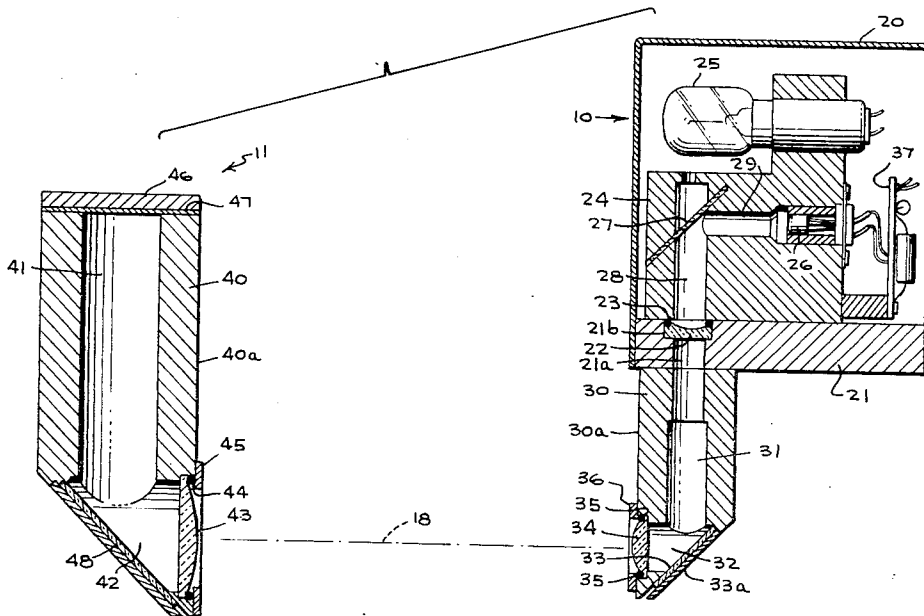


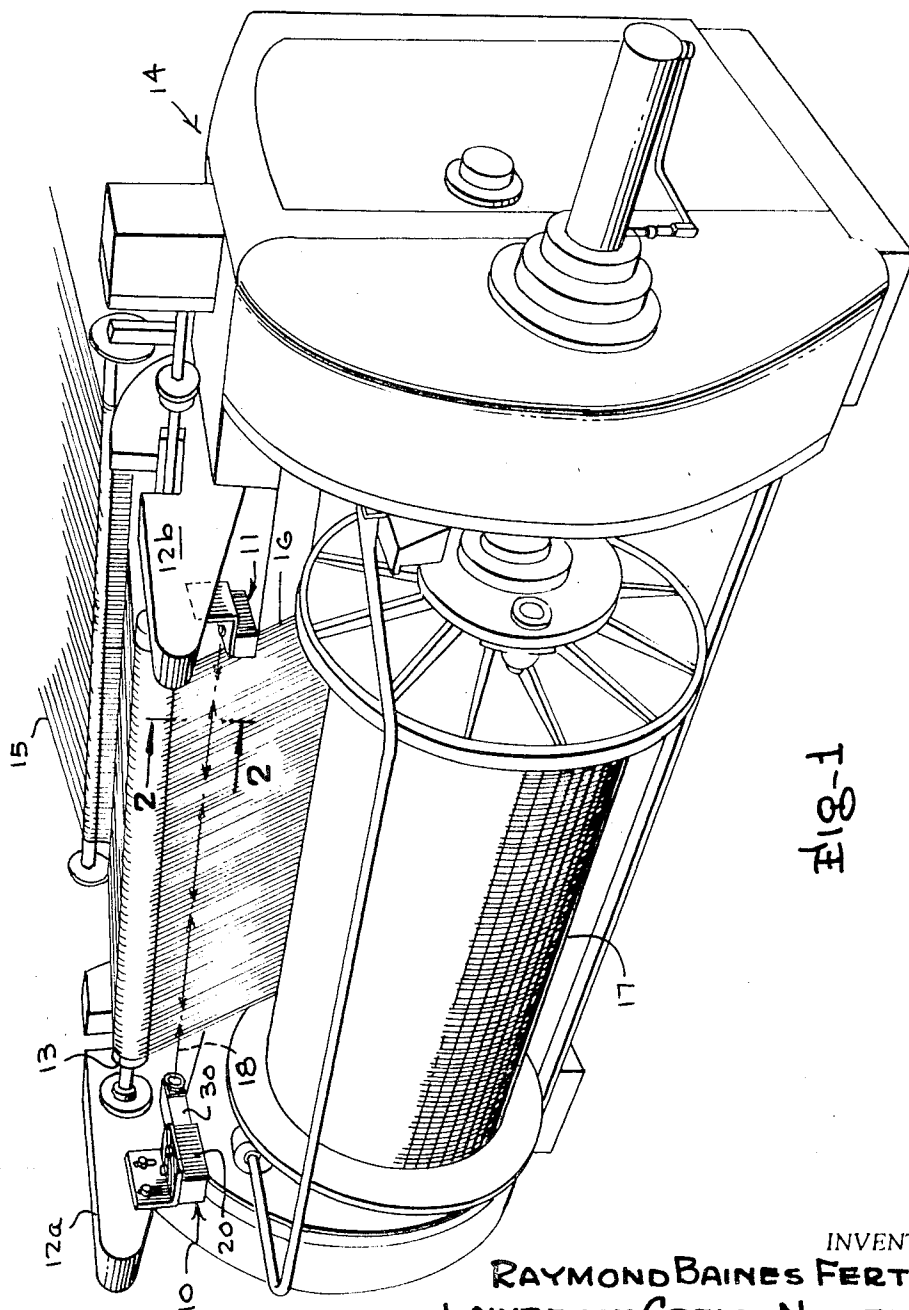
[72] Inventors **Raymond Baines Fertig;**
Lawrence Creigh Nickell; Henry T.
Sessions, all of Ronceverte, W. Va.
 [21] Appl. No. **80,943**
 [22] Filed **Oct. 15, 1970**
 [45] Patented **Dec. 14, 1971**
 [73] Assignee **Appalachian Electronics Instruments Inc.**
Ronceverte, W. Va.

