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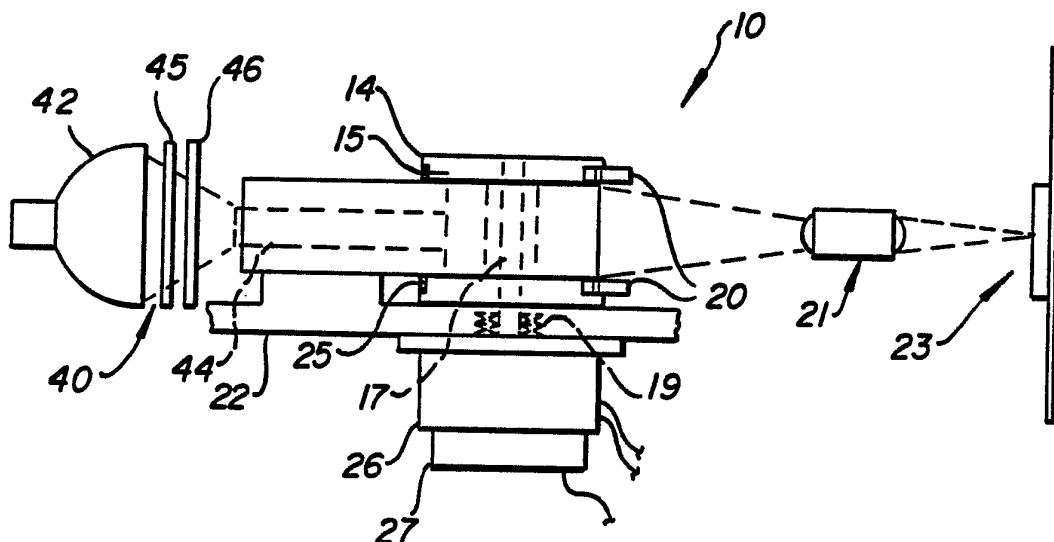
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(54) Title: FILM SCANNER



(57) Abstract

A film scanner is disclosed which comprises a dynamic film gate (11). The film gate (11) includes a pair of capstans (12) for supporting the film (16) at an imaging station (18) and a pair of belts (20) which clamp the film against the capstans. The capstans (12) are driven to advance the film through the imaging station (18). An integrating cylinder (41), located between the capstans (12), produces a line of light on the film (16), and light transmitted through the film is imaged onto a linear CCD image sensor (23). In order to provide a more efficient drive mechanism for the capstans (12), the drive shaft (17) for the capstans (12) is incorporated in the integrating cylinder (41).

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⁺ It is not yet known for which States of the former Soviet Union any designation of the Soviet Union has effect.

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FILM SCANNER

This invention relates to a film scanner,
and more particularly, to such a scanner having a
5 dynamic film gate.

In various types of imaging apparatus, a
photographic film must be clamped in a workstation
while a particular operation is performed on the
film. In certain types of apparatus, for example,
10 film scanners, the film must be held extremely flat
in order for an image on the film to be recorded
properly. One problem in maintaining the film flat
is that photographic film has a natural curl due to
an emulsion coated on one side of the film. In one
15 known type of film gate, a film is clamped against a
flat platen, and the film and platen are moved
relative to an image sensor to scan the film. In the
use of such a film gate, the film must be clamped and
unclamped for each film frame, and the film platen
20 must be moved to a home position after each frame is
scanned. Such a technique requires a significant
number of moving parts, and it is relatively slow.
Further, devices of this type are likely to scratch
the film, and the motion of the platen introduces the
25 possibility of vibrations into the system.

It is also known to use a rotary film gate,
as disclosed, for example, in U.S. Pat. No.
4,281,351. U.S. Pat. No. 4,281,351 discloses
apparatus for the line-by-line optical scanning of a
30 film. In order to reduce friction of the film
adjacent the scanning region, rollers or endless
belts support the film at positions on the film
outside of the film frames. A disadvantage of the
apparatus disclosed in this patent is that the only
35 means for maintaining the film flat in the scan
region is through the tension in the film. Thus, any

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irregular motion in the drive system is transmitted to the film, and this tends to produce blurring in the scanned image. A further disadvantage is that elements of the drive mechanism for the rotary film gate are arranged such that a relatively complex optical arrangement must be used to provide light to an imaging station in the film gate.

