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[54] **INFRARED DETECTOR SYSTEM**

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[52] **U.S. Cl.** **250/232,** 250/235, 250/347, 250/353, 350/7

[51] **Int. Cl.** **G01d 5/36**

[58] **Field of Search** 250/203, 233, 234, 235, 250/236, 229, 232, 338; 343/757, 763, 765, 766; 356/28; 350/7

[56] **References Cited**

UNITED STATES PATENTS

2,332,154	10/1943	Lindsay et al.	250/338
2,392,873	1/1946	Zahl	250/83.3
2,406,318	8/1946	Brace	250/236 X
2,425,541	8/1947	Konet	244/14.3
2,454,841	11/1948	Sackville	250/349
2,513,367	7/1950	Scott	244/14.3
2,713,134	7/1955	Eckweiler, Jr.	250/233 X
2,720,643	10/1955	Hays, Jr.	313/765 X
2,721,275	8/1955	Jackson	343/5 X
2,794,926	6/1957	Watts et al.	250/345
2,859,652	11/1958	Hopgood	178/7.6
2,860,179	11/1958	Blackstone	350/33
2,878,710	3/1959	Willey	350/7
2,878,711	3/1959	Blackstone	356/28
2,878,712	3/1959	Blackstone et al.	356/28
2,878,713	3/1959	Blackstone	356/28

FOREIGN PATENTS OR APPLICATIONS

477,037	12/1937	Great Britain	250/338

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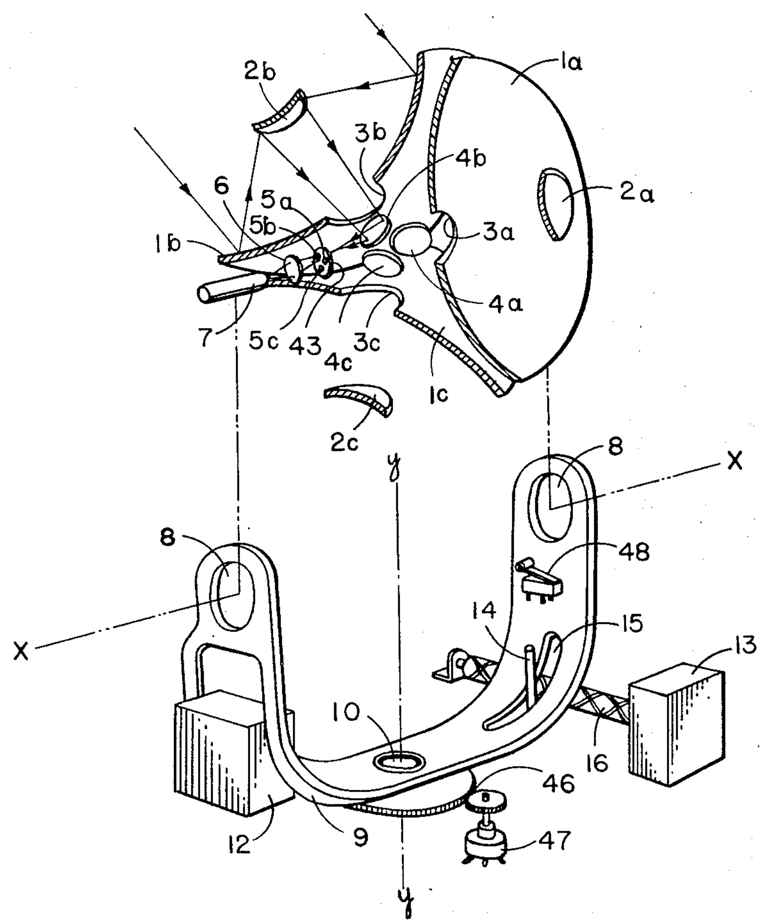
EXEMPLARY CLAIM

4. A passive optical detector comprising: a support having a vertical axis of rotation; a reflector system mounted on said support, said reflector system having a horizontal axis of rotation, said reflector system comprising at least one reflector, each reflector having an optical axis extending radially of said horizontal axis; photodetector apparatus mounted on said support in fixed relation with respect to said support; means in said reflector system for directing images from said reflector onto said photodetector apparatus; means for rotating said reflector system on said horizontal axis at a high rate of speed; and means for simultaneously oscillating said support at a slow rate of speed through a predetermined angle on said vertical axis.