[56] **References Cited**
UNITED STATES PATENTS
 3,530,690 9/1970 Nickell et al. 250/219 S X
Primary Examiner—James W. Lawrence
Assistant Examiner—T. N. Grigsby
Attorney—Mason, Fenwick, & Lawrence

[54] **BROKEN END DETECTION SYSTEM FOR**
WARPERS UTILIZING NOVEL OPTICAL SYSTEM
10 Claims, 5 Drawing Figs.
 [52] U.S. Cl. 250/219 S,
 66/163, 250/222
 [51] Int. Cl. G01n 21/30,
 G06m 7/00, H01j 39/12
 [50] Field of Search. 250/219 S,
 222, 216; 66/163

ABSTRACT: A broken end detector for a warper, wherein a detector head unit has a light source, a phototransistor and a beam splitter mirror and first and second lenses with a front surface mirror therebetween to intercept light traveling from the source through the first lens and redirect the light at right angles through the second lens as a monitoring beam spanning the width of the yarn sheet immediately below the warper measuring roll. A target unit having a lens, a 45° mirror, and a retroreflective surface at the other edge of the yarn sheet retroreflects light from the beam back along the beam axis to the detector head lenses and mirrors and the phototransistor.





INVENTORS
RAYMOND BAINES FERTIG,
LAWRENCE CREIGH NICKELL &
HENRY T. SESSIONS

BY
Mason, Fenwick & Lawrence
ATTORNEYS

Fig-3

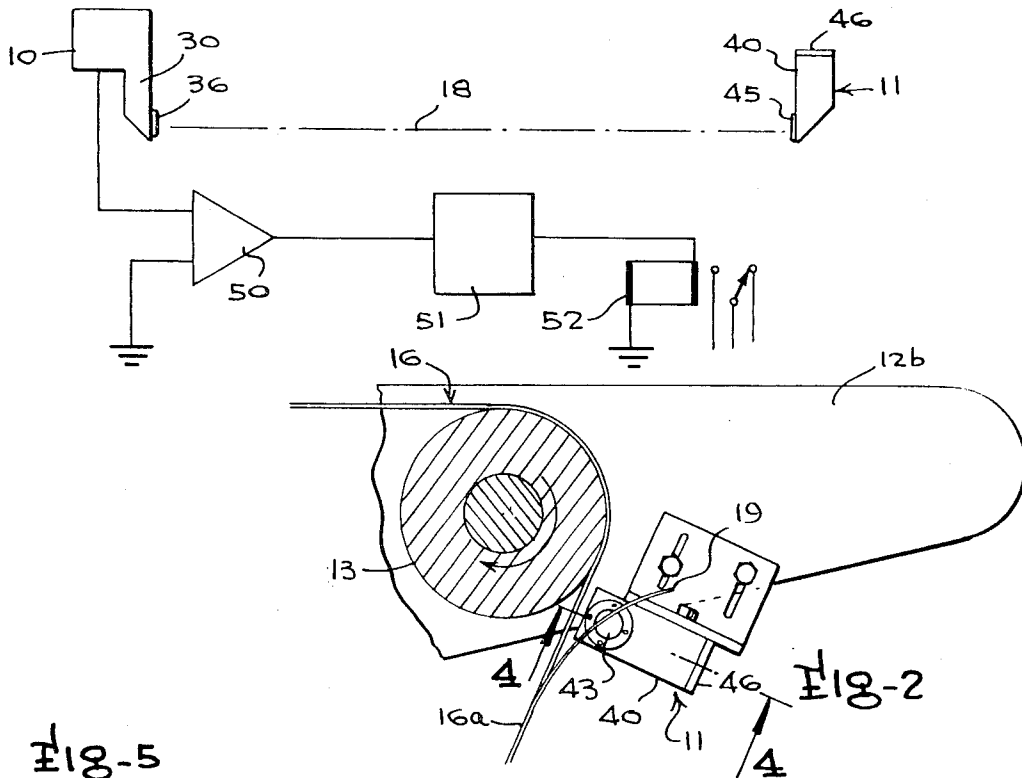
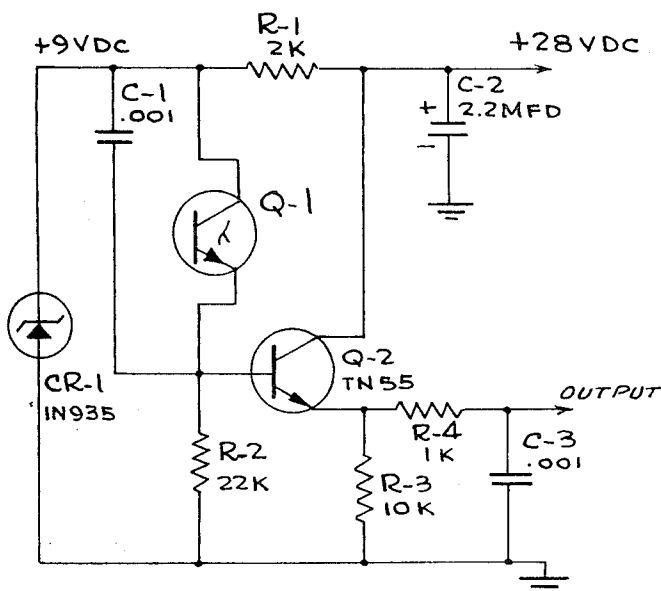
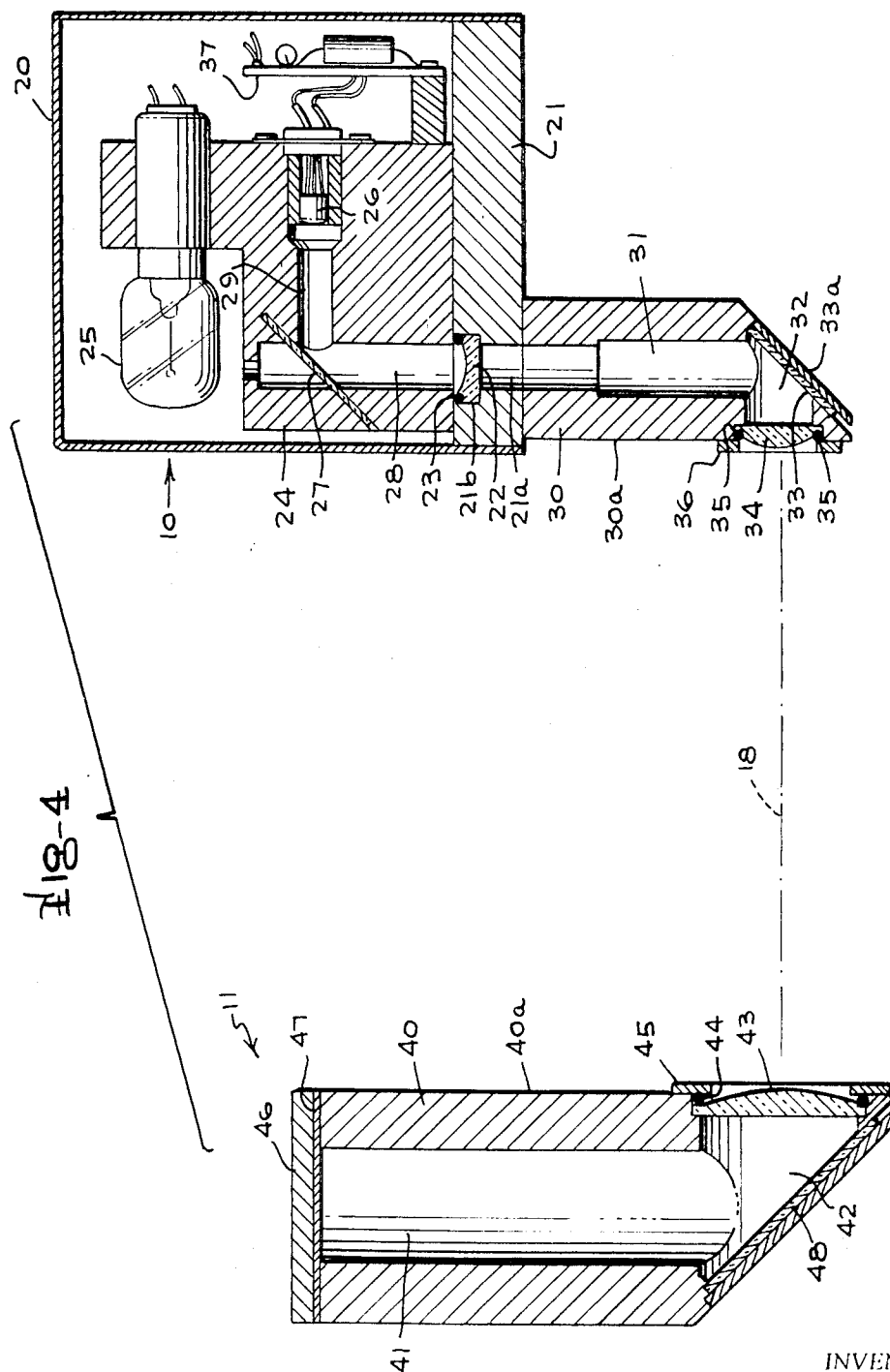


