, there is shown an embodiment of the twistor matrix memory device 17 designed for computers which require random access to stored information that is changed very infrequently. The device 17 shown in FIG. 6 includes permanent magnets 62—62 arranged in a pattern on cards 63—63 for storing the information. The presence or absence of one of the permanent magnets 62 is sensed nondestructively by one of the twistor wires 10—10 which is wrapped with the magnetic twistor tape 14 adjacent to the location of the permanent magnets 62. A stored word is read by a linear selection system 66 using a biased core access switch.

As noted in the article, a number of factors must be considered in the design of the twistor matrix memory 17. One factor is that the permanent magnets 62—62 must be registered accurately with bit locations 67 defined by the coils 12—12 on the twistor wires 10—10 and elongated word solenoids 68 extending perpendicular to the twistor wires 10—10. Because the permanent magnets 62—62 are minute and the twistor wires 10—10 are fine, it may be appreciated that the pitch of the coils



12—12 is critical to such accurate registration of the permanent magnets 62—62 and the bit locations 67.

Referring now in detail to FIG. 1, the supply stand 21 is shown including a support 75 which mounts a carrier wire supply reel 76 for rotation on a horizontal axis 77. The carrier wire 11 pays out from the supply reel 76 and advances past the wrapping device 22 to receive the coils 12—12 of the twistor tape 14. The twistor wire 10, formed by the carrier wire 11 wrapped with the coils 12—12 of the twistor tape 14, extends around the capstan 23 and onto a driven take-up reel 79. The capstan 23 is driven by a motor 81 through an electromagnetic clutch 82 to provide a variable speed drive for the twistor wire 10. In the normal operation of the clutch 82, the capstan control circuit 60 renders the clutch 82 effective to provide a selected amount of coupling between the motor 81 and the capstan 23 so that the twistor wire 10 is advanced from the wrapping device 22 at the nominal rate. The capstan control circuit 60 is adapted to increase or decrease the coupling provided by the clutch 82 so that increased or decreased rates of advancement of the twistor wire 10 may be provided.

The wrapping device 22 may be constructed according to standard specifications and is provided with a serving head 91 which rotates at a fixed rate around the advancing carrier wire 11. A twistor tape supply 92 on the serving head 91 pays out the twistor tape 14 as the serving head rotates, so that the coils 12—12 of the twistor tape are wrapped onto the carrier wire 11. Because the rate of rotation of the serving head 91 is fixed, the pitch 18 between adjacent coils 12—12 of the twistor tape 14 is dependent upon the rate of advancement of the carrier wire 11 through the serving head 91. It may be understood that with the clutch 82 adjusted to advance the twistor wire 10 at the nominal rate, the pitch 18 of the coils 12—12 will be the desired value shown in FIG. 2. If the rate of advancement exceeds the given rate, the pitch of the coils 12—12 will be the unacceptable pitch 53 (FIG. 3) which exceeds the desired pitch 18 (FIG. 2), whereas if the rate of advancement is less than the given rate, the pitch of the coils 12—12 will be less than the desired pitch 18.

The optical sensing unit 25 is mounted adjacent to the path of advancement of the twistor wire 10 to monitor the pitch of the coils 12—12. Referring to FIG. 2, the optical sensing unit 25 is shown including the light source 31 mounted within a housing 101 for projecting a beam 102 of light through a collimating lens 103. The beam 102 of light is reflected downwardly by a partial mirror 107 mounted above and at a 45° angle with respect to the path of advancement of the twistor wire 10. The light beam 102 is transmitted through a lens 108 and illuminates a section 109 of the carrier wire and the pair of adjacent coils 12—12, such as the coils 36 and 38, of the twistor tape 10.

Portions of the light beam 102 are reflected by the illuminated section 109 of the carrier wire 11 and by the adjacent coils 36 and 38 of the tape. The light-reflecting properties of the coils 36 and 38 differ from that of the carrier wire 11; hence, the beams 34 and 37 of light reflected from the respective coils 36 and 38 are visually and optically distinguishable from what may be termed background light reflected by the carrier wire 11. The beams 34 and 37 of light reflected from the respective coils 36 and 38 are reflected and projected substantially vertically through the partial mirror 107 toward the mask 41.

