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(54) METHOD AND APPARATUS FOR CORRECTING THE AIMING OF A TARGET AIMING SYSTEM

(71) We, SOCIÉTÉ DE FABRICATION d'INSTRUMENTS DE MESURE SFIM, a Societe Anonyme organised and existing under the laws of France, of 91301 Massy 13, Avenue Ramolfo Garnier, France, do hereby declare the invention for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:–

This invention relates to a method and apparatus for correcting the aiming of a target aiming system.

The principle of aiming at a target by means of an optical illuminator is known: the illuminator radiates energy towards the target, which energy is generally distributed symmetrically and in monotonically decreasing fashion about its optical axis, and the gun-layer observes the target through a sighting system of which the optical axis is provided, for example, by a reticle projected ad infinitum, the line of sight and the axis of the illuminator having to be harmonised.

In the ensuing description and appended claims the expression "harmonised" means disposed strictly parallel, or coincident, or converged at a predetermined angle. Thus optical axes which are harmonised are parallel, or they coincide, or converge one with another at a predetermined angle.

The harmonisation is sometimes not satisfactorily maintained or is defective, particularly when the illuminator and the means providing the reticle are mounted on separate relatively movable structures, or on moutings on the same structure which between the mountings is deformable so that one mounting moves relatively to the other.

In the case of combat vehicles, in particular, the illuminator and the sighting system are often mounted at a certain distance from each other and very often the structures of the carrier vehicle are insufficiently rigid to allow and maintain a good spatial concordance of the axes of illumination and of sighting so the axes become de-harmonised. Such a phenomenon appears more particularly on helicopters whose structures are relatively lightweight and vibrate continuously.

One object of the invention is to overcome or at least mitigate this defect, i.e. to correct for possible errors which can occur due to the optical axes of the illuminator and sighting system becoming de-harmonised by relative movement between the illuminator and sighting system.

The invention can be applied particularly to a target aiming system used in the sending of a moving body provided with an optical self-directing system to a target, the moving body being for example a missle, shell or any other mobile weapon suitable for offensive action.

The self-directing means of the missile, which directs the missile towards a target illuminated by the optical beam from the illuminator, homes the missile onto a point on the target at which point there is reflected (or diffused) a maximum of the energy incident on the target from the illuminator. But generally that point does not coincide with the place where the maximum energy of the beam is incident on the target, that place being where the optical axis of the illuminator is intersected by the target. The reason for this failure to coincide is due to the optically heterogeneous character of the target (tank, piece of ordnance, artillery, etc . . .), this heterogeneous character being sometimes deliberately increased by the presence of optical decoys. The missile will therefore strike the target at the centre of the energy returned by said target, i.e. at a point other than the point of maximum incident energy, which latter point is also the point aimed at if the optical axes of the illuminator and sighting system are harmonised. If the precision of modern sighting and optical homing systems of weapons is taken into consideration, which precision is of the order of a few decimetres at the distances of combat, an error of this order between centre of the incident energy and centre of the energy returned significantly reduces the accuracy of the weapons.

Another object of the invention to overcome or at least mitigate this drawback, i.e. to correct for possible errors due to the fact a point from which a maximum of energy reflected by the target is different from the point at which the incident energy is a maximum.

According to a first aspect of the invention there is provided a method for correcting the aiming of target aiming apparatus that includes an optical illuminator directed at a target observed by means of a sighting system, wherein the aiming correction is in response to a difference between the direction of the reflected light and an optical axis of the sighting system, the method comprising harmonising the optical axis of the sighting system with an optical axis of the illuminator, electro-optically detecting the direction of maximum light of the illuminator reflected by the target, measuring the angle formed by this direction and the optical axis of the sighting system and utilising the result of this measurement to control deflecting means acting on the orientation of the optical axis of the illuminator or of the optical axis of the sighting system with the result that the direction of maximum light of the illuminator reflected by the target coincides with the optical axis of the sighting system.

An angular deviation measuring device (ADM device) adapted to receive the light of the illuminator reflected by the target can be used as detector.

The angular deviation measuring device supplies a deviation signal characterising the angle existing between its optical axis and the direction in which it receives the maximum of reflected light.

The deviation signals are used for controlling an orientation of the optical axis of the illuminator so that the direction of the maximum of reflected light coincides with the optical axis of the sighting system.

Alternatively, the deviation signals are used for controlling an orientation of the optical axis of the sighting system so that the direction of the maximum of reflected light coincides with the optical axis of the sighting system.

The direction of the maximum reflected light originates from a first target point different than a second target point corresponding to the point of intersection of the optical axis of the illuminator and the target.

Initially the optical axis of the illuminator is harmonised with the optical axis of the sighting system and an optical axis of the angular deviation measuring device, subsequently the initially harmonised optical axes of the illuminator and sighting system become de-harmonised due to uncontrolled relative movement between those axes caused by external uncontrolled factors, and the angular deviation measuring device supplies an error signal characterising the angle existing between the optical axis of the angular deviation measuring device and the direction of the maximum reflected light.

