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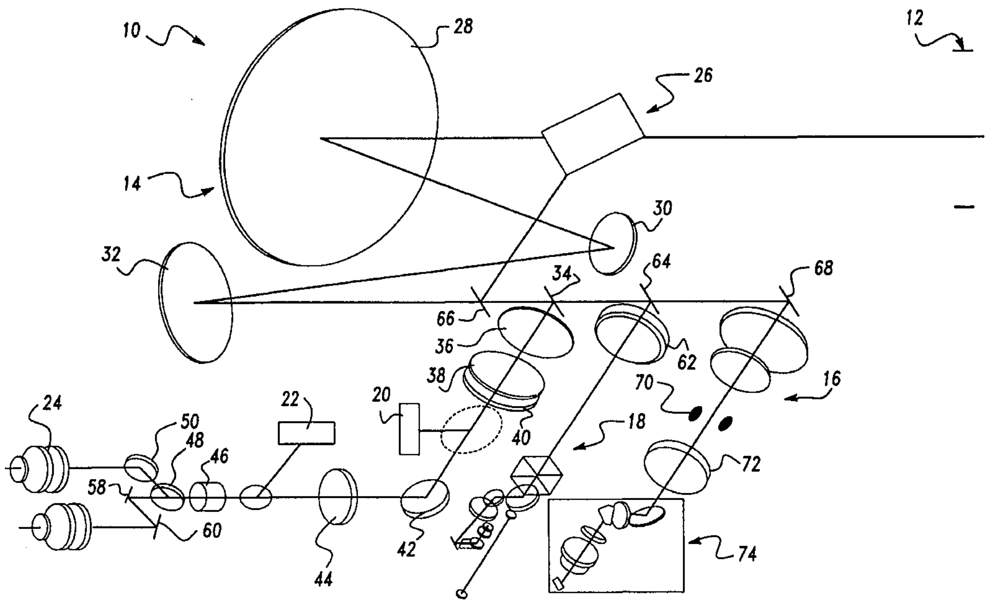

(57) Abstract

An imaging system (10) to interpret a plurality of signals has a single aperture (12) and a single telescope (14) to receive and transmit signals. The telescope (14) is aligned with the aperture (12). A plurality of sensor elements (16, 18, 20, 22, 24) is aligned with the telescope (14) to receive and transmit signals between the telescope (14) and sensor elements (16, 18, 20, 22, 24). The single telescope receives and transmits all signals regardless of the varying wavelengths for the plurality of sensing elements (16, 18, 20, 22, 24).

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SINGLE APERTURE THERMAL IMAGER, DIRECT VIEW, TV SIGHT AND LASER RANGING SYSTEM SUBSYSTEMS INCLUDING OPTICS, COMPONENTS, DISPLAYS, ARCHITECTURE WITH GPS (GLOBAL POSITIONING SENSOR)

Background of the Invention

1. Technical Field

The present invention relates to an imaging system and, more particularly, to a system which utilizes a single aperture and single telescope to generate a plurality of sensor functions.

2. Discussion

When sensing a target, it is desirable to have an image of the target as well as an accurate distance or range between the target and the sensor operator. Optical systems exist which provide either a visual image (direct or TV) or thermal image, as well as a range between the target and the operator. Ordinarily, these systems include a separate visible telescope, a separate thermal imager, and if a laser is used, often a separate laser telescope. Also, each of these subsystems require its own aperture. The requirement of separate telescopes for each sensor is due to the fact that the wavelength for each of the sensors is different and thus has varying requirements. Accordingly, the optical system is large, bulky, heavy and expensive since each subsystem requires its own telescope. In addition, a major portion of the optical elements are refractive adding additional weight to the system. With this multiple aperture sensor approach, the ultimate goal of achieving a common pointing direction for all of the various subsystems is very difficult if not impossible to achieve and maintain.

Summary of the Invention

Accordingly, the new and improved reflective imaging system of the present invention provides the art with a system which utilizes a single aperture as well as a single telescope to generate a plurality of images. The present invention provides a single reflective telescope capable of providing multiple wavelengths which, in turn, are utilized by various subsystems. The single telescope with a plurality of subsystems enables the system to be smaller, lightweight, and more transportable than previous designs. The present invention enables signal transmitting and receiving through the same telescope and through a single aperture. Thus, in the present invention, if a laser is used, the system enables the power of the laser to be very low. Also, the present invention may include a global positioning system which may be coupled with laser range data to generate position of a target from the transformation of the laser range data and the global positioning system data.

In the preferred embodiment of the invention, the imaging system includes a single aperture and a single telescope to receive and transmit signals. The telescope is aligned with the aperture. A plurality of sensor elements are aligned with the telescope to receive and transmit signals between the telescope and sensor elements. The single telescope receives and transmits all signals for the plurality of sensor elements regardless of the wavelengths of the sensor elements. Also, a control mechanism may be included to operate the sensor elements as desired by an operator.

Generally, the telescope is an afocal three-mirror anastigmat telescope. The plurality of sensor elements may be selected from a group including a charge couple device, high speed visible array, such as a video camera, a high speed infrared array, a laser designator, laser range finder, direct view optics, such as a binocular eye piece, or a cathode ray tube display. Also, a switching element may be included to change the optical system between a wide field of view for search and acquisition operations and a narrow field of view for identification and tracking operations.

From the subsequent description and appended claims, taken in conjunction with the accompanying drawings, other objects and advantages of the present invention will become apparent to those skilled in the art.

Brief Description of the Drawings

In the accompanying drawings:

Figure 1 is a schematic view of the present invention with a plurality of sensor elements.

Figure 2 is a schematic view like that of Figure 1 of an alternative embodiment of the present invention.

Figure 3 is a schematic view like Figure 1 of an additional alternate embodiment of the present invention.

Figure 4 is a schematic block diagram of the present invention.

Figure 5 is a schematic block diagram of an additional embodiment of the present invention.

Figure 6 is a schematic block diagram of an additional embodiment of the present invention.

Figure 7 is a perspective conceptual layout of an imaging system in accordance with the present invention.

Figure 8 is a perspective conceptual layout of an alternate embodiment of the present invention.

Figure 9 is a perspective view of a conceptual layout of an additional embodiment of the present invention.

Figure 10 is a perspective view of a conceptual layout of an alternate embodiment of the present invention.

Detailed Description of the Preferred Embodiment

Turning to the figures, an imaging system is illustrated and designated with the reference numeral 10. The system includes a single aperture 12, a reflective telescope 14, and a plurality of sensor elements 16, 18, 20, 22, 24. Also, a switching mechanism 26 is present to change the system from a wide field of view to a narrow field of view.

Turning to Figure 1, the aperture 12 is ordinarily large approaching an eight-inch diameter. This is useful in longwave infrared applications. Radiation passes through the aperture 12 into and out of the system.

The telescope 14 is preferably an afocal three-mirror anastigmat telescope. The three-mirror anastigmat telescope includes a primary mirror 28, a secondary mirror 30, and a tertiary mirror 32. The primary mirror 28 is a positive power mirror and is generally a higher order aspheric mirror. The secondary mirror 30 is positioned off-axis with respect to a central axis. The secondary mirror 30 is a negative power mirror and is generally a higher order aspheric mirror. The tertiary mirror 32 is a positive power mirror. The tertiary mirror is generally a higher order aspheric mirror.

In Figures 1-3, radiation transmits an image of an object to be viewed to the primary mirror 28. The radiation is reflected from the primary mirror 28 to the secondary mirror 30. The secondary mirror 30 receives and reflects the radiation to the tertiary mirror 32. The radiation is then passed through an optical element such as 34 to one of the sensor elements such as 20.