The mask 41 is shown in detail in FIGS. 2 and 4 including an opaque disk 110 mounted horizontally in the upper end 111 of a vertical section 112 of the housing 101. The disk 110 is oriented around a vertical axis 114 so that the apertures 42 and 43 are spaced by a distance 117 (which may span two adjacent coils or a series of coils) (FIG. 4) extending in a direction parallel to the path of

the twistor wire **10**. The distance **117** is determined by the formula:

$$\text{distance } 117 = kms$$

where:

$k$=the number of coils **12—12** of twister tape **14** within the optical field,

$m$=the optical magnification of the system (lens **108** in above example), and

$s$=the nominal pitch **18** between the coils **12—12**.

The configuration of each aperture **42** and **43** is congruent to the portion of one of the coils **12—12** illuminated by the light beam **102**.

With such spacing and configuration, the apertures **42** and **43** pass the light beams **34** and **37** simultaneously, as shown in FIG. 2. More particularly, as the twistor wire **10** advances past the optical sensing unit **25**, the coils **36** and **38** advance (to the right as viewed in FIG. 2) into vertical alignment with the vertical section **112** of the housing **101**. As the coils **36** and **38** so advance, the reflected light beams **34** and **37** advance to the right and initially impinge upon respective areas **122** and **121** (FIG. 2) of the mask **41**. As the reflected light beams **34** and **37** advance to the right, the beams **34** and **37** are simultaneously vertically aligned with the respective apertures **42** and **43**. Such simultaneous alignment produces the simultaneous pulses **46** and **47** which are simultaneously applied to the photosensitive detectors **48** and **49**.

On the other hand, when the coils **12—12** are spaced incorrectly, as illustrated in FIG. 3 by the coils **51** and **52** having the unacceptable pitch **53**, the reflected light beams **54** and **55** do not pass simultaneously through the respective apertures **42** and **43**. Rather, as the twistor wire **10** advances to the right, as viewed in FIG. 3, the reflected light beams **54** and **55** initially impinge upon the respective sections **121** and **122** of the mask **41**. As the reflected beams **54** and **55** impinge on the mask **41**, the reflected light beam **55** is spaced from the beam **54** by a distance greater than the spacing of the apertures **42** and **43**. Thus, the beam **54** advances into vertical alignment with the aperture **42** before the beam **55** is vertically aligned with the aperture **43** so that the light pulse **58**, representing the maximum amount of light that the aperture **42** passes, is passed before the light pulses **59** formed when the beam **55** is aligned with the aperture **43**.

The photodetectors **48** and **49** are mounted in the upper end **111** of the vertical section **112** of the housing **101** adjacent to the respective apertures **42** and **43**. The photodetectors **48** and **49** may be standard detectors such as photoemissive cells, photoconductors, or phototransistors which generate electrical signals in response to a pulse of light. As shown in FIG. 2, in response to the simultaneous light pulses **46** and **47**, the photodetectors **48** and **49** generate the simultaneous signals **44** and **45** which are effective to render the monitoring circuit **28** ineffective to generate the error signal **61**.

In responsive to the successive light pulses **58** and **59** (FIG. 5), the photodetectors **48** and **49**, respectively, generate the successive signals **56** and **57** which are applied by respective conductors **131** and **132** to respective amplifiers **134** and **136**. The successive signals **56** and **57** are spaced by a phase difference $\theta$ which is proportional to the difference between the nominal pitch **18** and the unacceptable pitch **53**. The amplified signals **56** and **57** are applied to respective band-pass filters **141** and **142** which apply signals **143** and **144** having the phase difference $\theta$ to respective amplifiers **151** and **152**. The amplified signals **151** and **152** are applied to a phase detector **153** which generates the error signal **61** having an amplitude which is proportional to the phase difference $\theta$ between the signals **56** and **57**, and a sign which indicates whether or not the signal **56** leads or lags the signal **57**.

The error signal **61** operates a recorder **156** which indicates the amplitude and the sign of the error signal **61**. Also, the error signal **61** is applied to the capstan control



circuit **60**. The capstan control circuit **60** includes a chopper amplifier **161** which applies the amplified error signal **61** to a control winding **162** of a servo resolver or two-phase motor **165**. A rotor **167** of the motor **165** is located in a rotary orientation according to the amplitude and sign of the error signal **61**. The rotor **167** controls a potentiometer **169** of a control network **173** provided for controlling the electro-magnetic clutch **82**. More particularly, when the error signal **61**, generated in response to the successive signals **56** and **57**, is applied to the motor **165**, the rotor **167** rotates the potentiometer **171** to provide more resistance between a clutch power supply **181** and the clutch **82**. With more resistance provided, less coupling is effected by the clutch **82** between the capstan drive motor **81** and the capstan **83**, so that the capstan **83** advances the twister wire **10** at a lower rate of speed.