It is an object of the present invention to overcome the problems in the prior art discussed above and to provide an improved film scanner.

In accordance with the present invention, there is provided a film scanner comprising: means for supporting a film at an imaging station; illumination means for producing a line of light on the film as it is contacted by the supporting means, the illumination means including an integrating cylinder having a cavity therein; and means for driving the supporting means to advance the film relative to the illumination means, the driving means having a portion thereof located in the cavity.

In one embodiment of the present invention, the film scanner comprises a pair of capstans which support the film as it passes through an imaging station. The film is pressed against the capstans by a pair of belts, and the capstans are driven to advance the film through the imaging station. An integrating cylinder provides a line of light on the film at the imaging station, and light transmitted through the film is imaged onto a CCD image sensor. The integrating cylinder is located between the capstans and is coaxial with the two capstans. The integrating cylinder includes a hollow baffle along its longitudinal axis, and a drive shaft for the capstans passes through the baffle.

An advantage of the present invention is that the film is advanced at a constant rate through

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the imaging station. The film can be driven at a selected scan speed and at a fast frame-to-frame advance, since the same motion serves to scan the film and advance the film to the next scan area.

- 5 Belts provide for dynamic clamping of the film in the imaging station, and use of the belts eliminates the need for tensioning the film in the imaging station. Further, the belts are arranged to wrap the film around a portion of the rollers in a direction to
10 remove the inherent curl of the film; this makes the film very flat in the imaging station, and as a result, imaging optics having a smaller depth of field can be used. The drive mechanism for the capstans is integrated within the illumination source
15 in order to provide a very compact and efficient device.

Embodiments of the present invention will now be described, by way of example, with reference to the accompanying drawings in which:

- 20 FIG. 1 is a front elevational view of the film scanner of the present invention;

FIG. 2 is a top plan view of the film scanner shown in FIG. 1;

- FIG. 3 is an enlarged front elevational view
25 showing the integrating cylinder and the film gate;

FIG. 4 is a top plan view of the elements shown in FIG. 3; and

- FIG. 5 is an exploded perspective view of the integrating cylinder and the capstans used in the
30 film scanner.

With reference to FIG. 1, there is shown a film scanner 10 which is constructed in accordance with the present invention. Film scanner 10 comprises a dynamic film gate 11 which is adapted to
35 support a film 16 as it is moved through an imaging station indicated at 18, an illumination source 40

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which is adapted to provide a line source of light at station 18, an imaging lens 21, and a linear CCD image sensor 23.

Film gate 11 comprises a pair of capstans 12 and a pair of belts 20 which are adapted to clamp the film 16 against capstans 12 as the film is advanced through station 18. As shown in FIG. 2, each of the capstans 12 includes an outer cylindrical portion 14 and an inner cylindrical portion 15 of a reduced diameter. The capstans 12 are spaced such that the film 16 rides on the portions 15.

As shown in FIGS. 2 and 4, inner cylindrical portions 15 include a coating 25 of a material having a high coefficient of friction, such as urethane. The velocity of high resolution scanners, such as scanner 10, must be closely controlled in order to avoid perturbations which will cause artifacts in the output media. Since scanner 10 drives the film 16 by means of the pressure applied by belts 20 at the belt-film interface, slippage at this interface would cause a speed variation. Further, if the coating 25 is too thick and/or not of sufficient hardness, the coating could deflect under belt load which would cause a slight change in capstan radius. Such a change in radius would cause a velocity change in the nip area. Thus, it is important that a relatively thin coating 25 of a proper hardness be used on portions 15 of capstans 12. When the hardness of the coating 25 is increased, the coefficient of friction is decreased, and an increase of the load on the belts 20 is required. If the load on the belts 20 is too high, belt life and motor performance can be adversely affected. One suitable coating 25 for portions 15 is a dual durometer coating which is less than 0.020 inch thick.

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Capstans 12 are driven by means of a drive shaft 17 which is supported in a bearing 19 in scanner support structure 22. Drive shaft 17 is connected to a drive motor 26 (FIG. 2). Motor 26 can be, for example, a bidirectional DC servo motor of a type well known in the art. Motor 26 is adapted to operate under an electronic servo control (not shown) which receives position signals from an encoder 27 attached to shaft 17.