12 Claims, 9 Drawing Figures



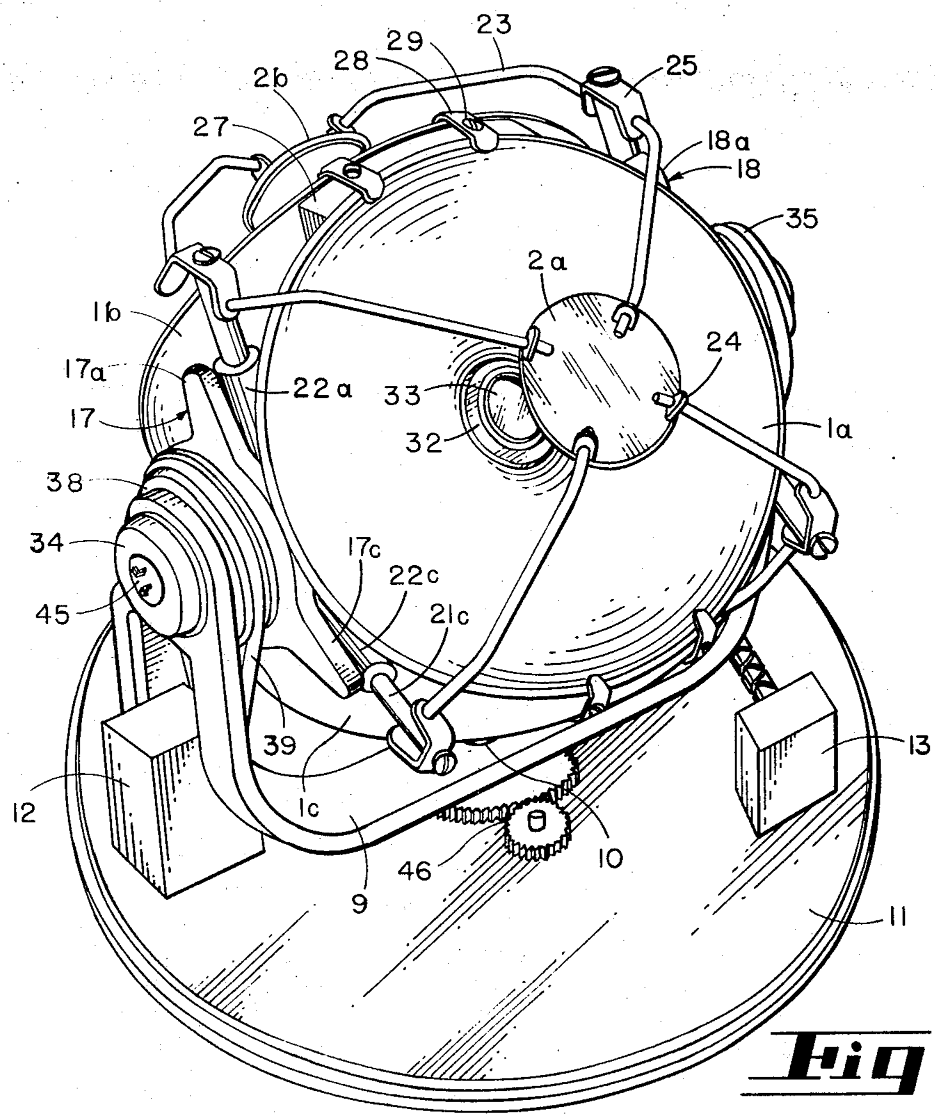


Fig 1

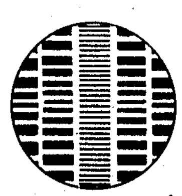


Fig 7A

Fig 7B

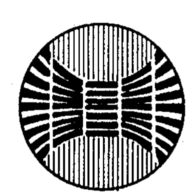


Fig 7C

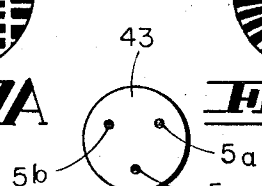


Fig 6

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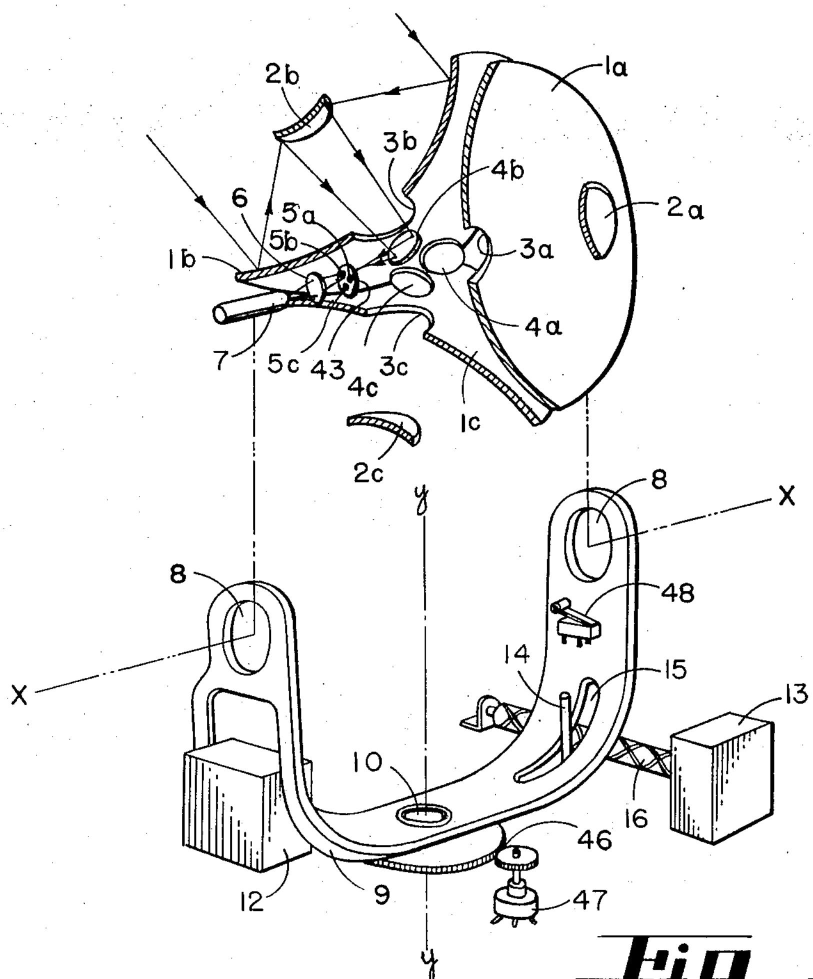