The sensor element 20 is generally a charge couple device or other high speed visible array or television camera. Also, a plurality of optical elements such as lenses 36, 38 and 40 may be used to focus the radiation to the sensor 20. At the discretion of the operator, the radiation may be directed towards another optical element 42 which directs the radiation towards the direct view optical system 24. Additional optical elements 44, 46, 48 and 50, as well as fold mirrors 58 and 60, direct the radiation to the direct view optics 24 such as a binocular eyepiece.

A laser 18 may utilize an optical element 62 to expand the laser beam. An optical element 64 directs the laser beam towards the three-mirror anastigmat telescope. The laser beam is then aimed at the target through the aperture 12.

An additional optical element 68 receives radiation from the three-mirror anastigmat telescope and reflects it to the forward looking infrared (FLIR) imager array and dewar. The imager may include a thermal reference source 70 as well as a telescope 72. The image may be additionally reflected to a scanning imager system 74.

Referring to Figure 2, the elements which are the same as those in Figure 1 are designated with the same reference numerals. The differences between Figure 1 and Figure 2 is that the aperture 12′, while being large, has a diameter of approximately six inches. Also, the forward looking infrared (FLIR) imager 16′ is different from that in Figure 1. In Figure 2, the forward looking infrared (FLIR) imager is an all-reflective imager which includes a plurality of reflective element mirrors to reflect the radiation to a staring detector array.

Figure 3 is substantially similar to Figure 2 with the same reference numerals identifying the same elements. The difference between Figure 2 and Figure 3 is that the forward looking infrared (FLIR) imager 16″ includes a plurality of refractive elements to focus the energy onto a detector array.

Figures 4, 5 and 6 illustrate block diagrams of the systems of Figures 1, 2, 3, respectively. Figure 4 illustrates the block diagram of system components shown in Figure 1, showing further details of the system components along with associated system electronics. The display electronics 82 and the GPS sub-system 84 are identical to those discussed in conjunction with Figures 5 and 6. However, the thermal receiver unit 16 and the electronics unit 80 differs as follows.

The thermal receiver unit 16, in addition to including an imager 90, includes a flip-flop mirror scanner 92 which operates preferably at either 30 Hz or 60 Hz, and a detector assembly 100 including a 480 x 4 detector element array 98 cooled to cryogenic temperatures by dewar assembly 102 and assembly controller 104. The detector array outputs detected signals to a digitizer 103. The digitizer 103 digitizes the detected signals before outputting the signals to electronics unit 80. The receiver unit also includes a point of load controller 105 which includes voltage regulators that control levels of voltages applied to the detector assembly and digitizer, and analog multiplexers that determine system status.

The electronics unit 80 additionally includes a video processor 106 and video control 108 that process the digitized signals output from the digitizer 103 before outputting the signals to display electronics 132. The video processor 106 performs FLIR processing, automatic gain and level control, and global gain and level control based on inputs from the control panel. The video control 108 adds reticle and symbology to the detected video scene, as well as other functions beyond the scope of the present invention. The electronics unit 80 also includes an EMI filter 110'' to filter unwanted spikes and noise from the supply lines. The electronics unit 80 also includes both an internal power supply 117 to provide power at various required levels to internal components of the electronic unit, and an auxiliary power supply 115 to power the display electronics, as well as the battery 116. In addition, an interface control card 120 controls the gain of signals input into the electronics unit to control the type of picture desired on the system display.

Figure 5 illustrates a block diagram of the system shown in Figure 2 showing certain system components along with associated system electronics in greater detail. The system includes a staring thermal receiver unit 16′, an electronics unit 80′, display electronics 82′ and a GPS sub-system 84′. The thermal receiver unit 16′ differs from the unit 16 in that the imager 90′ outputs imaged radiation directly onto a 640 x 480 element staring detector array 98′ in the detector assembly 100′. The detector assembly 100′ is housed within a dewar assembly 102′ maintained at cryogenic temperatures by a cooler controller 104′. The detector assembly produces an output signal which is input to command and control electronics 105′ that apply correction terms such as gain and level correction to the detector output. The command and control electronics outputs the signal to a forward-looking infrared (FLIR) video pre-amplifier 107′. The pre-amplifier amplifies the signal to create a more robust signal before the signal is output to the electronics unit 80′.

The electronics unit 80′ differs somewhat from the electronics unit 80 in Figure 4. The electronics unit includes a non-uniformity correction (NUC) sub-system 113′ that conditions the signal in a manner similar to that described above in connection with the NUC card 106, when the signal is input from the thermal receiver unit 16′ to the system controller 108′. After signal levels are adjusted through the NUC sub-system 113′, the signals are output through an output processor 111′. Components within the electronics unit 80′ and the thermal receiver unit 16′ are powered by a conventional internal power supply 117′ that provides required voltage levels to system components. The internal power supply in turn is powered by a battery 119′, which is preferably a 28V D.C. battery.

Figure 6 illustrates a block diagram of the system previously described in Figure 3 showing system components and electronics in more detail. In particular, the system thermal receiver unit 16″, as well as a system electronics unit 80'', display electronics 82'' and GPS system 84'', are shown in more detail in association with the telescope 14. Each of the above-mentioned components are described below.

Referring to the thermal receiver unit 16'', an imager 90'' transmits radiation from an object scene passed through the telescope 14 onto a standard rotary polygonal mirrored scanner 92'' rotated by a scanner motor 93''. A scan control unit 94'' controls the rotational timing of the scanner wheel 92'', by controlling the speed of the scanner motor 93'', as is well known in the art. The scan control unit also synchronizes a thermal reference source (TRS) 95'', telescope focus control 96'', and filter wheel 97'' which contains multiple filters for filtering the detected scene based upon particular wavelength characteristics.

Still referring to the thermal receiver unit 16'', imaged radiation is scanned by the scanner wheel 92'' onto a detector array 98'' housed within a detector assembly 100''. The detector array preferably includes 240 x 4 detector element sub-arrays housed within a dewar 102'' and cooled to cryogenic temperatures. Therefore, the detector elements detect scene energy input through the telescope optics and not peripheral forms of energy, such as energy from the warm sides of the dewar housing. Each detector element is sensitive to light in the infrared spectrum and has a detector element output coupled to the system electronics unit 80''. The detector elements are controlled by a conventional detector assembly output control 104'' which consists primarily of signal preamplifiers.

The electronics unit 80'' is also coupled to the output control 104'' and conditions the detected radiation for viewing by the display electronics 82''. The electronics unit includes a non-uniformity correction (NUC) subsystem 106'' that corrects array element signal output level non-uniformities in response to signal level adjustment commands from a system controller 108'' and the TRS to adjust signal brightness and responsivity parameters. The NUC sub-system 106'' includes an S/HMUX

110'' that clocks the signals input from the detector elements for sampling and multiplexing of the outputs. The outputs are converted to digital signals by the analog to digital converter 112''. The output, in turn, is transmitted to a histogram processor card 114''. The card and other system components are powered by a conventional internal power supply 115'', which, in turn, is powered preferably by a 28V D.C. battery 116''.

The histogram processor card 114'' further multiplexes the digital signals input from the electronics unit 80. The signals are then reconstructed in a frame memory 117'' operatively associated with the card 114''. The card includes a histogram 120'' that determines scene temperature distributions and that inputs the data into a look-up table 122''. The look-up table 122'' compresses scene information into a display dynamic range by mapping a larger input dynamic range into a smaller output dynamic range. Once the signals are processed through the look-up table, the signals are output through a digital to analog converter 124'' to the display electronics 82''.