Fig-5



INVENTORS
 RAYMOND BAINES FERTIG,
 LAWRENCE CREIGH NICKELL &
 HENRY T. SESSIONS
 BY
 Mason, Fawcett & Lawrence
 ATTORNEYS



INVENTORS

RAYMOND BAINES FERTIG,
LAWRENCE CREIGH NICKELL &
HENRY T. SESSIONS

BY
Mason, Fenwick & Lawrence
ATTORNEYS

BROKEN END DETECTION SYSTEM FOR WARPERS UTILIZING NOVEL OPTICAL SYSTEM

BACKGROUND AND OBJECTS OF THE INVENTION

The present invention relates to a broken end detector system for use with warpers, and more particularly to an optical system for producing a narrow light beam close to the measuring roll of a warper between the measuring roll and the warper beam adjacent the yarn sheet formed of a large group of yarns moving substantially in unison in side by side relation downwardly from the measuring roll, together with means to produce an electrical signal when a broken yarn end passes through the light beam to cause stopping of the warper.

Feeding of yarns in large groups as yarn sheets occurs in many different types of yard-handling apparatus, such as knitting machines, particularly of the tricot or warp-knitting machine type, in weaving machines, in feeding of yarns from a warping machine or warper to the beam or beams of knitting machines, and similar yarn making and textile manufacturing installations. When breakage occurs in any of the yarns making up such a yarn sheet, the sudden release of tension on the yarn, its twist characteristics, and the condition of the yarns in such yarn sheets cause the broken yarn end to engage and become entangled or cling or adhere to an adjacent yarn rather than the broken yarn end falling freely out of the plane of the unbroken yarns. Immediate detection of any broken yarn end is essential for a number of reasons, as to avoid costly waste from production of defective fabric by the knitting machine into which the yarns are being fed, and to avoid rapid multiplication of yarn breakage as broken yarns cling to adjoining yarns and exert stresses thereon which would increase the time required to correct the breakage situation and place the knitting machines back in service. Various types of photoelectric broken end detectors have been devised, wherein a light beam is directed transversely across the width of the yarn sheet and is spaced slightly to one side of the plane of the yarn sheet, in association with some type of pressurized air tube located adjacent the opposite side of the yarn sheet directing air currents therethrough in a direction to propel any broken yarns through the light beam so as to vary the intensity thereof and produce an output signal from the photocell indicating detection of the broken yarn. U.S. Pat. No. 2,438,365 to Hepp and U.S. Pat. No. 2,711,093 to Edelman are typical of such detectors. However, such systems have been subject to considerable problems, due to the considerable vibration present in the textile machines and the difficulty of making such optical detection systems compatible with this vibration, the vulnerability of such signals to respond to spurious signals, the presence of particles of dust in lint in the region of the detecting system, and difficulties in obtaining a desirable signal-to-noise ratio. Also, it has been difficult to find appropriate places to locate both the sizable light-transmitting unit and the sizable light-receiving unit of such systems in the limited space available.

It has been found that warpers introduce particular problems, because they produce vibration which would be hard for conventional transmitter and receiver-type photoelectric systems to tolerate, and it has been most difficult to find appropriate locations where such conventional photoelectric systems could be mounted on a warper.