According to a second aspect of the invention there is provided an apparatus for correcting the aiming of a target aiming system in combination with the target aiming system that includes an optical illuminator to be directed at a target observed by means of a sighting system, optical axes of the illuminator and the sighting system being capable of being harmonised, and the aiming correcting apparatus comprising:

an angular deviation measuring device having an optical axis harmonised with the optical axis of the sighting system, said angular deviation measuring device being adapted to receive the light from the illuminator reflected by the target and to supply signals corresponding to the angular deviation existing between the optical axis of said sighting system and the direction of maximum reflected energy; and

deflecting means being associated with said angular deviation measuring device, said deflecting means acting on the direction of the optical axis of the sighting system or on the direction of the optical axis of the illuminator as a function of the signals from said angular deviation measuring device, in order to orientate the optical axis of the sighting system or of the illuminator so that the direction of maximum light of the illuminator reflected by the target coincides with the optical axis of the sighting system.

The deflecting means, the angular deviation measuring device, the illuminator and the sighting system can be mounted on a gyrostabilised platform.

A gyrostabilised optical reflector can be disposed on the trajectories of light beams corresponding to the illuminator, the sight, and said angular deviation measuring device for directing towards the target or receiving therefrom the respective light beams, and the deflecting means is positioned between an observable sighting position of the sighting system and the optical reflector.

In one embodiment the sighting system is a day sighting system, the deflecting means comprises a gyrostabilised optical reflector controllable by the deviation signals from said angular deviation measuring device and sending the beam from the illuminator to the target and the image of the target toward the sight of the day sighting system, said apparatus further comprising

first means mounting said day sighting system, said gyrostabilised optical reflector and said illuminator, and

second means including a gyrostabilised platform mounting said angular deviation measuring device and a night sighting system,

said first and second mounting means not being rigidly connected together, and said reflector reproducing movement of said gyrostabilised platform.

The deflecting means can comprise a plurality of prisms rotatable relatively one to another.

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

Fig. 1 is a diagram as an aid illustrating the principle of the invention;

Fig. 2 is a diagrammatic representation of one embodiment of an arrangement for carrying out the invention, the sighting system being a day-night sighting system;

Fig. 3 is a diagrammatic representation of another embodiment of an arrangement for carrying out the invention, the sighting system being a day sighting system, and

Fig. 4 is a diagrammatic representation of a further embodiment of an arrangement for carrying out the invention, this arrangement combining features of the arrangements in Figs. 2 and 3.

Fig. 1 schematically shows an illuminator 1, a sighting system 2 and an ADM device 3, having optical axes indicated by broken lines 4, 5 and 6 respectively. Initially all these optical axes were harmonised with each other, namely the optical axis of the illuminator 1 was parallel with the parallel optical axes 5 and 6. But since that harmonising a support carring the illuminator 1 on the one hand and the sighting system and the ADM device 3 on the other hand has undergone deformation resulting in the optical axis of the illuminator 1 shifting through an angle *a* from its former position into the position shown at 4 at which the optical axis 4 also makes angles of the same size as *a* with the axes 5 and 6 which have (or are assumed to have) remained parallel.

Angle *a* is generally of the order of several tens of milliradians whilst an angle *b* (which will be referred to hereinbelow) is of the order of 1 milliradian but may be smaller.

The target aimed at is assumed to be target 7, the particular point on the target aimed at by the sighting system 2 being where the optical axis 5 intersects the target. In Fig. 1 the aimed at point happens to coincide with, or happens at least to be closely adjacent to, point 8 which receives maximum incident energy from the illuminator. But of the energy incident on the target 7 from the illuminator, a maximum reflection of this energy is from a point 9 which is different from point 8.

The ADM device 3 sees this maximum of reflected energy at the angle *b* to the optical axis 6, that maximum reflected energy being also at an angle to axis 5 of the same size as *b*. The spaced relationship between the optical axes 5 and 6 and between the ADM device 3 and the sighting system 2 is known. Fig. 1 is diagrammatic and in fact as in the embodiments to be described with reference to Figs. 2 and 4, the ADM device and sighting system are disposed close to one another so that their optical axes are close and may for practical purposes be regarded as coincident. When the direction of maximum reflected energy coincides with the optical axis 5, angle *b* has a known predetermined value of zero and ADM device 3 issues a zero signal indicative that the maximum reflected energy is coming from substantially the point aimed at by the sighting system. If the angle *b* measured by the ADM device 3 differs from zero the ADM device issues an error or command signal to actuate an optical deflector 10 which acts on the optical axis 4 of the illuminator 1. When the deflector 10 is actuated, it swings the optical axis 4 causing the energy beam incident on the target 7 to sweep the target until the angle *b* measured by ADM device 3 is consistent with the direction of maximum reflected energy coinciding with the axis 5, i.e. the angle *b* is zero. Then the ADM device 3 issues a zero signal and actuation of the deflector 10 stops so that the beam of energy is directed onto such a position on the target that the maximum reflected energy from the target is from the point aimed at by the sighting system. Thus the arrangement has accomplished a correction compensating for the axis 4 being out of harmony with axes 5 and 6 and ensuring the maximum reflected energy is from the point aimed at.