The display electronics 82'' includes a set of console controls 130'' that control the sensor and viewing elements of the system in a manner well known in the art. The display electronics also include conventional cathode ray tube (CRT) electronics 132'', as well as direct viewing optics (DVO)/thermal image select controls 136 to allow a system user to select a particular viewing application in accordance with the preferred embodiment of the present invention.

Still referring to Figure 6, the GPS sub-system 84'' includes an antenna 140 that receives GPS position-based signals, and inputs the received signals into a conventional GPS module 142''. The GPS module 142'' includes signal processing electronics of the type well known in the art that process and condition received GPS signals before the signals are input into the GPS navigational processor 144'' with directional data from an associated compass 146. The processor processes the information from the GPS module 142'' and the compass 146, along with distance vector information from the laser range finder, and outputs a target position signal to a system user at 150.

Turning to Figures 7 and 8, a conceptual layout of the system of Figure 1 and 4 is illustrated. The housing includes the system components as illustrated. In Figure 7, the binocular display optics are on the side of the housing. In Figure 8, a monocular eyepiece is positioned within the main housing.

Figure 9 illustrates a conceptual layout of the hardware package for the system of Figures 2 and 5. As can be seen, the housing includes a side portion which includes the binocular display optics. Also, the forward looking infrared receiver module is positioned at the bottom in the front of the housing.

Figure 10 is a view like that of Figure 9 with the forward looking infrared sensor optic illustrated in Figures 3 and 6.

The present system provides an optical system which may be utilized in long range thermal imaging and ranging applications. The present application may be utilized to view distant targets with a wide field of view for acquisition and then transforms the system to a narrow field of view to identify the target. With the global positioning system, the target position may be accurately defined.

One application of the present invention is a target designator. For instance, it may be desirable to locate a target while viewing the target while at the same time utilizing a laser rangefinder to determine the target's position. Through the use of a global positioning system with the laser rangefinder, the exact position of the target is determined. Also, the optical system enables the use of a single aperture as well as a single telescope to analyze radiation received from a viewed target from both a visual as well as a thermal imaging system. Thus, the present optical system would enable simultaneous visible as well as thermal imaging utilizing different wave lengths through the same telescope.

It should be understood that while the invention has been described in connection with particular examples hereof, that various modifications, alterations and variations of the disclosed preferred embodiment may be made after varying the benefits of a study of the specification, drawings and the following claims.

WHAT IS CLAIMED IS:

1. An imaging system (10) for interpreting a plurality of signals comprising:

a single aperture (12);

a single telescope (14) for receiving and transmitting signals, said telescope (14) aligned with said aperture (12);

a plurality of sensor elements (16, 18, 20, 22, 24), said sensing elements aligned with said telescope (14) for receiving and transmitting signals between said telescope (14) and sensor elements (16, 18, 20, 22, 24), said single telescope (14) receiving and transmitting all signals for said plurality of sensing elements (16, 18, 20, 22, 24).

2. The imaging system according to Claims 1 and 6, wherein said telescope (14) is a three-mirror anastigmat telescope (28, 30, 32).

3. The imaging system according to Claims 1 and 6, wherein said plurality of sensing elements (16, 18, 20, 22, 24) are selected from the group comprising a charge couple device visible TV capability (20), an IR compatibility (16), laser designator and laser range finder (18), direct view optics (24), and a display capability (22).

4. The imaging system according to Claims 1 and 6, including reflective element (26) for changing between a wide field of view and a narrow field of view.

5. The imaging system according to Claims 1, 6 and 7, including a global positioning system (84).

6. The imaging system according to Claim 1, further comprising a controller (80, 82) for operating the sensor elements (16, 18, 20, 22, 24) as desired by an operator.

7. The imaging system according to Claim 6, wherein said controller including:

a signal processing unit (80) that receives said plurality of electronic signals and that conditions said plurality of electronic signals for display purposes; and

a system display (82) that is operative to display an image of said detected target scene based on conditioned signals output from said signal processing unit.

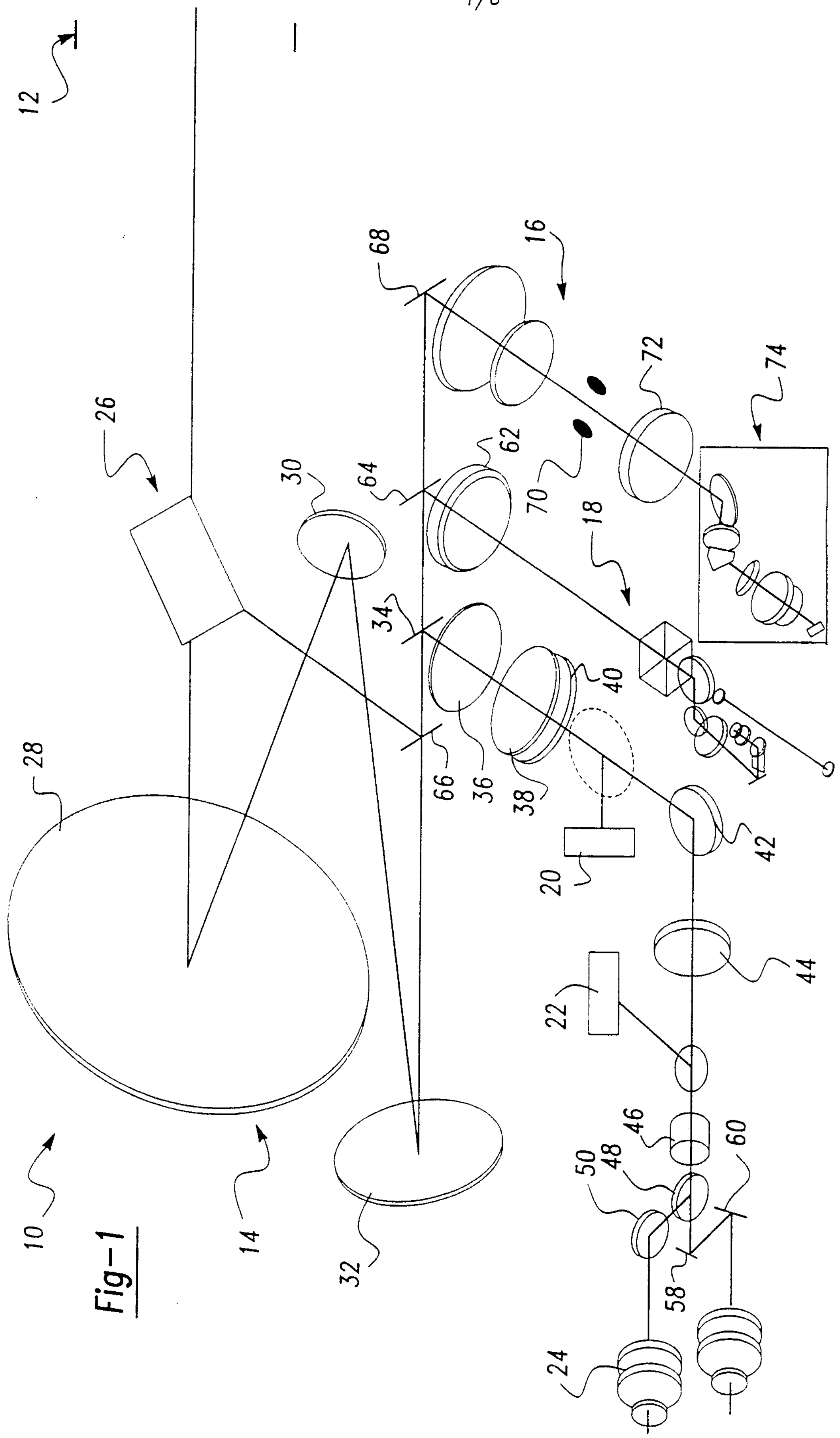
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Fig-1