An object of the present invention is the provision of a novel broken end detector system for use with warpers, which provides a high signal-to-noise ratio and is capable of tolerating the vibration encountered in warpers, and which is constructed so as to be accommodated on a warper in a configuration suitable for mounting in the space available near the measuring roll of the warper.

The system of the present invention involves a detector head having a light source and a phototransistor located at one side of the yarn sheet, and a retroreflective target unit located at the other side of the yarn sheet, collectively producing a narrow light beam which is positioned very near the surface of the yarn sheet closely adjacent the warper measuring roll ar-

ranged so that a broken end traveling at several hundred yards per minute will go through the light beam and cause an electrical signal to be produced while the normal yarn sheet bends around the measuring roll and goes to the warper beam.

Other objects, advantages and capabilities of the present invention will become apparent from the following detailed description, taken in conjunction with the accompanying drawings illustrating a preferred embodiment of the invention.

BRIEF DESCRIPTION OF THE FIGURES

FIG. 1 is a perspective view of a typical warper having the broken end detector system of the present invention mounted thereon;

FIG. 2 is a somewhat diagrammatic, fragmentary vertical section view through the warper measuring roll and adjacent portions of the yarn sheet, taken along the line 2—2 of FIG. 1;

FIG. 3 is a block diagram of a complete broken end detector system of the present invention;

FIG. 4 is a diagrammatic view of the optical system of the present invention, with the detector head and the target unit shown in section, taken along the line 4—4 of FIG. 2; and

FIG. 5 is a schematic diagram of the preamplifier circuit employed in an embodiment of the detector head.

BRIEF DESCRIPTION OF A SPECIFIC EMBODIMENT

Referring to the drawings, wherein like reference characters designate corresponding parts throughout the several figures, the broken end detector system of the present invention includes the basic components of a detector head unit 10 and a target unit 11, which are designed to be mounted on the frame portions 12a and 12b in which the ends of the shaft of a warper measuring roll 13 of a typical warper 14 are journaled. In the typical warper, the supply yarns 15 are drawn to the measuring roll 13 where they bend around the measuring roll and travel as a yarn sheet, indicated at 16 to the warper beam 17. The optical system of the detector head unit 10 and target unit 11 is designed to produce a narrow light beam closely adjacent the surface of the yarn sheet 16 just beyond the point where the yarn sheet leaves the surface of the measuring roll 13 and begins its downwardly inclined travel to the warper beam 17. The monitoring light beam 18 is so located that a broken end of yarn, indicated at 19, in FIG. 2, which is traveling at several hundred yards per minute, will pass through the light beam 18 while the rest of the yarn making up the yarn sheet 16 travels around the measuring roll and down the inclined planar path 16a to the warper beam. By locating the monitoring light beam 18 at this location very close to the measuring roll, the broken end detector system is able to detect any broken ends that have been missed by other detection systems such as the drop wire type or any broken ends that have occurred between such detection systems and the measuring roll of the warper.