Fig 2

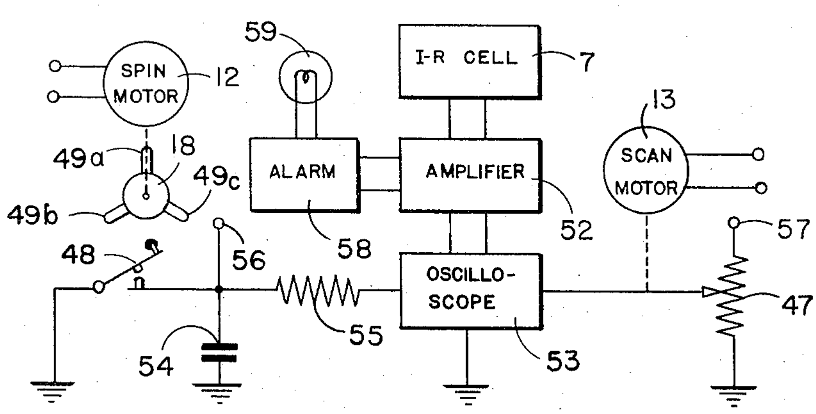

Fig 5

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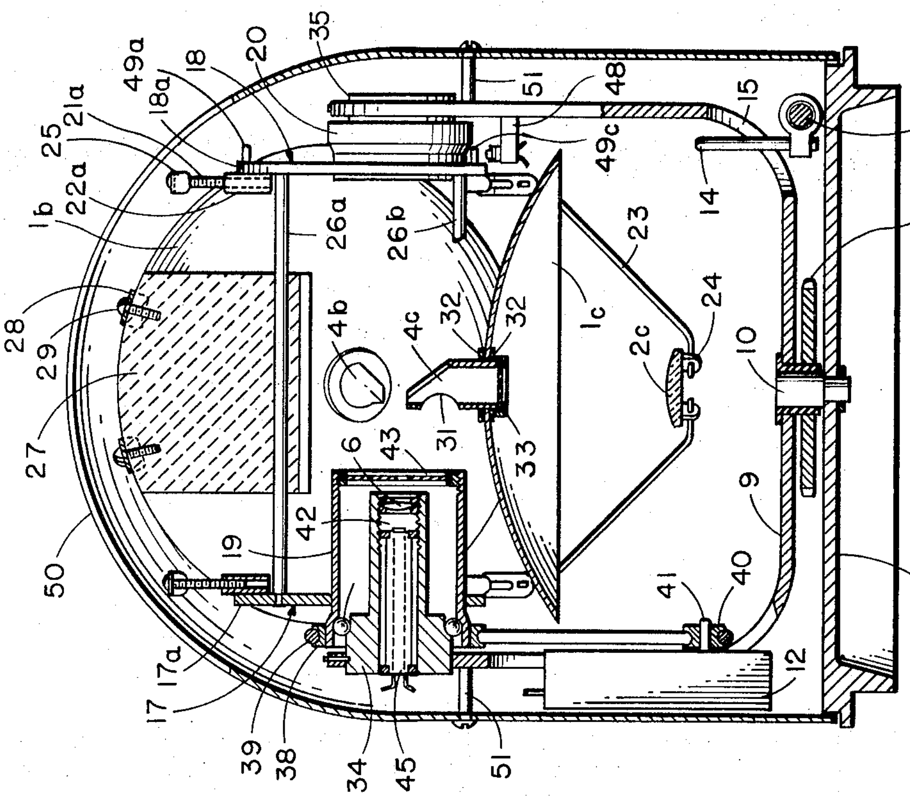