With the rate of speed adjusted, the optical unit **26** senses a smaller error in the pitch **53** and causes a smaller error signal **61** to be generated and, hence, a smaller rate correction to be made until the nominal rate is achieved. At this time, the pitch of the coils **12—12** equals the nominal pitch **18**.

The optical sensing unit **26** senses the coils **12—12** having the nominal pitch **18** and causes the simultaneous pulses **46** and **47** to be applied to the respective photodetectors **48** and **49**. No error signal **61** is generated by the monitoring circuit **28** in response to the simultaneous pulses **46** and **47**, indicating that the twister wire **10** is advancing at the nominal rate and is rendering the wrapping device **22** effective to wrap the coils **12—12** having the nominal pitch **18**.

It should be noted that the pitch **18** of adjacent coils **12—12** (FIG. 1) may be adjusted by changing the relative speeds of the advancement of carrier wire **11** and the application of coils **12—12** to the carrier wire. In the above-described embodiment, such relative speeds are adjusted by changing the speed of carrier wire advancement (i.e., the speed of capstan **23**). It should be clear that relative speed adjustment may also be accomplished by changing the speed of application of coils **12—12** to the carrier wire (i.e., the speed of wrapping device **22**), or by making a coordinated change in both speed of carrier wire advancement and of coil application.

In the above-described embodiment, light beams **32** were produced by reflection from coils **12—12**. It should be clear that beams indicative of the spacing of coils **12—12** may also be produced by illuminating the coils from below to produce images or shadows of adjacent coils indicative of coil spacing. Detectors **48** and **49** would then sense spaced shadow beams rather than spaced reflected light beams to produce signals **26** and **27**.

It is to be understood that the above-described arrangements are simply illustrative of the application of the principles of this invention. Numerous other arrangements may be readily devised by those skilled in the art which will embody the principles of the invention and fall within the spirit and scope thereof.

What is claimed is:

**1**. An apparatus for applying reflective elements to a carrier member in a predetermined, spaced relationship, which comprises:

means for supplying said reflective elements to said carrier member at a constant rate;

means for advancing said carrier member at a variable rate to permit said carrier member to receive acceptable reflective elements at acceptable intervals spaced by a first distance and unacceptable reflective elements at unacceptable intervals spaced by a second distance;

means for illuminating said reflective elements on said carrier member to reflect from said unacceptable reflective elements first and second beams spaced by said second distance;

blocking means for successively passing said first and second beams spaced by said second distance;

means responsive to said successively passed first and second beams for generating successive signals indicative of spacing of said unacceptable reflective elements by said second distance; and

means responsive to said successive signals for operating said advancing means at a selected speed to advance said carrier member at a given rate for reception of said reflective elements at said acceptable intervals.

2. Apparatus for providing an elongated carrier member with a helical serving having a desired pitch, which comprises:

means for longitudinally advancing the carrier member,

means for applying a serving about the advancing carrier member,

means for illuminating the serving to produce beams therefrom having spacing proportional to the pitch of the serving, and

means responsive to the spacing of the beams for adjusting the relative rates of the advancing and applying means to apply a serving upon the carrier member having the desired pitch.

3. Apparatus for applying a strand to an elongated member, which comprises:

means for wrapping said strand around said member;

means for advancing said member relative to said wrapping means to render said member receptive to coils of said strand spaced by a pitch distance, the value of said pitch distance bebing dependent upon the rate of advancement of said member relative to said wrapping means;

means for illuminating said coils to produce first and second beams spaced according to said pitch distance;

means for simultaneously passing said first and second beams spaced by a first distance and for successively passing said first and second beams spaced by a second distance; and

means responsive to said successively passed first and second light beams for regulating the relative rates of the wrapping and advancing means to adjust said pitch distance to a desired value.