Each of the belts 20 is trained around idler pulleys 30 which are mounted for rotation in a portion (not shown) of support structure 22. Pulleys 30 are positioned such that a belt 20 of the proper length will provide a wrap angle α (FIG. 3) on a capstan 12 of an amount sufficient to buckle the film and to give enough traction to drive the film. Each belt 20 will clamp the film 16 against a capstan 12 with enough force so that the film will be held in the desired position and will be moved by the capstan as the capstan is driven by motor 26.

Each belt 20 is relatively narrow so that it only contacts an edge of the film 16 and does not extend into the image area. The belts 20 can be constructed of a fiberglass core, or similar non-stretch material, which is coated on both sides with a urethane or similar high friction material. The belts 20 supply the dynamic clamping of the film to the capstans 12, and the coating on belts 20 is sufficiently elastic to ensure that any perturbations in the system will not be transferred to the image sensor. Alternatively, the belts 20 can be formed of a stretch material such as urethane.

When motor 26 is actuated, capstans 12 will be rotated at a selected angular velocity and direction, for example, in the direction of arrow 33 (FIG. 1). The encoder 27 mirrors the velocity of

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motor 26 and supplies signals to the servo controller (not shown). When no film is present in the scanner 10, the belts 20, which are in direct contact with the high coefficient of friction material 25 on capstans 12, track the arc imparted by the capstans 12 over the angle α . Nips 28 and 29 are formed between the belts 20 and the capstans 12 at the points where the belts 20 begin to withdraw from the capstans 12. When a film 16 is fed to, for example, nip 28, a pinching action on the film 16 will capture the film 16 and pull it into the interface between belts 20 and capstans 12. The film 16 will be advanced through the film gate 11 in the direction of arrow 33 at a constant speed which is controlled by the speed of motor 26.

Illumination source 40 is mounted between capstans 12 and is adapted to provide a line of illumination at the imaging station 18. Light transmitted through the film is imaged onto linear CCD sensor 23 by means of lens 21. The illumination source 40 includes an integrating cylinder 41 and a lamp 42 such as a 24 volt DC tungsten halogen lamp, type ELC, sold by General Electric Co. Light from lamp 42 is delivered into a cavity 43 in cylinder 41 by means of a light pipe 44 which permits lamp 42 and other optical elements to be displaced from the cavity 43. Light from lamp 42 is delivered to light pipe 44 through a hot mirror (IR reflector) 45 and an IR absorber 46. A suitable light pipe for introducing light into cavity 43 is a rod which is formed from fused quartz or a fused silica material and has a very high transmission, for example, a fused quartz rod obtainable from Heraeus-Amersil, Inc.

An important feature of the present invention is the provision for the drive shaft 17 for capstans 12 to be incorporated in the integrating

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cylinder 41. As best shown in FIG. 5, integrating cylinder 41 includes a hollow baffle 47 which is disposed along a longitudinal axis 46 of cavity 45. Baffle 47 is supported in end plates 49 of cylinder 41. A spacer 50 disposed in baffle 47 determines the spacing of capstans 12 for the type of film being scanned. Drive shaft 17 passes through spacer 50 and is fixed to capstans 12. As a result of incorporating a portion the capstan drive in the cylinder 41, the scanner 10 can be very compact, and light can be provided to the film in the imaging station 18 in a simple and efficient manner.

The integrating cylinder 41 can be constructed generally as disclosed in U.S. Pat. No. 4,868,383, to Kurtz et al., granted September 19, 1989. A preferred form of integrating cylinder for use in the present invention, however, is disclosed in the aforementioned U.S. Patent Application, entitled "Linear Light Source." The integrating cylinder disclosed in this patent application produces a line of diffuse illumination which has a uniform linear and angular distribution.

Image sensor 23 can be a linear CCD image sensor such as a No. KLI-5001A/B sensor, manufactured by Eastman Kodak Co., Rochester, New York. The image sensor can also include an array which consists of three separate photodiode linear arrays for capturing red, green, and blue signals. The image sensor 23 must be precisely located relative to scanning station 18, and to this end, it can be supported in a mount as disclosed in U.S. Patent No. 4,972,079. Signals from image sensor 23 can be processed in a well known manner in order to produce an electronic record of the images on film 16.