Fig 4

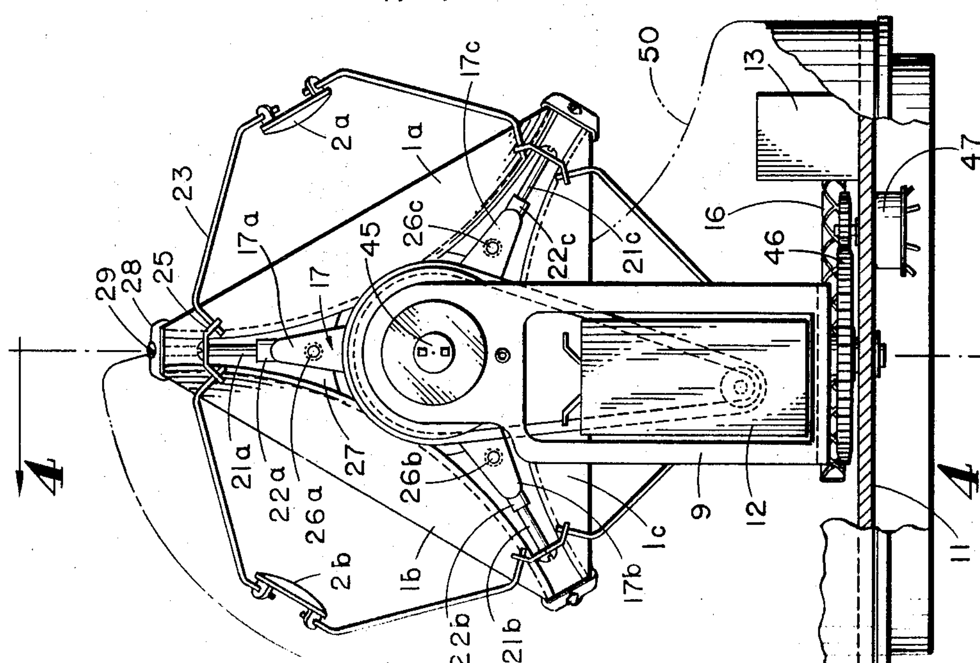

Fig 3

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INFRARED DETECTOR SYSTEM

This invention relates to a system for detecting the presence and location of objects in space and more particularly to a passive infrared system for locating objects in space by detecting the heat generated from the object.

In the past many optical systems and search mechanisms have been developed for use with infrared. However, these systems have been designed to solve very specific problems and contained inherent restrictions and inefficiencies. Many acceptable reflective systems have been constructed, but in most cases they have been bulky, and awkward to mount and handle. When these have been used for search and track functions they have been combined with mechanisms which were usually adaptations of the mechanics from other techniques such as radar, search lights, and simliar gimbaled devices.

If it is desired to search a sector of a sphere for possible infrared energy, it is desirable to have a constant maximum range detectability which defines the search field, and the velocity of search should be constant. With spiral type scans a very disproportionate amount of time is spent searching the outside sectors unless speed corrections are continuously made. During the time spent in the outside sectors, the target may move and be missed entirely due to strobe effect. A rosette type scan is not satisfactory since it inherently misses pie-shaped areas or it spends too much time in overlap near the center of the field, thereby reducing the probability of detection.

An extended study of the many prior art systems reveals that a rectilinear television type scan is optimum. However, in the prior art mechanisms, a rectilinear scan is produced by rotating a reflector on two axes through predetermined angles and with flyback of the reflector on at least one of the axes. As is well known in the prior art, mechanical flyback produces a violent change in direction and speed, and requires rugged and complicated apparatus.

Moreover, in the prior art infrared search systems, the infrared detector cell has been mounted in a relatively fixed position with respect to the movable reflectors, but in a relatively movable position with respect to support for the system. This has required the use of slip rings to make the necessary electrical or electronic connections and in this way considerable noise has been introduced.

Also, for the purpose of reducing or eliminating the effects of background infrared radiation, the prior art has used rotating or spinning type chopper grids. This type of prior art chopper is based on the principle that for a certain amount of background light permitted to fall upon the infrared photocell by a slit or pie-shaped opening, there is an equal amount of light cut off by a diametrically opposed opening. The prior art systems are satisfactory provided that the background gradient scan noise is not too high. However, when there is translatory motion as well as the rotary motion of the spinning chopper, all kinds of relative motions and frequencies develop and the signal noise ratio is degraded. Furthermore, rotating type choppers require bulky and complicated equipment to produce the spinning action and many inaccuracies are inherently present in the system.

It is an object of this invention to provide a television type rectilinear scan for a passive infrared detector by

simple electrical and mechanical means and without the necessity for flyback.

Another object of this invention is to provide an optical system having a plurality of spaced reflectors mounted for rotation at a high rate of speed on one shaft, and for rotation at a relatively slower rate of speed on a shaft perpendicular thereto.

Another object of my invention is to provide an infrared optical system employing three identical sets of reflectors, each spaced **120** degrees for rotation and a horizontal spin axis.

Another object of this invention is to simplify the optics of a passive infrared detector which is rotatable on at least two axes by maintaining stationary the infrared detector cell.

Still another object of this invention is to produce an infrared search head having a vertical scan up to 360 degrees in the search pattern with no lost time waiting for the optics to return to the starting point, and with no requirement for flyback.

Still another object of this invention is to provide an infrared search head mounted to provide the combination of a rapid spin on a horizontal axis to give a vertical line sweep without mechanical flyback, and a slow rocking motion on a vertical axis to provide a field scan.

Another object of this invention is to reduce effects of background radiation by means of a system of chopper grids which are fixedly mounted on the spinning search head.

Another object of this invention is to provide a system of chopper grids which is fixedly mounted on a spinning search head and which enables the locating of a target within the field of search.

For a more complete understanding of the nature and objects of this invention, reference should now be made to the drawings, in which:

FIG. **1** is a perspective view of one preferred form of the invention;

FIG. **2** is a blow-up view showing certain details of the invention;

FIG. **3** is an end view of the system;

FIG. **4** is a view partly in section along line **4-4** in FIG. **3**;

FIG. **5** is a schematic block diagram showing the electrical controls for the operation of the system;

FIG. **6** is an enlarged view of the chopper grid assembly; and

FIGS. **7***a*, **7***b* and **7***c* illustrate suitable chopper grid patterns useful with this invention.