4. Apparatus for controlling the pitch of coils of tape wrapped around an elongated member, which comprises:

means for advancing said member along a path extending in a given direction;

means for wrapping said tape onto said advancing member to form said coils having a nominal pitch proportional to the rate of advancement of the member;

means for illuminating a pair of adjacent coils to produce parallel beams having a spacing indicative of the pitch of the adjacent coils;

a mask having a pair of spaced apertures therein, said apertures being spaced in said given direction to successively pass said beams from adjacent coils having an undesired pitch differing from said nominal pitch;

photoelectric means successively responsive to said successively passed beams for generating an error signal indicative of the difference between the nominal pitch and the undesired pitch; and

control means responsive to said error signal for regulating the relative speeds of said advancing and wrapping means to render said wrapping means effective to form said coils having said nominal pitch.

5. A wrapping apparatus, which comprises:

a supply stand for feeding a wire in a given direction;

a wrapping head for wrapping coils of a tape onto said wire;

take-up means for taking up said wrapped wire at a selected rate, said selected rate governing the pitch of said coils on said wire;



a mask mounted adjacent to said wrapped wire, said mask having a pair of apertures therein spaced in a direction parallel to said given direction, the spacing between said apertures being proportional to a desired pitch of adjacent coils;

means for illuminating said wrapped wire to produce a pair of beams from said adjacent coils, said beams from said adjacent coils having an undesired pitch being passed through said apertures in succession;

photosensitive means responsive to said successively passed beams for generating an error signal indicative of the amount of deviation of said undesired pitch from said desired pitch; and

means responsive to said error signal for controlling the relative speeds of the take-up means and wrapping head to cause wrapping of coils having said desired pitch.

6. Apparatus for controlling the pitch of coils of tape wound onto a carrier wire, which comprises:

a serving head for wrapping said tape onto said carrier wire to form said coils, said serving head normally being effective to wrap said coils having a first pitch;

a light projector for illuminating the wrapped carrier wire to cause each coil of tape to produce a beam;

a mask having a pair of apertures, said apertures being spaced by a distance proportional to said first pitch;

capstan means for advancing said wrapped carrier wire, said advancement of said wrapped carrier wire relative to said mask causing said beams from adjacent coils having a second pitch different from said first pitch to scan said mask and pass in succession through said apertures;

photoelectric means responsive to said successively passed beams for generating an error signal; and

means responsive to said error signal for controlling the relative speeds of the advancing means and the serving head to render said serving head effective to wrap coils having said first pitch.

7. Apparatus for controlling the pitch of coils of tape wrapped around an elongated member, which comprises:

means for advancing said member at a variable rate of advancement along a path extending in a given direction;

means for wrapping said tape onto said advancing member to form said coils having a nominal pitch proportional to said variable rate of advancement;

means for illuminating a pair of adjacent coils to reflect therefrom parallel bands of light having a spacing indicative of the pitch of the adjacent coils;

a mask having a pair of spaced apertures therein, said apertures being spaced in said given direction to sucsively pass said parallel bands of light reflected from adjacent coils having an undesired pitch differing from said nominal pitch;

photoelectric means successively responsive to said successively passed bands of light for generating an error signal indicative of the difference between the nominal pitch and the undesired pitch; and

control means responsive to said error signal for regulating the relative rates of the advancing and wrapping means to form coils on the elongated member having said nominal pitch.

8. An apparatus for controlling the speed of advancement of a carrier member having spaced, reflective elements thereon; acceptable, adjacent elements being spaced by a first distance and unacceptable, adjacent elements being spaced by a second distance; which comprises:

means for illuminating said reflective elements to reflect from said unacceptable reflective elements first and second light beams spaced by a distance proportional to said second distance,

blocking means for selecting beams spaced by a distance proportional to said first distance,

means for advancing said carrier member at a variable

rate to render said blocking means effective to pass said first and second beams in succession,

means responsive to said successively passed first and second beams for generating successive signals indicative of spacing of said unacceptable reflective elements by said second distance, and

means responsive to said successive signals for regulating said advancing means to adjust the rate of advancement of said carrier member to a selected rate.



**References Cited**

UNITED STATES PATENTS

| | | | |
|---|---|---|---|
| 2,760,137 | 8/1956 | Andrews | 242—55.11 X |
| 3,155,221 | 11/1964 | Grinner | 250—223 X |
| 3,242,661 | 3/1966 | Siler | 57—3 X |


FRANK J. COHEN, *Primary Examiner.*

A. J. SIDOTI, *Assistant Examiner.*