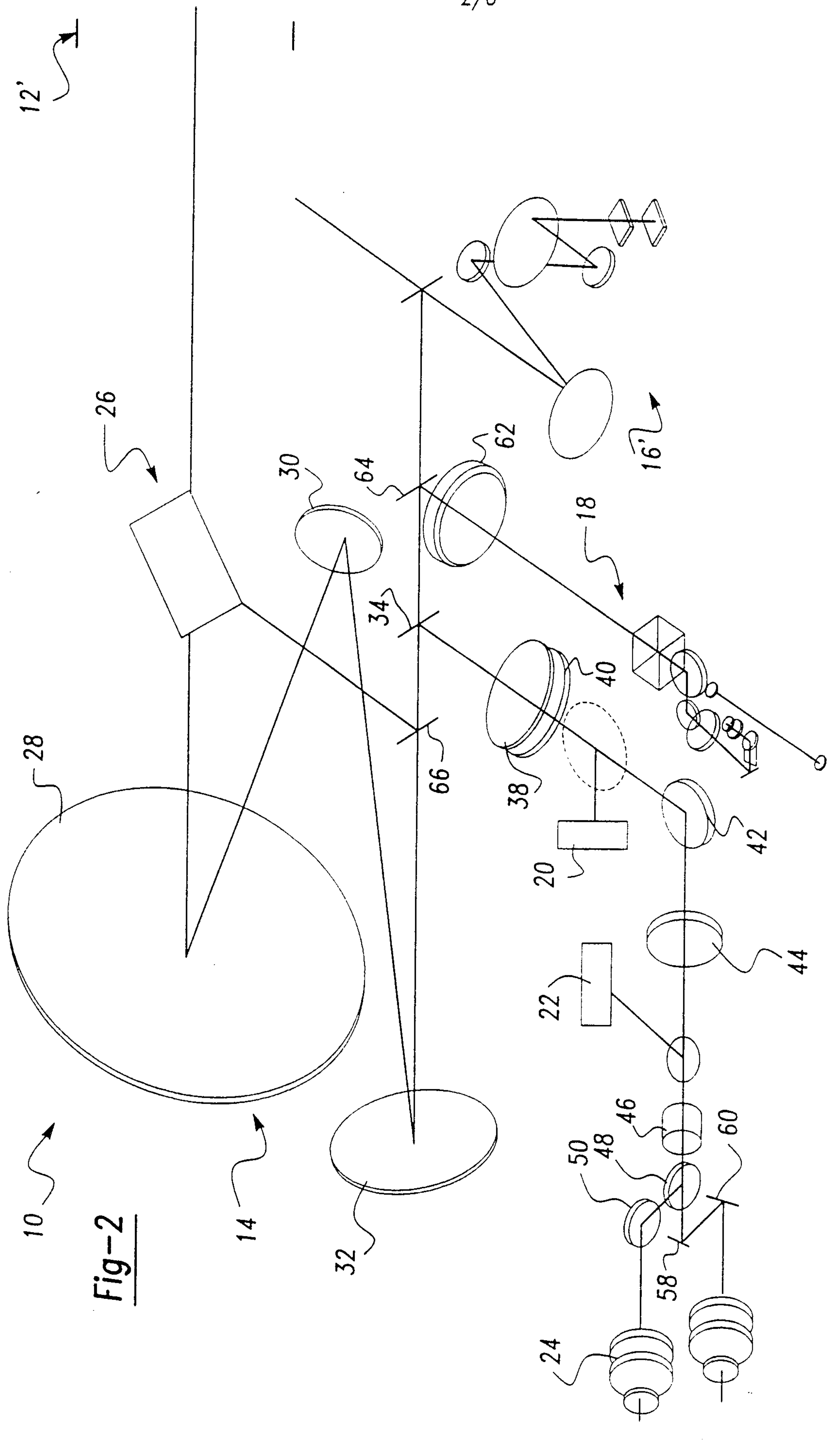
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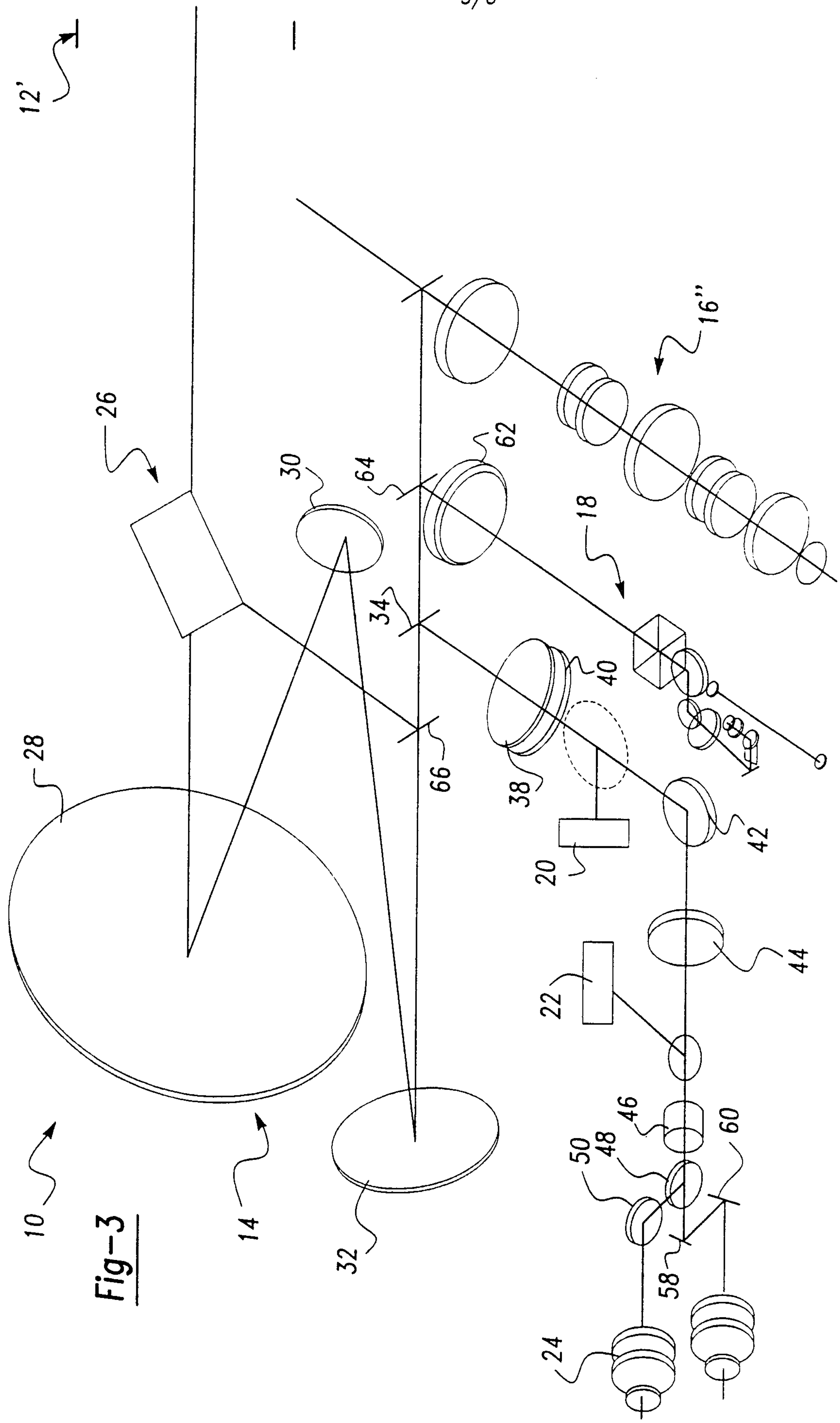
Fig-2