Briefly stated, the invention comprises a multiple optical head having three primary reflectors rotatably mounted 120 degrees apart on a horizontal spin axis, each reflector being arranged to sweep in turn a 120 degree vertical angle, i.e., as one reflector has swept and is about to leave the 120 degree sector, the next reflector is about to enter the sector at the opposite side. In addition, the horizontal spin axis is mounted on a yoke which is rotatable on a perpendicular axis. As the reflectors spin on the horizontal axis at a high rate of speed the yoke is nodded back and forth on the vertical axis to scan a predetermined horizontal sector. The combination of the rapid spin to give the vertical line sweep and a much slower speed horizontal nodding or rocking motion for the field scan produces the desired rectilinear television type scan. A simple form of interlace may be introduced to this motion by displacing the entire search field horizontally by one-half the width of the optical field of view on every alternate search field. The reflectors are each focused at infinity, and any source of infrared energy within the field will be focused onto the reflectors, and then by an appropriate optical system to an infrared photocell which is fixedly mounted within the spin shaft.

Referring now to the drawings, the detector system illustrated consists of an optical head mounted in a manner to be described for rotation on a horizontal spin axis X—X. The optical head comprises a trimirror system of primary mirrors **1** in the form of parabolic reflectors, the respective reflectors being designated **1***a*, **1***b* and **1***c*. Infrared energy detected by the primary mirrors **1** is focused onto a secondary system of mirrors **2**, comprising the reflectors **2***a*, **2***b* and **2***c*, respectively, and then focused through corresponding apertures **3***a*, **3***b* and **3***c* onto a third mirror system **4**, comprising plane mirrors **4***a*, **4***b* and **4***c*. From there the detected images are directed through chopper grids **5**, the respective grids being designated **5***a*, **5***b* and **5***c*, and through a conventional Ramsden lens **6** onto a single stationary infrared photocell **7** to produce an indicating electric current.

Depending on the use of the system, many types of infrared photocells have been used for detection purposes. For use as an anti aircraft device, sensitivity of 3 to 5 microns is desirable. Weighing the sensitivities of the various infrared photocells against wave lengths and time constants, cells comprised of Indium Antimonide and Gold doped Germanium have been employed with considerable success.

As indicated in FIG. **2**, the spin axis X—X of the optical head is defined by a line drawn through the centers of the opposing bores **8** in the upstanding arms of yoke **9** which is, in turn, mounted on a shaft **10** for rotation about a vertical axis Y—Y on a stationary platform **11**. For providing a vertical scan, a vertical spin motor **12** is mounted in a convenient manner on one arm of the yoke **9** to impart rotation in a manner to be described to the three sets of mirrors **1**, **2** and **4** on the X-axis, while the yoke **9** is rotated on the vertical shaft **10** to provide a horizontal scan about the Y-axis. Rotation on the shaft **10** is produced by means of an electric motor and suitable gearing **13** fixedly mounted on the platform **11** and coupled to one arm of the yoke **9** by means of a pin **14** extending at one end through a slot **15** and coupled at the other end by suitable means to a worm gear **16**. For the purpose of producing an interlaced scan, horizontal displacement of the field of search by one-half width of the optical field of view on every alternate search field can be accomplished by proper design of the endless worm gear **16**.

The mounting for the mirrors comprises two three-armed centrally apertured supporting members **17** and **18**, press fitted or otherwise secured to the outer periphery of hollow cylindrical hub members **19** and **20**, respectively. The three arms **17***a*, **17***bb* and 17*c* of the support member **17** and the three arms **18***a*, **18***b* and **18***c* of the support member **18** are each adapted to carry a telescopic support comprising externally threaded male members **21** and the internally threaded female members **22**, the respective members being designated *a*, *b*, and *c* in the drawings. The female members **22** may be welded or otherwise secured to the corresponding arms of the support members **17** and **18** in any suitable manner, or may be made integral therewith.

Each secondary mirror **2** may be suspended between the telescopic members **22** by means of a set of four suspension members **23** secured at one end to an eyelet **24** on the secondary mirrors **2** and at the other end to a bracket member **25** secured to the male members **21**. The position of the secondary mirrors **2** relative to the primary mirrors **1** and the apertures **3** may be adjusted by threading the male members **21** into or out of the female member **22** and, if necessary, adjustment can also be provided by making the members **23** movable within the eyelets **24**.

The mounting for the primary mirrors **1***a*, **1***b* and **1***c* comprises horizontal rods **26***a*, **26***b* and **26***c* each supported at its ends from the three armed supporting members **17** and **18**. The horizontal rods **26***a*, **26***b* and **26***c* support spacers **27***a*, **27***b* and **27***c*, respectively, in fixed space relationship and each of the primary mirrors **1** is secured to the spacers by means of clamps **28** and screws **29**.