In the operation of film scanner 10, a film 16, for example, a 35 mm film, is threaded into the

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nip 28 in gate 11, and the film is advanced therein by means of the cooperative action of belts 20 and capstans 12. As the film 16 is advanced, the image is scanned in a page scan direction, and the line
5 scan is performed by the clocking of the individual image elements in the sensor 23. When an end of film 16 reaches nip 29, the film 16 will move out of the gate 11, and the film can be recovered.

Alternatively, motor 26 can be reversed just before
10 the end reaches nip 29, and the film can be returned to its starting position.

The invention has been described in detail with particular reference to the preferred embodiments thereof, but it will be understood that
15 variations and modifications can be effected within the spirit and scope of the invention. For example, although scanner 10 has been described herein with reference to the scanning of film, it will be apparent that other webs of material, such as paper,
20 could also be scanned to record information contained thereon.

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Claims:

1. A film scanner comprising:
means (12, 20) for supporting a film (16) at
an imaging station (18);
5 illumination means (40) for producing a line
of light on said film (16) as it is contacted by said
supporting means (12, 20), said illumination means
(40) including an integrating cylinder (41) having a
cavity (43) therein; and
10 means (26, 17) for driving said supporting
means (12, 20) to advance the film (16) relative to
said illumination means (40), said driving means
having a portion (17) thereof located in said cavity
(43).
- 15 2. A film scanner, as defined in claim 1,
wherein the portion of said driving means (26,17)
located in said cavity (43) is a drive shaft (17).
3. A film scanner, as defined in claim 2,
wherein said driving means (26,17) includes a motor
20 (26) connected to said shaft (17).
4. A film scanner, as defined in claim 2,
wherein said integrating cylinder (41) has a baffle
(47) in said cavity (43), and said shaft (17) is in
said baffle (47).
- 25 5. A film scanner, as defined in claim 1,
wherein said integrating cylinder (41) is located
adjacent said supporting means (12).
6. A film scanner, as defined in claim 1,
wherein said supporting means (12,20) includes
30 capstan means (12).
7. A film scanner, as defined in claim 6,
wherein said capstan means includes two capstans (12)
which are spaced to contact opposite edges of said
film (16).
- 35 8. A film scanner, as defined in claim 7,
wherein said cylinder (41) is located between said
capstans (12) and coaxial therewith.

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9. A film scanner, as defined in claim 7, wherein said supporting means (12,20) includes two belts (20) which are spaced to contact opposite edges of said film (16).

5 10. A film scanner, as defined in claim 9, wherein a first belt (20) is operable to hold film (16) onto one of said capstans (12).

11. A film scanner, as defined in claim 10, wherein a second belt (20) is operable to hold film
10 (16) onto the other of said capstans (12).

12. A film scanner, as defined in claim 11, wherein said belts (20) are driven by said capstans (12).

13. A film scanner comprising:
15 a pair of spaced-apart capstans (12) for supporting a film (16) at an imaging station (18);
belt means (20) for urging the film (16) against said capstans (12), said belt means (20) including a first endless belt (20) which urges one
20 edge of said film (16) against one of said capstans (12) and a second endless belt (20) which urges an opposite edge of said film (16) against the other of said capstans (12);

means (26,17) for moving said capstans (12)
25 and said belts (20) to advance film (16) held therebetween relative to said imaging station (18);
and

illumination means (40) for producing a line of light on said film (16) at said imaging station
30 (18), said illuminating means (40) including an integrating cylinder (40) having a cavity (43) therein which is generally coaxial with said capstans (12); and

an image sensor (23) for receiving light
35 transmitted through said film (16).

14. A film scanner, as defined in claim 13, wherein means (21) are provided for imaging light

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transmitted through said film (16) onto said sensor (23).

15 15. A film scanner, as defined in claim 13, wherein said moving means (26,17) includes means for driving said capstans (12).

16. A film scanner, as defined in claim 15, wherein said means for driving said capstans (12) includes a drive shaft (17) which passes through said cavity (43).

10 17. A film scanner, as defined in claim 16, wherein a baffle (47) in said cavity (43) surrounds said drive shaft (17).