12'
16''
26
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62
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44
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58
24
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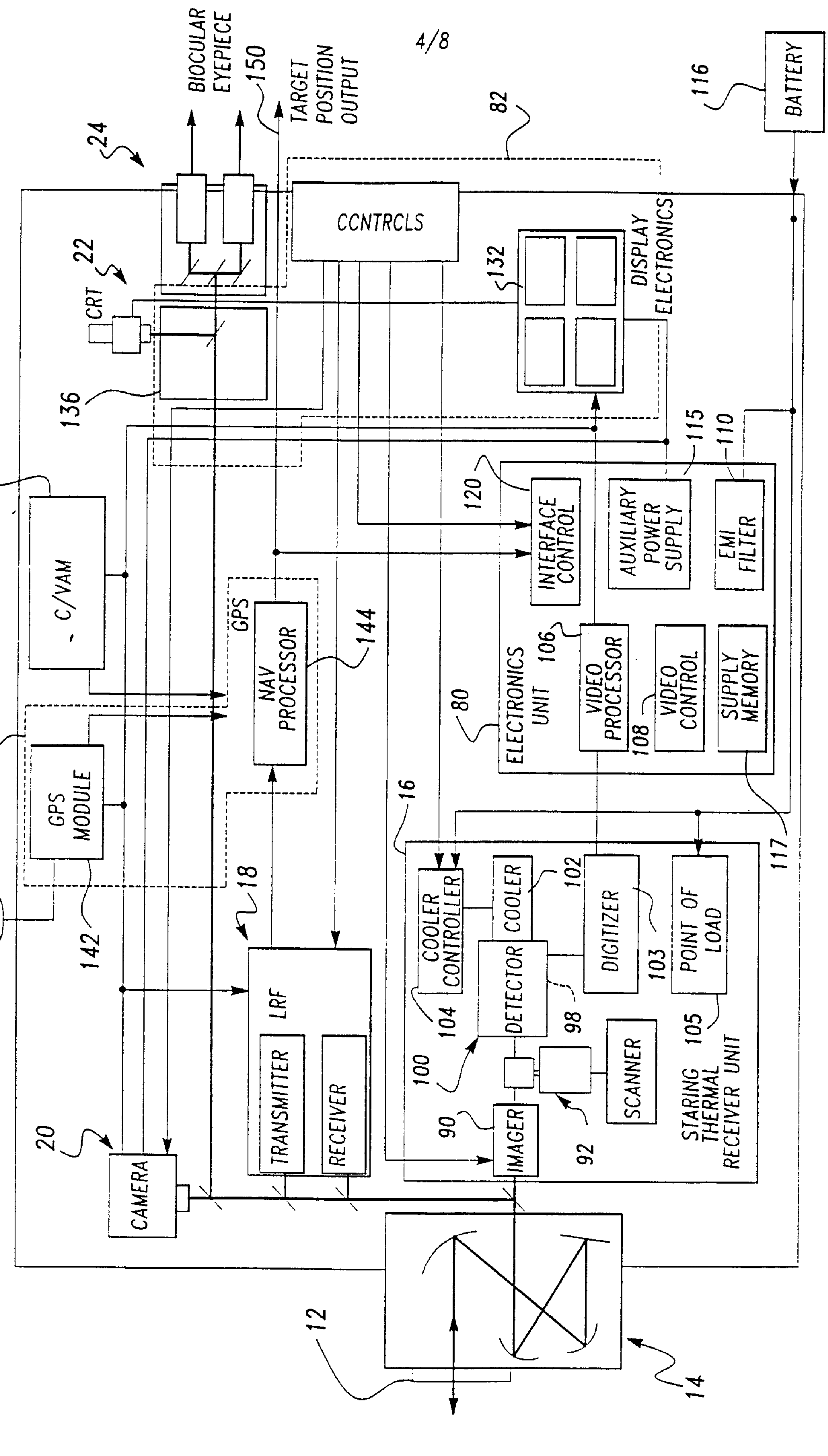
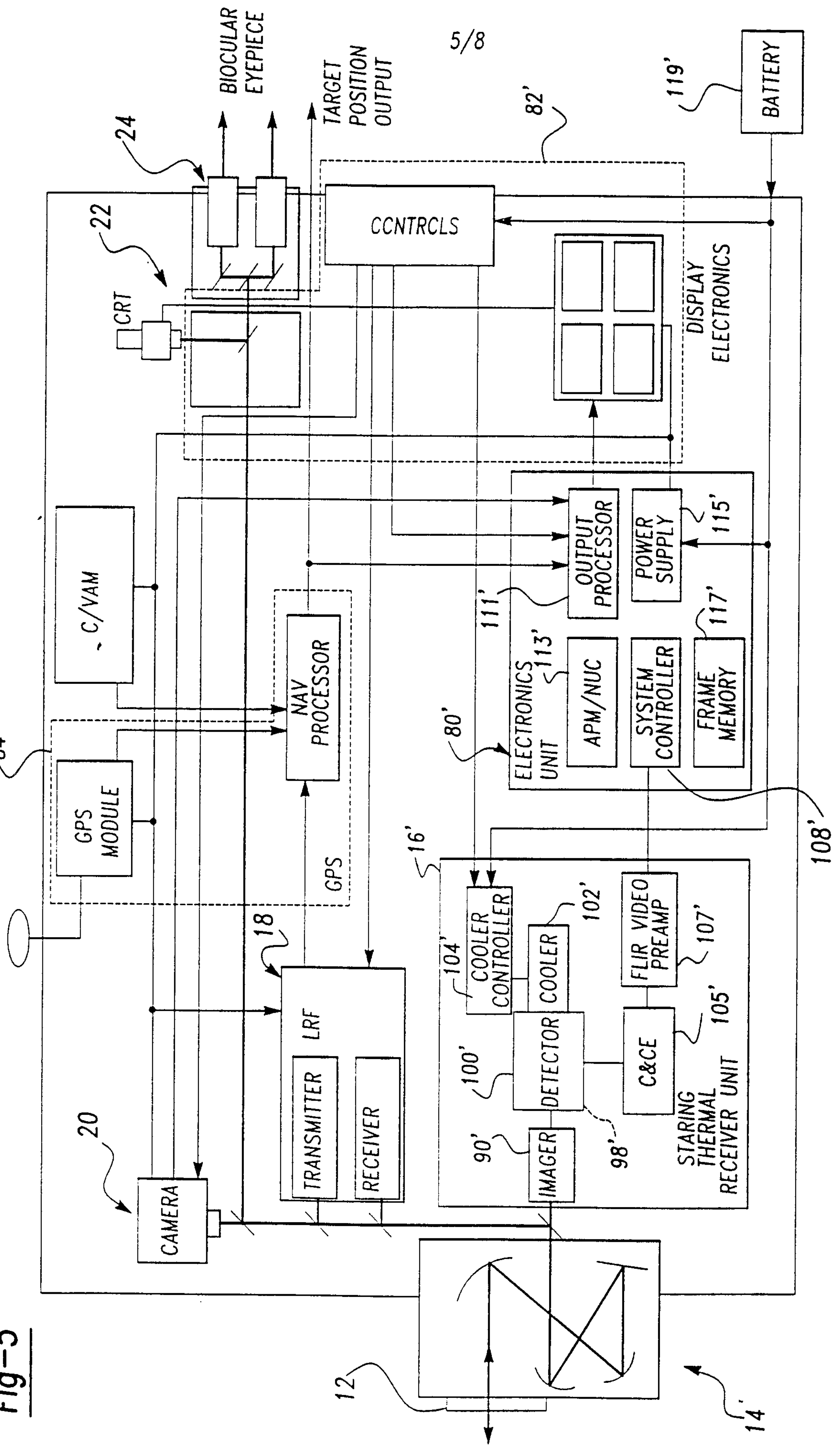
14
32