The mounting for the system of plane mirrors **4** comprises metal cylinders **30** positioned in the apertures **3**. The cylinders **30** are open at one end to receive the focused rays from the secondary mirrors **2** while mirrors **4***a*, **4***b* and **4***c* are mounted at the opposite end of a respective cylinder **30** at an angle which is appropriate for redirecting the rays towards the infrared cell **7** through an aperture **31** in the side of the cylinder. The cylinders **30** are each provided with external threads, for the purpose of adjusting the position of the mirrored surface with respect to the cell **5**, and the locking nuts **32** are provided for fixing the assemblies in place. A filter **33** may be mounted over each cylinder **30** in the manner shown for the purpose of reducing or eliminating undesirable rays focused onto the infrared detector cell **7**.

It may be seen from the description to this point that the entire mirror system including the primary mirrors **1**, the secondary mirrors **2** and the third mirror system **4** is mounted in fixed spaced relationship on the hollow hub members **19** and **20**. The hub members **19** and **20** are in turn rotatably mounted on bearings **34** and **35** which are press fitted or otherwise fixed in the bores **8** of the yoke **9**. The outer peripheries of the bearings **34** and **35** provide inner races while the inner periphery of the hollow hub members **19** and **20** provide outer races for sets of ball bearings **37**. A pulley **38** is mounted on the outer periphery of the hub member **19**. The entire optical head including the mirrors **1**,**2** and **4** is driven on the X-axis by means of the spin motor **12** coupled to the pulley **38** through an endless belt **39** driven from a pulley **40** on the motor shaft **41**.

The lens **6** and the infrared cell **7** are fixedly mounted by any convenient means within the bore **42** of the bearing **34**. The mounting disc **43** for the chopper grids **5***a*, **5***b* and **5***c* is interposed in the image plane between the plane mirrors **4** and the lens **6**, and may be mounted in any convenient manner on an end of the hub member **19** for rotation therewith. As may be seen more clearly in FIG. **6**, the disc **43** comprises three reticles in which the chopper grids **5***a*, **5***b* and **5***c* are mounted and through which the rays from the plane mirrors **4***a*, **4***b* and **4***c*, respectively, are directed. Since the chopper grids are mounted from the hub members **19**, the grids **5** are fixed with respect to the spinning system of mirrors. However, as the system rotates, the target image which is directed towards the infrared cell **7** moves vertically across each of the chopper grids **5** in order, i.e., as the mirrors rotate, images from the plane mirror **4***a* traverse the grid **5***a;* then images from the plane mirror **4***b* traverse the grid **5***b*, and images from the plane mirror **4***c* traverse the grid **5***c*. Since the chopper grids are relatively stationary with respect to the optical head, inherent inaccuracies are avoided, and moreover, background discrimination techniques may be optimized by using a unidirectional pattern with the motion of the image across the grids at right angles thereto. This type of arrangement develops a constant frequency and duty cycle no matter where the target is in the field of view and therefore yields a constant signal-to-noise ratio. Several types of chopper grids which may be employed under certain operating conditions are shown in FIG. **7**.

FIG. 7*a* represents a chopper grid for use with an optical system having good resolution, except for field curvature. The checker boarding of the grid pattern reduces extended background intensity gradient signals. The pattern illustrated in FIG. 7*b* represents lines which would be generated by an optical system in which the resolution was not good and, thus, in which there is coma and flare. Each line of the pattern represents an image generated of a point source taken at different successive elevations and moving horizontally. FIG. 7*c* is an improved grid pattern used to compensate for the coma distortions illustrated in FIG. 7*b*.

It is noted that the adjacent vertical rows of chopper grids illustrated in FIGS. 7*a* and 7*c* have different spacings. As a beam of radiant energy traverses the grid and the detector cell, different frequencies will be generated, depending on where the beam is located in the field of view. By using an appropriate filter system, greatly improved target direction resolution will result.

Since the infrared cell **7** is at times subjected to large amounts of heat and since the conductivity of the cell varies with the degree of heat, refrigerating apparatus may be required to maintain a substantially constant cell temperature. A cryostat **45**, illustrated schematically in FIG. **4** and connected in a closed refrigerating system (not shown) may be used to provide the necessary cooling.

The electrical output from the infrared cell generally requires pre-amplification and for this purpose a pre-amplifier (not shown) may be fixedly mounted from either of the bearing members **34** or **35**. In this way both the infrared cell and the pre-amplifier are maintained stationary while the mirror system is free to rotate. This type of arrangement eliminates all necessity of slip rings, thereby avoiding a considerable amount of noise and, thus, providing a substantial improvement over the prior art.

For providing the necessary sweep circuitry for a suitable indicator such as a cathode ray tube, the vertical shaft **10** carries a set of gears **46** for driving the tap of a potentiometer **47**. In addition, a microswitch **48** is secured to one of the yoke arms **7** and is positioned relative to the supporting member **18** in such a way that projecting lugs **49***a*, **49***b* and **49***c*, positioned near the extremity of each of the arms **18***a*, **18***b* and **18***c*, respectively, will cause the closing of microswitch **48**, with each 120 degrees revolution of the entire mirror assembly on the spin axis.

The entire unit may be enclosed within an opaque cover **50** secured to the yoke arm **7** for rotation therewith by means of bolts **51**. The cover **50** is provided with a suitable opening for permitting the entire view of the mirrors **1***a*, **1***b* and **1***c* as the optical head spins.