A narrow light beam 18 is desirable so that the broken end will block as much of the total light beam as possible in order to produce a good signal-to-noise ratio. When a broken end passes over the measuring roll 13, it may not go forward very far and thus not block very much of a large diameter light beam. This would result in a poor signal-to-noise ratio. By providing a narrow beam, a relatively small lens can be used in the reflector target unit which helps reduce the size of the target. A front surface mirror mounted at a 45° angle to change the direction of the light beam by 90° and a suitable hollow mounting block for each mirror is provided for each of the detector head and target unit to permit the head and target to be made in a configuration suitable for mounting in the space available near the measuring roll and to produce the small diameter light beam at the desired location relative to the yarn sheet and measuring roll.

The detector head unit 10 comprises an outer casing 20 of generally box-shaped configuration open at one end to receive an apertured plate member 21 forming a wall which is secured to the outer casing 20 by suitable screws. The plate member

21 is provided with an opening forming an optical aperture, which in the illustrated embodiment comprises a smaller diameter opening portion 21a and a larger diameter opening portion 21b, the latter being designed to receive and support a planoconcave lens 22, for example a 25 mm. focal length planoconcave lens, and a resilient O-ring 23. Secured to and extending above the plate member 21 as viewed in FIG. 4 is a mounting block 24 to be disposed within the casing 20 and rigidly support in proper alignment the lamp 25, a photodetector such as a phototransistor 26, and the semitransparent beam splitter mirror 27. The mounting block 24 is drilled to provide a first bore 28 which is axially aligned with the aperture portion 21a in the plate 21 and has a constricted opening at its upper end near the lamp 25, and to provide a second bore 29 extending at right angles to and communicating with the first bore 28 for receiving the phototransistor 26.

A mirror-mounting block 30 is secured to and extends downwardly from the plate member 21 as viewed in FIG. 4, and in the illustrated embodiment is provided with a first bore 31 which in the illustrated embodiment is formed of an upper bore section of smaller diameter corresponding to the diameter of the opening portion 21a and bore 28 and a lower bore section of larger diameter, and a second bore 32 extends through the front wall 30a of the mirror-mounting block and has its axis located at right angles to the bore 31. The mounting block has a surface at its lower end disposed at a 45° angle to the axes of the bores 31 and 32 on which a front surface mirror 33 is supported, for example, by a removable-mounting plate 33a fastened by screws to the block 30. A front planoconvex lens 34 is seated in an enlarged diameter portion of the bore 32 opening through the front surface 30a of the mounting block and is retained in position by an O-ring 35 and lens-mounting ring 36. The lens 34 may be an 87 mm. focal length lens and, in one satisfactory example, the lamp 25 is a tungsten lamp GE number 1876. Also located within the casing 20 and supported from the mounting block 24 is a small printed circuit board indicated at 37 providing a preamplifier circuit, the schematic diagram for which is illustrated in FIG. 5. The function of the preamplifier circuit 37 is to provide a low-input impedance at the output of the detector head without appreciably loading the phototransistor circuitry. It includes a calibrating resistor R2 for making the sensitivity of all the detector heads the same.

The retroreflective target unit 11 comprises an elongated mounting block 40 of rectangular external configuration having a first bore 41 therein extending vertically as illustrated in FIG. 4 from the upper end of the block 40 and joining at its lower end a second bore 42 arranged with its axis at right angles to the axis of the bore 41 and opening through the front wall 40a of the mounting block 40. The end portion of the second bore 42 opening through the front surface 40a is slightly enlarged in diameter to provide a seat for supporting a planoconvex lens 43 which is held in position by an O-ring 44 and a lens-mounting ring 45 secured, for example, by screws to the mounting block 40. A closure plate 46 is removably secured, as by screws, to the top of the mounting block 40 as viewed in FIG. 4, to support a panel or sheet of retroreflective tape, for example the retroreflective tape manufactured under the trade name SCOTCHLITE, by Minnesota Mining and Manufacturing Company, at the upper end of the first bore 41. The retroreflective tape has the property of returning light along the same path as the incidence light rays regardless of the angle of incidence. The lower end of the block 40 is also provided with a surface inclined at 45° to the axes of bores 41 and 42, against which a front surface mirror 48 is mounted, for example by removable mounting plate 48a fastened to the block by screws.