Fig-3


BIOCULAR EYEPIECE
150
TARGET POSITION OUTPUT
24
82
116
BATTERY
CCNTRCLS
22
CRT
132
DISPLAY ELECTRONICS
136
146
C/VAM
115
110
120
INTERFACE CONTROL
AUXILIARY POWER SUPPLY
EMI FILTER
GPS
NAV PROCESSOR
144
106
VIDEO PROCESSOR
VIDEO CONTROL
SUPPLY MEMORY
108
ELECTRONICS UNIT
80
84
GPS MODULE
140
16
117
18
COOLER CONTROLLER
COOLER
102
DIGITIZER
POINT OF LOAD
142
103
LRF
104
DETECTOR
98
105
TRANSMITTER
RECEIVER
100
SCANNER
20
90
IMAGER
92
STARING THERMAL RECEIVER UNIT
CAMERA
12
14

Fig—4

5/8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CCNTRCLS
CRT
DISPLAY ELECTRONICS
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OUTPUT PROCESSOR
POWER SUPPLY
115'
111'
117'
113'
APM/NUC
SYSTEM CONTROLLER
FRAME MEMORY
ELECTRONICS UNIT
80'
84'
GPS MODULE
GPS
16'
108'
COOLER CONTROLLER
COOLER
102'
104'
FLIR VIDEO PREAMP
107'
18
LRF
TRANSMITTER
RECEIVER
DETECTOR
100'
C&CE
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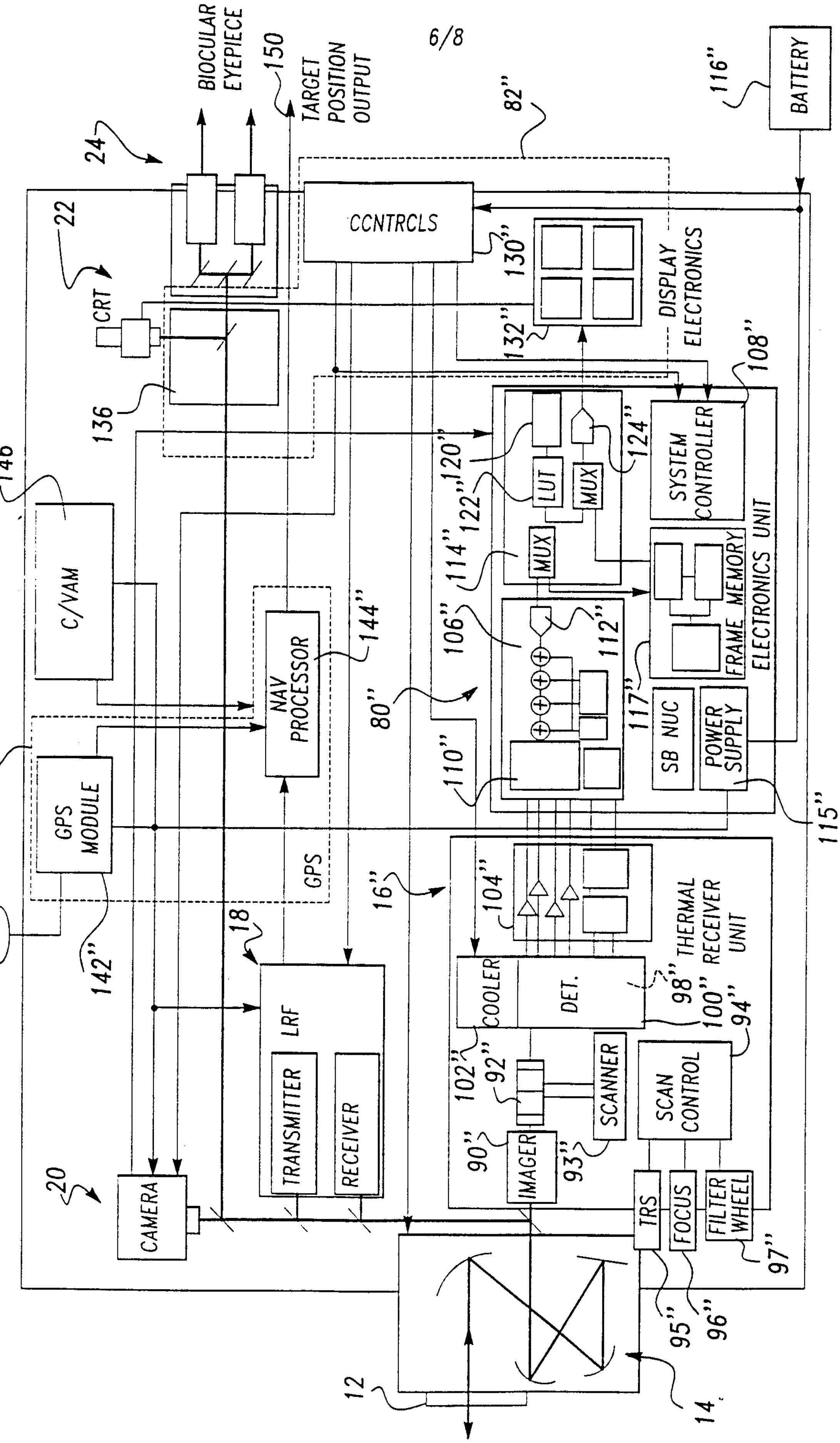
98'
IMAGER
90'
STARING THERMAL RECEIVER UNIT
20
CAMERA
12
14'

Fig–5


BIOCULAR EYEPIECE
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TARGET POSITION OUTPUT
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BATTERY
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108"
SYSTEM CONTROLLER
124"
MUX
LUT
120"
122"
114"
MUX
FRAME MEMORY
ELECTRONICS UNIT
106"
112"
117"
SB NUC
POWER SUPPLY
115"
110"
80"
136
146
C/VAM
NAV PROCESSOR
144"
84"
GPS MODULE
GPS
142"
140"
18
LRF
TRANSMITTER
RECEIVER
16"
104"
THERMAL RECEIVER UNIT
COOLER
DET.
98"
100"
94"
102"
92"
SCANNER
SCAN CONTROL
90"
IMAGER
93"
TRS
FOCUS
FILTER WHEEL
97"
95"
96"
20
CAMERA
12
14