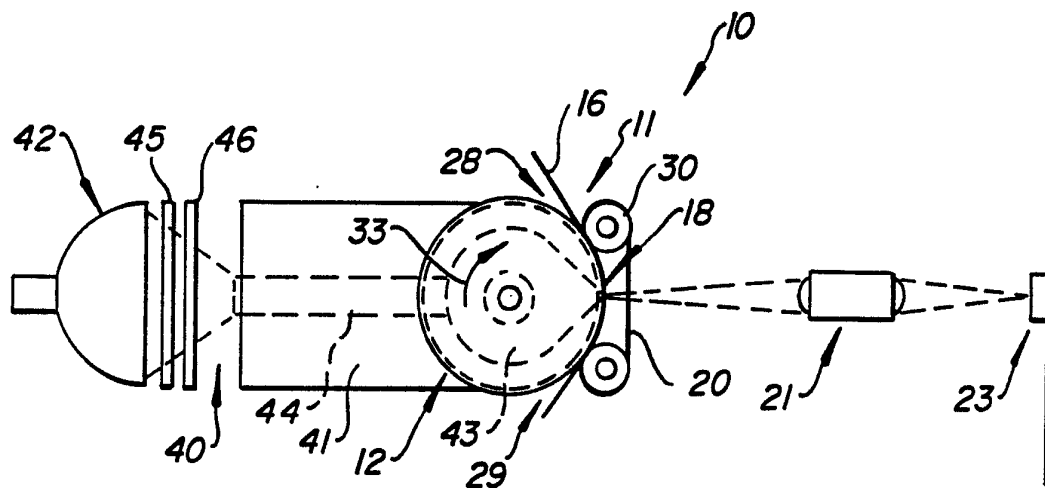
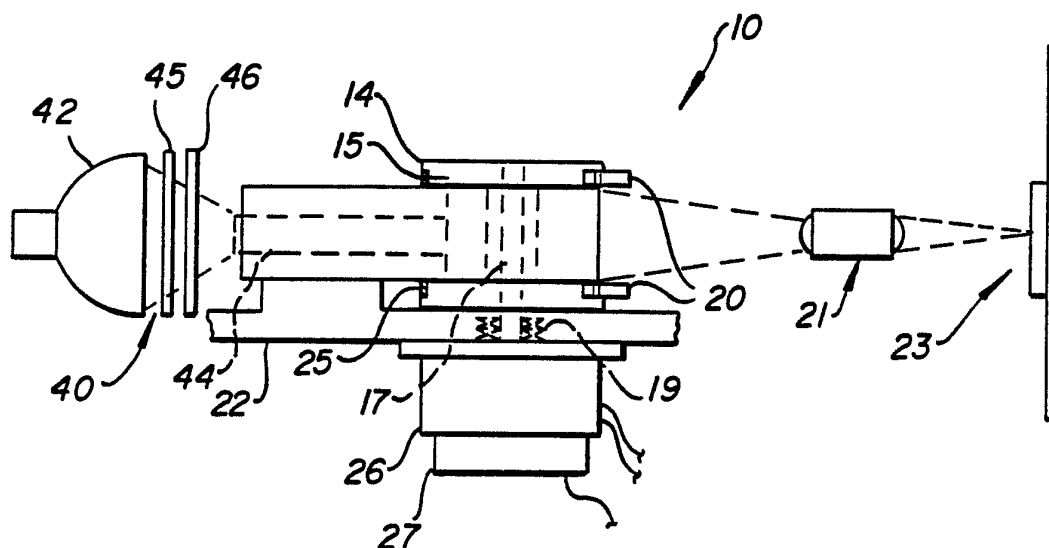
18. A film scanner, as defined in claim 13, wherein each of said capstans (12) includes a first portion (14) of one diameter and a second portion (15) of a diameter less than said one diameter, and said film (16) is supported on said second portions (15).