The schematic diagram in FIG. **5** illustrates a suitable control system for the detector. The electrical output from the infrared photocell **7** may be coupled to a multi-stage amplifier **52** illustrated in block form, and then to the control circuit of a suitable display device such as the intensity grid of a cathode ray oscilloscope **53**. When there is no target generating a source of infrared energy the output from the photocell **7** is zero and no indications will appear on the cathode ray oscilloscope. However, when the exhaust of a jet aircraft or the frictional heat generated by a ballistic missile or any other source of infrared energy is detected, the control grid of the cathode ray tube will be intensity modulated by the amplified output from the cell **7**, and target will appear on the oscilloscope **53**.

For the purpose of locating the position of the target in azimuth and elevation, the oscilloscope is provided with horizontal and vertical sweeps. The vertical sweep is provided by the microswitch **48** which is connected in circuit with the R-C network comprising a condenser **54**, a resistor **55** and battery or other suitable source of supply **56**. When the microswitch **48** is open, the voltage on the condenser builds up at an exponential rate to drive the vertical sweep of the cathode ray oscilloscope **53**. However, when the projecting lugs **49***a*, **49***b* and **49***c* on the three armed supporting member **18** causes the momentary closing of the microswitch, the condenser **54** is instantaneously discharged to produce flyback of the cathode ray beam. It will be seen that this event occurs at precisely the moment that one mirror is leaving the field of search and the next mirror is entering the field of search. Thus, if the mirrors are rotating clockwise as viewed in FIG. **3**, the projecting lug **49***b* will close the microswitch **48** at the same instant that the reflector **1**a is leaving the field of search and the reflector **1***b* is entering the field, and it will be seen that the position of the cathode ray beam will correspond with the position of each mirror as it traverses or scans the vertical field of search.

At the same time, the yoke **8** which is being nodded by means of the horizontal scan motor **13** and worm **16** will drive the potentiometer **55** from one end to the other, and therefore the voltage applied from another suitable direct current source **57** to the horizontal sweep of the oscilloscope will vary linearly from one end of the potentiometer to the other. This will cause horizontal deflection of the cathode ray from one side of the scope to the other in accordance with the position of the optical head as it scans in the horizontal plane.

An alarm system may also be included. A satisfactory alarm system may comprise any suitable variable conducting device such as a rectifier **58**, coupled to the amplifier **52**, and biased so that it is nonducting except when an infrared source of a given high intensity is detected. When a high intensity ray is received, the rectifier conducts, thereby illuminating a warning lamp **59** or operating any other suitable alarm. Thus, when an enemy aircraft is detected and tracked, the illumination of the lamp **59** will indicate an extraordinary source of infrared such as may be caused by the ignition gases from a launched missile.

In actual operation, the optical head may be rotated at a rate of 120 revolutions per second while the horizontal yoke **8** may be nodded or rocked through an angle of 60 degrees in a period of 2 seconds. Since the mirror system is being rotated on the horizontal axis at a high rate of speed, and since the mirrors have a substantial mass, the optical head become self-gyro-stabilized. This produces several advantages.

Thus, since the rotating cluster of optics possesses considerable momentum, and since it is free on the spin shaft except for spin motor torque, it will maintain the required constant rotational velocity irrespective of short-term angular movements of the system.

Another advantage of the gyroscopic effect of the optical system is that the horizontal scan motor **13** and the associated gears, etc. can be eliminated, and the rocking or nodding action of the yoke **8** can be produced by utilizing the precessional characteristics of a gyroscope. This may be accomplished by mounting the optical head with its mounting shaft in a gimbal assembly and applying a torque with any suitable torque device on the roll axis shaft of the gimbal ring. The torque applied to the shaft will cause precession of the optical system on the vertical axis at a rate which is a function only of the torque. A system constructed in this manner and mounted on an aircraft or ship will be space stabilized.

While I have described a preferred embodiment of my invention, it is to be understood that many modifications may be made by those skilled in the art.

Thus, while the system illustrated employs a triple mirror system, it is to be understood that depending on the purposes for which the detector is designed any number of mirrors may be used. Thus, if it is desired to sweep a vertical angle of 180 degrees, two mirrors may be used, while if it is desired to sweep an area of 90 degrees four mirrors may be used.

Moreover, if the optical system must be mounted in a location where it will be subject to weather, it may be desirable to use sealed optical elements such as a Maksutov sealed beam unit. This type of system, because of the curvature of the glass covers, requires optical corrections and for this reason it may be advantageous, instead, to protect the mirrors by means of a dome similar to that illustrated, but preferably constructed from flat, plane parallel sheets comprised of arsenic trisulphide glass (As_2S_3) which introduces no optical aberrations.

Also, while a spinning motion on the horizontal axis and a rocking motion on the vertical axis are illustrated, these motions may be made about any convenient axis, e.g., the spin axis may be on the vertical axis and the rocking axis may be on the horizontal axis.