Fig-6

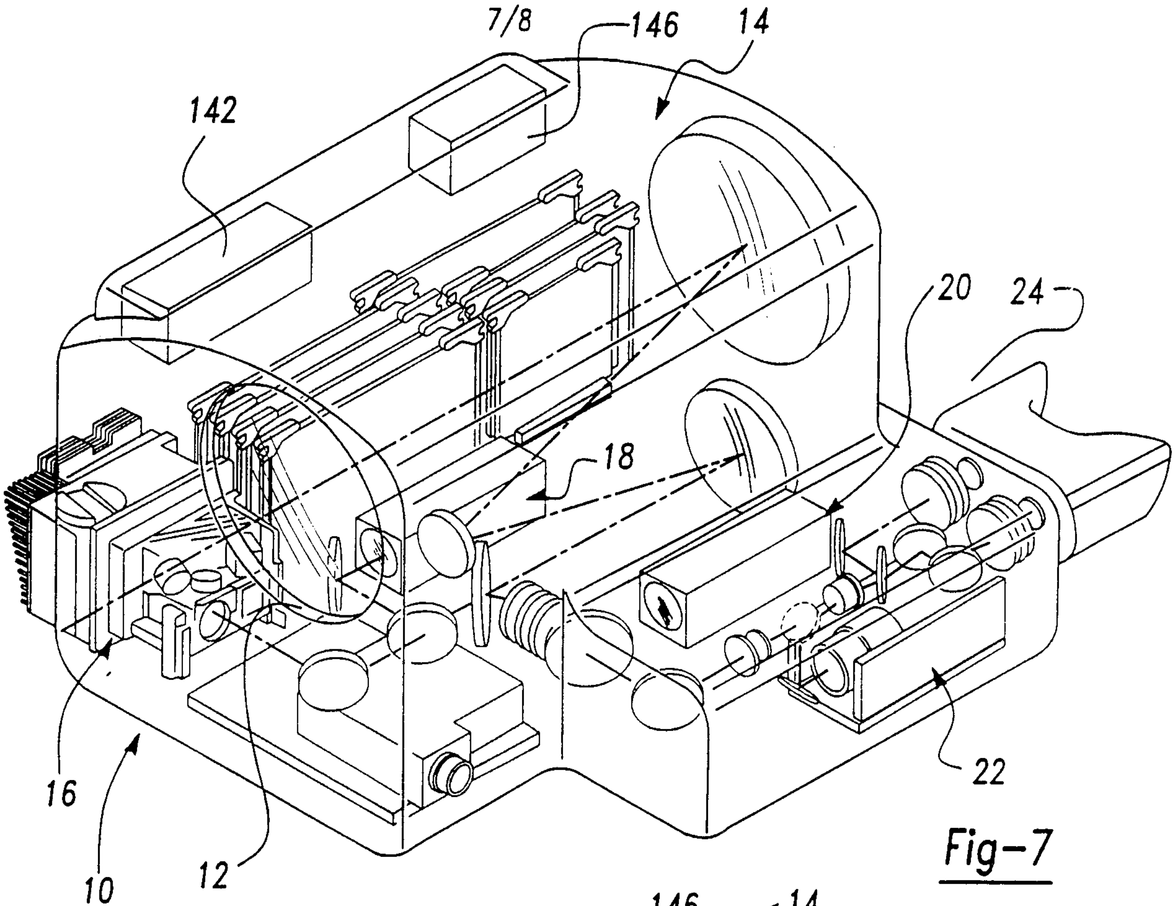

Fig-7

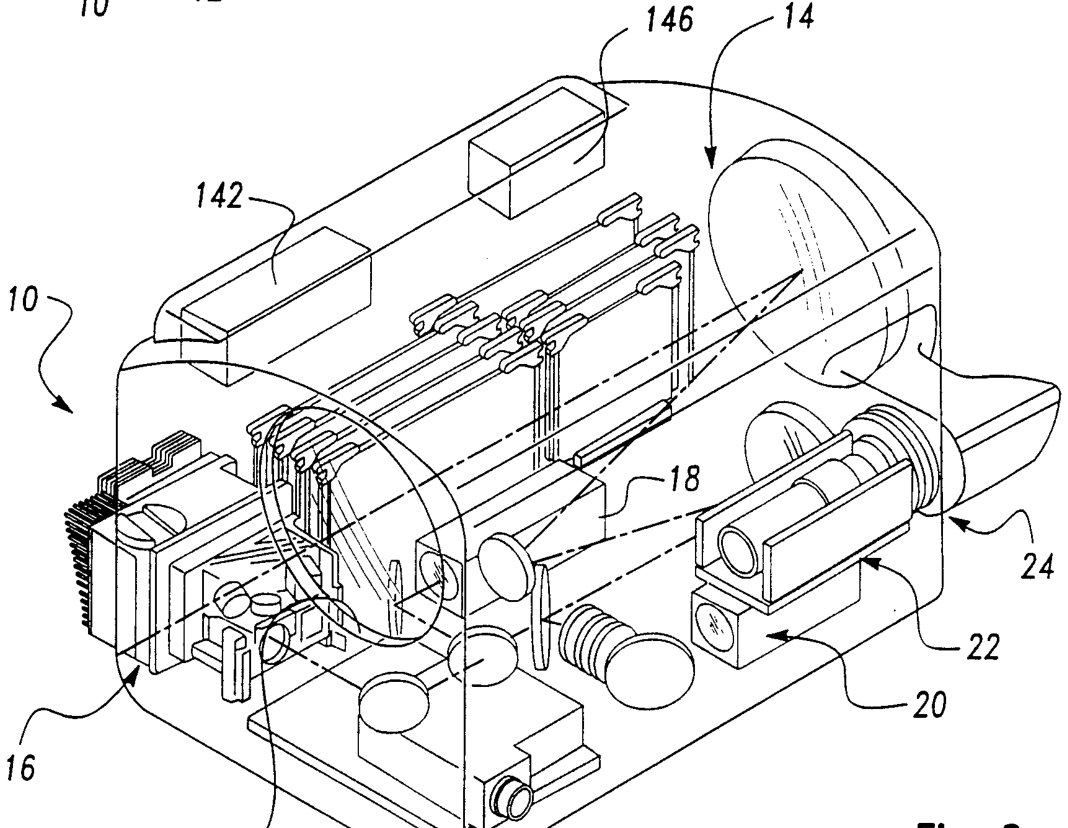

Fig-8

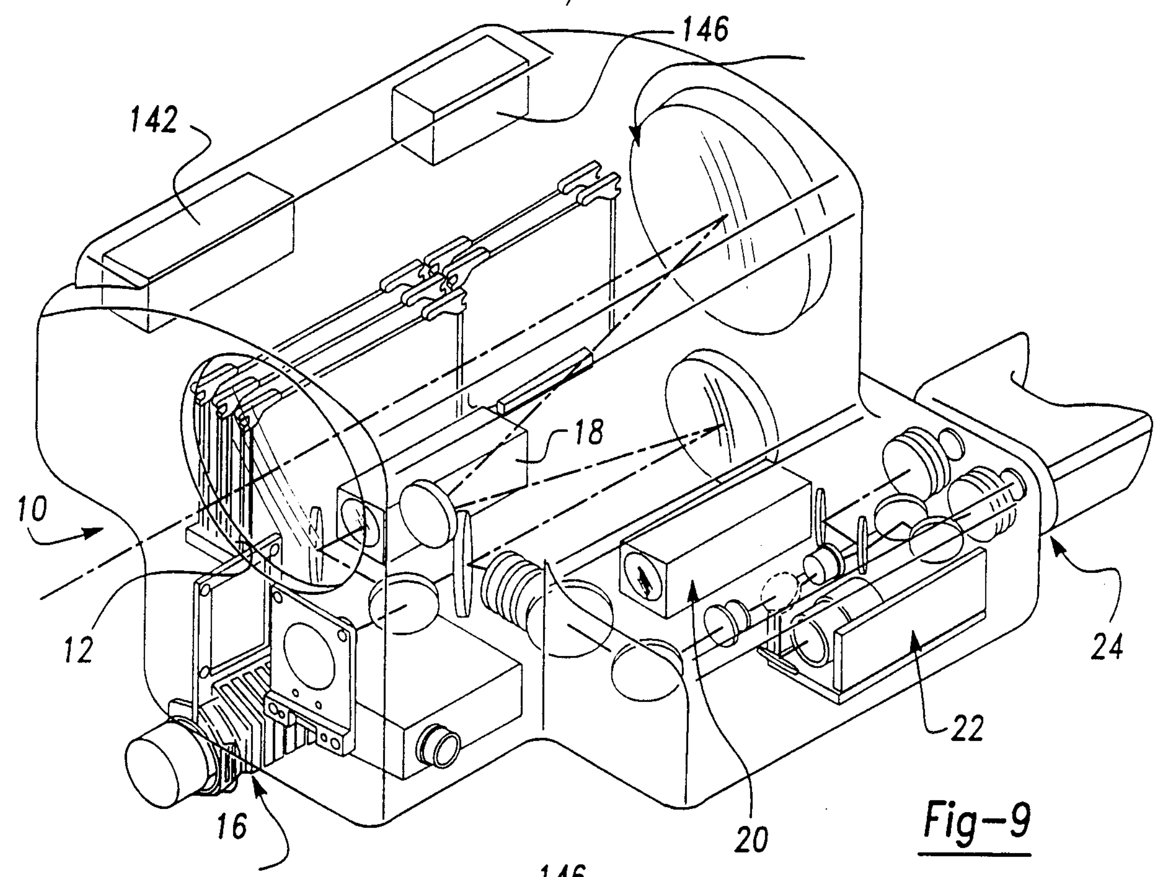

Fig-9

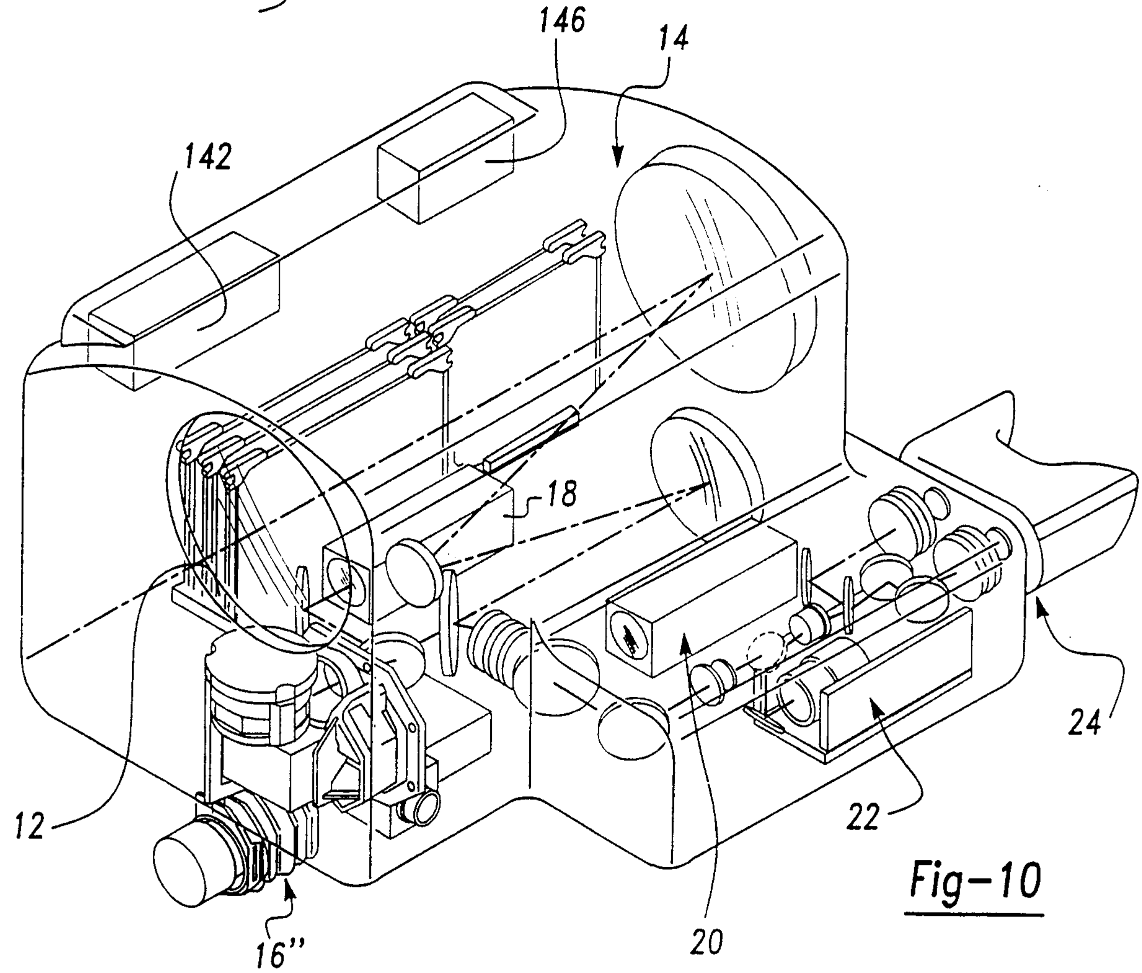

Fig-10

INTERNATIONAL SEARCH REPORT

Inte onal Application No
PCT/US 98/19226

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 G01S17/02 F41G3/06 G01S7/481

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 G01S F41G

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0 156 181 A (SIEMENS AG) 2 October 1985 see abstract see page 16, line 1 - page 26, line 15; figures 1-19	1
A	EP 0 117 983 A (TEXAS INSTRUMENTS INC) 12 September 1984 see abstract see page 5, line 4 - page 22, line 13; figures 1-16	1
A	US 5 363 235 A (KIUNKE PUL C ET AL) 8 November 1994 see abstract see column 2, line 51 - column 13, line 17; figures 1-9	1,2

-/--

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
12 January 1999	20/01/1999

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Blondel, F

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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	DE 33 41 066 A (ELTRO GMBH) 23 May 1985 see abstract see page 4, line 1 - page 5, line 26; figures 1,2	1
A	EP 0 441 079 A (GIAT IND SA) 14 August 1991 see abstract see page 4, column 4, line 5 - page 6, column 7, line 60; figures 1-5	1