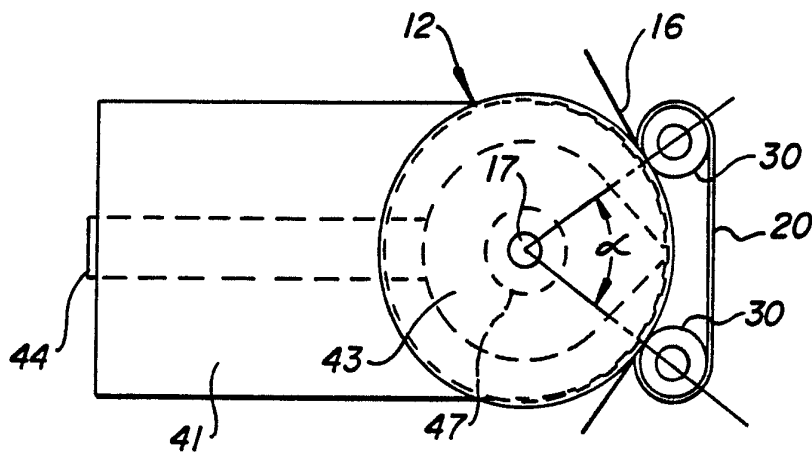
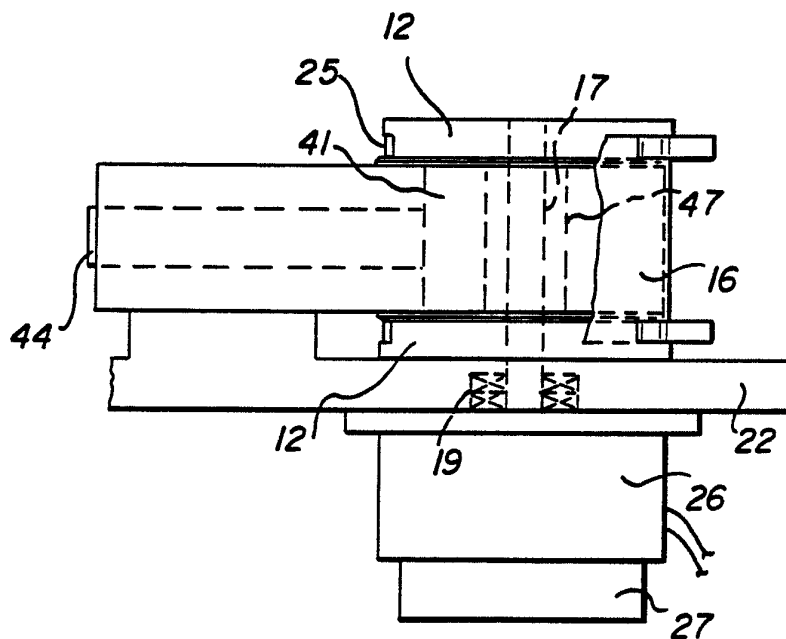
20 19. A film scanner, as defined in claim 18, wherein each of said belts (20) is adapted to extend around a predetermined circumferential portion (α) of a capstan (12) in order to clamp said film (16) against the capstan (12) in said circumferential portion.