Having described a preferred form of my invention, what is claimed is:

1. An optical detector system comprising: a support having a vertical axis and being mounted for rotation on said vertical axis; a photodetector mounted on said support in fixed relationship to said support; an optical system having a horizontal axis, said optical system being mounted on said support for rotation on said horizontal axis, said optical system comprising three optical sets radially mounted on said support in fixed spaced relationship relative to one another 120 degrees apart, said optical sets being adapted to sweep in turn a predetermined vertical angle in space; each of said optical sets including a parabolic reflector for focusing optical images each of said reflectors having an optical axis, said parabolic reflector having a central aperture, a secondary mirror mounted along the optical axis of each reflector to reflect said focused images through said apertures, and a plane mirror mounted opposite each aperture for redirecting the reflected images from said secondary mirror and toward said photodetector; means for rotating said optical system at a high rate of speed about said horizontal spin axis; and means for rotating said support at a relatively slow rate of speed about said vertical axis.

2. The invention as defined in claim **1** and a chopper grid for each of said optical sets fixedly mounted with respect to said optical sets at the image point thereof between said photodetector and said plane mirror.

3. The invention as defined in claim **2**, and an electronic amplifier system coupled to said photodetector for yielding electrical indications of optical images received by said reflector system; and an alarm system coupled to said amplifying system, said alarm system comprising a variable conducting device connected in circuit with a warning device, said variable conducting device being biased non-conductive except when said electrical indications exceed a predetermined magnitude.

4. A passive optical detector comprising: a support having a vertical axis of rotation; a reflector system mounted on said support, said reflector system having a horizontal axis of rotation, said reflector system comprising at least one reflector, each reflector having an optical axis extending radially of said horizontal axis; photodetector apparatus mounted on said support in fixed relation with respect to said support; means in said reflector system for directing images from said reflector onto said photodetector apparatus; means for rotating said reflector system on said horizontal axis at a high rate of speed; and means for simultaneously oscillating said support at a slow rate of speed through a predetermined angle on said vertical axis.

5. The invention as defined in claim **4** and a chopper grid positioned transversely to the path of said focused image at the focal point of said reflector system, said chopper grid being fixed with respect to said reflector system.

6. The invention as defined in claim **5** wherein said chopper grid comprises a plurality of parallel rows, each of said rows consisting of a plurality of alternate transparent and opaque parallel portions disposed in a direction transverse to said rows, the spacing of said portions differing in each of said rows.

7. The combination comprising: a support; a photodetector mounted on said support in fixed relationship to said support; an image focusing system having an axis of rotation and an optical axis perpendicular to said axis of rotation, said image focusing system being mounted on said support for rotation on said axis of rotation; a chopper grid mounted on said image focusing system at the image point thereof and in fixed relationship to said image focusing system; means for rotating said image focusing system whereby said optical axis is radially swept across a sector in space; and means for directing focused images through said chopper grid to said photodetector, said chopper grid consisting of a plurality of parallel rows, said rows being disposed in a direction corresponding to the direction said optical axis is swept, each of said rows having a plurality of alternate transparent and opaque portions, each of said portions being substantially parallel with one another and being disposed in a direction perpendicular to said rows, the number of portions in each of said rows differing from the number of portions in the others of said rows.

8. A scanning system including in combination a rotor, a plurality of optical systems each having a focal plane for radiation emerging from said system and an optical axis, means mounting said optical systems on said rotor with their focal planes intersecting, a detector, stationary means mounting said detector adjacent the intersection of the focal planes to receive radiation emerging from said systems, means for rotating said rotor successively to focus the energy collected by the respective systems on the detector and means for oscillating said rotor in a direction at right angles to the direction of its rotary movement to cause said system to scan a target area.

9. A scanning system including in combination a rotor, a plurality of optical systems each having a focal plane for radiation emerging from the system and an optical axis, each of said optical systems covering an angle substantially equal to 360°/*n* where *n* is the number of said systems, means mounting said optical systems on said rotor with their focal planes intersecting, a detector, stationary means mounting said detector adjacent the intersection of said focal planes to receive radiation emerging from said systems and means for rotating said rotor successively to focus the energy collected by the respective systems on said detector.

10. A scanning system as in claim 9 in which the optical axes of the respective systems intersect adjacent the intersection of the focal planes to form equal angles between adjacent pairs of intersecting axes.

11. A scanning system including in combination a rotor, a plurality of respective optical systems for collecting radiation from a target area, said optical systems being adapted to produce intersecting beams of collected radiation, means mounting said optical systems on said rotor, a support, means rotatably mounting said rotor on said support, a detector carried by said support for receiving collected radiation from said optical systems, means for continuously rotating said rotor on its mounting means successively to focus the beams of radiation collected by said systems on said detector and means for oscillating said rotor about an axis substantially perpendicular to the axis of said pivotal mounting means, and means for rotating said rotor at a relatively greater rate than the rate at which said oscillating means drives said rotor.

12. A scanning system including in combination a rotor, a plurality of optical systems each having a focal plane for radiation emerging from the system and an optical axis, each of said optical systems covering an angle substantially equal to 360°/*n* where *n* is the number of said systems, means mounting said optical systems on said rotor with their focal planes intersecting, a detector, stationary means mounting said detector adjacent the intersection of said focal planes to receive radiation emerging from said systems and means for rotating said rotor successively to focus the energy collected by the respective systems on said detector, each of said optical systems comprising a first mirror for collecting radiation from a target area and for directing collected radiation toward a focal point, said first mirror being formed with an aperture and a second mirror for receiving radiation from said first mirror and for directing received radiation through said aperture to said detector.

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