A	US 5 629 767 A (TCHEJEYAN SARKIS K) 13 May 1997 see abstract see column 2, line 35 - column 4, line 38; figures 1,1A,2	1
A	DE 31 04 318 A (ELTRO GMBH) 26 August 1982 see abstract see page 9, line 10 - page 11, line 18; figures 1-4	1
A	DE 24 05 186 A (JUNGNER INSTRUMENT AB) 22 August 1974 see page 3, line 10 - page 4, line 24; figures 1-4	1

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/US 98/19226

Patent document cited in search report		Publication date	Patent family member(s)			Publication date
EP 0156181	A	02-10-1985	DE	3408082	A	05-09-1985
			DE	3506088	A	21-08-1986
			US	4713544	A	15-12-1987
EP 0117983	A	12-09-1984	US	4542986	A	24-09-1985
			US	4561775	A	31-12-1985
			US	4569591	A	11-02-1986
			DE	3485272	A	02-01-1992
			JP	59210388	A	29-11-1984
			US	4733961	A	29-03-1988
			US	4771437	A	13-09-1988
US 5363235	A	08-11-1994	NONE			
DE 3341066	A	23-05-1985	DE	3329590	A	07-03-1985
			US	4618768	A	21-10-1986
			US	4902128	A	20-02-1990
EP 0441079	A	14-08-1991	FR	2656079	A	21-06-1991
			DE	69002824	T	09-12-1993
			US	5204489	A	20-04-1993
			US	5339720	A	23-08-1994
US 5629767	A	13-05-1997	NONE			
DE 3104318	A	26-08-1982	DE	3048809	C	30-09-1982
DE 2405186	A	22-08-1974	SE	365621	B	28-03-1974