The detector head unit 10 is mounted to one side of the yarn sheet on portions of the warper frame, for example as illustrated in FIG. 1, to produce a monitoring light beam 18 positioned very near the surface of the measuring roll 13 of the warper. The lamp 25 serves as the light source, and light from this lamp passes through the beam splitter mirror 27 to the

planoconcave lens 22. The lens 22 produces a virtual image of the lamp filament greatly reduced in size, which approaches a point source, for the front planoconvex lens 34. The light beam which passes through the planoconcave lens 22 is reflected by the front surface mirror 33, mounted at 45° to the axis of the light beam, to the front lens 34. The lens 34 in the preferred example is a 87 mm. focal length lens, and in conjunction with the planoconcave lens 22 produces a small and fairly uniform diameter light beam of a length suitable for use on the warper.

The light beam 18 projected across the width of the yarn sheet from the detector head unit 10 is positioned approximately in the center of the planoconvex lens 43 of the target unit 11 and passes through the lens 43 to the surface of the front surface mirror 48 of the target unit 11 which is mounted at a 45° angle to the axis of the light beam and to the axes of the first and second bores 41 and 42. The light beam is reflected from the front surface mirror 48 to the retroreflective tape 47 mounted between the removable plate 46 and the mounting block 40. In the preferred example, the focal length of the planoconvex lens 43 is 100 mm. and would normally focus an image of the light source filament on the tape. However, the dimensions of the target unit are chosen so that the light path from the lens 43 to the tape 47 is about 87.5 mm. which causes the image to be badly out of focus and much larger than it would be at a distance of 100 mm. By having the light spot cover more of the tape, small nonuniformities in the tape are averaged out. This allows more movement of the light spot on the tape such as may be caused by the vibration of the warper, than would otherwise be possible. Nonuniform tape would cause noise signals to be generated unless they were averaged out by using a sufficient area of the tape.

The light reaching the retroreflective tape 47 in the target unit is redirected back along the incident light ray path and returned to the detector head unit where it passes through the front planoconvex lens 34, reflects off the front surface mirror 33, passes through the planoconcave lens 22, and is reflected off the beam splitter mirror 27 to the phototransistor 26.

It is desirable that the light beam be fairly constant in diameter from the detector head to the reflector in order to have uniform sensitivity and to maintain a constant distance from the light beam to the measuring roll. The use of the optical system of the present invention permits a broken end detector installation on a warper near the measuring roll, which produces a narrow light beam having good uniformity and producing a good signal-to-noise ratio. If the lens 43 had not been used with the target unit 11, much of the reflected light from the retroreflective tape 47 would never have returned to the detector head due to the fact that the tape 47 is not a perfect retroreflector and produces considerable divergence of the light beam at the distances involved. By positioning lens 43 near the retroreflective tape 47, divergence of the light beam is kept to a minimum, resulting in much more light being returned to the detector head. This produces a good signal-to-noise ratio electrically with very little loss of high-frequency response. Good high-frequency response is necessary when high-speed warpers and small diameter yarns are being used. High-frequency loss at low-light levels is caused by the use of a large load resistor with the phototransistor or other type photodetector in order to get a usable electrical signal and the high resistance of the photodetector plus the associated capacitances. The optical system described above provides a sufficiently high-light level to avoid this high-frequency loss problem.

It will be appreciated that when a broken end, such as indicated at 19 in FIG. 2, passes through the monitoring light beam 18 located adjacent the yarn sheet near the measuring roll 13 at a location where broken ends will be thrown through the monitoring beam as the normal yarn sheet bends around the measuring roll, the light intensity of the beam returning through the lens 34 and 22 and reflected by the beam splitting mirror 27 to the phototransistor 26 will be momentarily diminished, producing an electrical signal which will be am-

plified by the preamplifier 37 in the detector head casing 20. This signal is fed to a main amplifier 50 which in turn causes a relay driver 51 to actuate a control relay 52 for stopping the warper or producing an alarm signal.