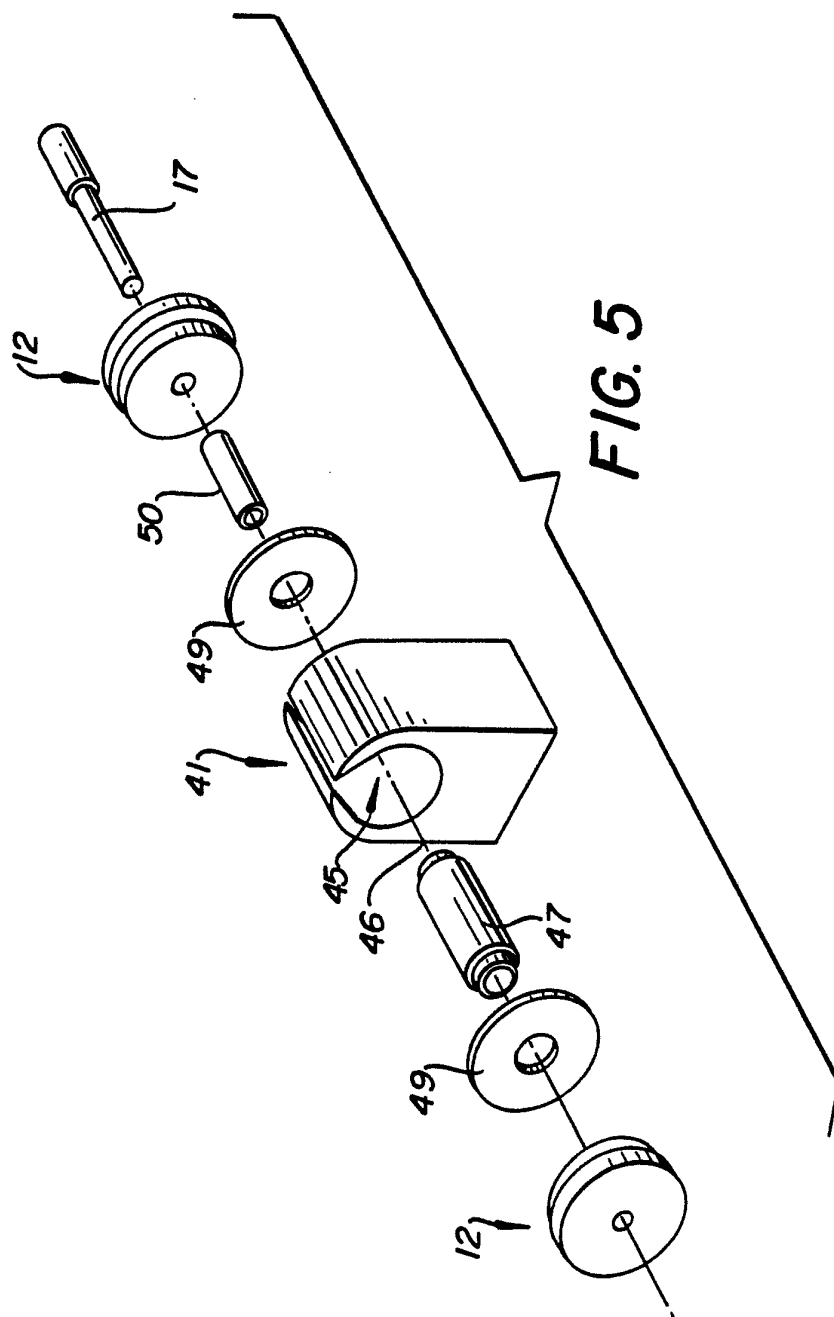
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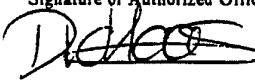
**FIG. 1****FIG. 2**

**FIG. 3****FIG. 4**



INTERNATIONAL SEARCH REPORT

International Application No PCT/US 91/05124

I. CLASSIFICATION OF SUBJECT MATTER (If several classification symbols apply, indicate all) ⁶		
According to International Patent Classification (IPC) or to both National Classification and IPC Int.C1.5 H 04 N 3/38		
II. FIELDS SEARCHED		
Minimum Documentation Searched ⁷		
Classification System	Classification Symbols	
Int.C1.5	G 03 B H 04 N	
Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched ⁸		
III. DOCUMENTS CONSIDERED TO BE RELEVANT⁹		
Category ¹⁰	Citation of Document, ¹¹ with indication, where appropriate, of the relevant passages ¹²	Relevant to Claim No. ¹³
A	DE,A,1965097 (BBC) 16 July 1970, see page 2, line 35 - page 4, line 1; figures 1,2 ---	1,13
A	US,A,4868383 (KURTZ et al.) 19 September 1989, see column 1, lines 24-29; column 1, lines 44-56; column 2, lines 47-68; column 5, lines 6-23; figures 1,12 (cited in the application) ---	1,13
A	GB,A,2089060 (PHILIPS) 16 June 1982, see page 1, line 79 - page 2, line 3; page 2, lines 40-53; figure 1 ---	1,13
A	US,A,4281351 (POETSCH et al.) 28 July 1981, see column 2, lines 20-50; column 3, lines 40-65; claim 1; figures 1,4-6 (cited in the application) -----	1,13
¹⁰ Special categories of cited documents: "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier document but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art. "&" document member of the same patent family		
IV. CERTIFICATION		
Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report	
30-10-1991	5. 12. 91	
International Searching Authority	Signature of Authorized Officer	
EUROPEAN PATENT OFFICE	 Danielle van der Haas	

**ANNEX TO THE INTERNATIONAL SEARCH REPORT
ON INTERNATIONAL PATENT APPLICATION NO.**

US 9105124
SA 50287

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report. The members are as contained in the European Patent Office EDP file on 27/11/91
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
DE-A- 1965097	16-07-70	FR-A- 2027615 GB-A- 1282481	02-10-70 19-07-72
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