What is claimed is:

1. In yarn inspection apparatus for a warper for detecting broken yarns in a yarn sheet extending in a feed plane between a measuring roll and a warper beam by detection of broken yarn ends thrown to one side of the feed plane through a selected inspection axis extending transversely of the yarn sheet immediately downstream from the measuring roll as the yarn sheet turns about the latter; an optical system producing a monitoring light beam along said inspection axis and spanning the yarn sheet comprising a detector head mounted at one end of the measuring roll outwardly adjacent one edge of the yarn sheet; said detector head including a lamp having a filament of selected size for producing light, a semitransparent mirror, and a first lens located along a first optical axis segment, a first reflecting mirror inclined at 45° to said first optical axis segment and to a second optical axis segment paralleling said inspection axis, and a second lens located along said second optical axis segment, said lenses and first reflecting mirror coacting to project light from said lamp passing through said semitransparent mirror and lenses and redirected 90° by said first reflecting mirror in a first direction in a narrow cross section monitoring beam along said inspection axis, said detector head including a photodetector located along a branch optical axis intersecting the first optical axis at said semitransparent mirror to receive returning light passing through said lenses toward said semitransparent mirror in a direction opposite said first direction; a retroreflective target assembly mounted at the opposite end of the measuring roll outwardly adjacent the opposite edge of the yarn sheet along said inspection axis, the target assembly including a target lens in the path of incident rays of the beam projected along the inspection axis by said first and second lenses, a second reflecting mirror inclined at 45° to the axis of said target lens to redirect light passing through the latter along a third optical axis segment at right angles to said inspection axis, a substantially flat surface of retroreflective material of selected area perpendicular to said third optical axis segment facing the incident rays projected from said detector head for retroreflecting incident rays of said beam striking said retroreflective material back along their incident ray paths, said detector head lenses providing a spot of light on the target lens having a maximum dimension which is only a fraction of the diameter of the target lens.

2. In yarn inspection apparatus an optical system as defined in claim 1, wherein said detector head includes a substantially rectangular casing housing the lamp and phototransistor and said first lens and semitransparent mirror, and a hollow mirror mounting block extending therefrom having a first bore along said first optical axis segment terminating in a surface at 45°

thereto supporting said first reflecting mirror and having a second bore perpendicularly intersecting the first bore at said first reflecting mirror, said second lens being supported across said second bore.

3. In yarn inspection apparatus, an optical system as defined in claim 1, wherein said first lens is a planoconcave lens disposed along said first optical axis segment for receiving light from said lamp transmitted through said semitransparent mirror and said second lens is a planoconvex lens spaced along said second optical axis segment from said second reflecting mirror toward said target assembly for collecting light from the planoconcave lens and focusing the same on said target lens.

4. In yarn inspection apparatus, an optical system as defined in claim 2, wherein said first lens is a planoconcave lens disposed along said first optical axis segment for receiving light from said lamp transmitted through said semitransparent mirror and said second lens is a planoconvex lens spaced along said second optical axis segment from said second reflecting mirror toward said target assembly for collecting light from the planoconcave lens and focusing the same on said target lens.

5. In yarn inspection apparatus, an optical system as defined in claim 1, wherein the light path length between said target lens and said retroreflective surface is less than the focal length of said target lens to produce an out-of-focus image at the retroreflective surface of the light beam spot reaching said target lens.

6. In yarn inspection apparatus, an optical system as defined in claim 2, wherein the light path length between said target lens and said retroreflective surface is less than the focal length of said target lens to produce an out-of-focus image at the retroreflective surface of the light beam spot reaching said target lens.

7. In yarn inspection apparatus, an optical system as defined in claim 3, wherein the light path length between said target lens and said retroreflective surface is less than the focal length of said target lens to produce an out-of-focus image at the retroreflective surface of the light beam spot reaching said target lens.

8. In yarn inspection apparatus, an optical system as defined in claim 4, wherein the light path length between said target lens and said retroreflective surface is less than the focal length of said target lens to produce an out-of-focus image at the retroreflective surface of the light beam spot reaching said target lens.

9. In yarn inspection apparatus, an optical system as defined in claim 3, wherein said planoconcave lens has a focal length of about 25 mm. and said planoconvex lens of said detector head has a focal length of about 87 mm.

10. In yarn inspection apparatus, an optical system as defined in claim 5 wherein said target lens has a focal length of about 100 mm.

* * * * *

55

60

65

70

75