Alternatively, the optical deflector can be placed in front of the sighting system so that when the optical deflector is actuated by signals from the ADM device, the optical axis of the sighting system is swung by the deflector to coincide with the direction of maximum reflected energy. Thus the person using the sighting system sees from which point on the target maximum energy is being reflected. Then he must swing the whole arrangement to change that point of maximum reflection until it coincides with the point at which he wants to aim.

The basic principle of the invention having been described, some particular embodiments thereof will now be described in detail, with reference to Figs. 2 to 4.

In the embodiment of Fig. 2, a sighting system 11, an illuminator 12 and an ADM device 13 are mounted on the same gyroscopic platform 14.

This platform with one or more windows is hung on gimbals via trunnions 16 and 17, which are single (overhanging) or double. The movements of the platform about the axes of the trunions (axes concurrent and perpendicular to each other) are controlled by motors 18 and 19, which can be electric or hydraulic. Each motor is preceded by a power amplifier 20 and 21 if necessary.

Each amplifier receives signals coming from a gyroscopic detector 22 securely connected to the platform. The gyroscopic detector 22 has a rotor (not shown) continuously driven about a first axis which has two degrees of freedom in that it can precess about second and third mutually perpendicular axes at right angles to the first axis. The second and third axes correspond to the axes about which the platform can rotate. The gyroscope has two precession or torque motors 23 and 24 which, under the action of electrical power signals coming from two amplifiers 25 and 26, can cause the aforesaid precession. The precession amplifiers 25 and 26 receive control signals coming from an "aiming stick" 27 with two degrees of freedom, through a switch box 28, whose role will be described hereinbelow.

The ADM device is electro-optical in that optical energy incident thereon is converted to electrical energy. It can for example be four similar photodiodes disposed, as is known per se, as respective quadrants of the same circular disc, the known device providing the zero signal when the energy reflected from the target hits the centre of the disc or all the quadrants equally, and providing the appropriate error or control signal when that energy incident on the disc is unevenly distributed between the quadrants. Or the ADM device may comprise a reflecting prism of pyramid shape with four similar side faces equally set about the apex of the pyramid, each side face being arranged to reflect the energy incident thereon onto a corresponding photo-multiplier, the zero signal being provided when all the photo-multipiers simultaneously receive the same amount of reflected energy.

An optical deflector 29 is preferably placed in front of the illuminator 12. This deflector is to swing the optical axis of the illuminator and can comprise a plurality of relatively rotatable prisms which act on the emergent beam from the illuminator to change the direction of the beam onto the target. Instead of prisms, the optical deflector can be formed by a mirror which is rotatable about two mutually perpendicular axes. Alternatively, the optical deflector can be placed in front of the sighting system to swing the optical axis of the sighting system but this can complicate the work of the gun-layer who aims the platform and therefore the sighting system, by means of the control stick 27.

The apparatus described hereinabove is used in two phases a first or "direct" phase and a second or "corrected" phase. In a first, so-called "direct" phase with the switch box set at "direct", the gun-layer aims the platform in the direction of the target, using on the one hand the control stick 27 and on the other hand the sighting system 11 and a screen 52. Optical rays conveying the scene observed by the sighting system can be conveyed therefrom along an optical path through the trunnions of the platform to display an image of that scene on the screen 52 equipped with an eyepiece through which the gun-layer observes the screen. Or the sighting system 11 can receive optical or thermal rays from the scene it observes. From the sighting system 11 those rays are conveyed along a suitable transmission through the trunnions to an optical or thermal television camera equipped with the screen 52 which in this case is a television (TV) screen which if it is small may be viewed with the aid of an eyepiece.

The sighting system 11 is provided with a reticle 11′ optically visible to the gun-layer (in the optical eyepiece or on the TV screen). Also this "direct" phase is characterised by the fact that the optical axes of the illuminator 12, of the ADM device 13 and of the sighting system 11 are adjusted mechanically or electrically so that the axes are harmonised, i.e. either strictly in parallel or with a predetermined convergence.

Once the target has been accurately aimed at by the gun-layer (said aiming facilitated by the gyroscopic stabilisation 22 which acts as a mechanical or electrical low-pass filter), the gun-layer switches switch box 28 onto "corrected". This commences the second or "corrected" phase, during which the gun-layer maintains his sight, whilst the ADM device 13 acts the role which has already been indicated hereinabove, in that it will produce an error or control signal if the direction of maximum reflected energy returned by the target does not coincide with the optical axis of the sighting system 11. This signal acting on the deflector 29 via two amplifiers 34,35 makes the necessary correction on the direction of emission of the illuminator 12 so that the direction of maximum reflected energy returned from the target coincides with the reticle on the optical axis of the sighting system.

On the box 28 a second aiming input 27′ is indicated. The input 27′ can come from an automatic target tracking arrangement and can be used, by switching the box 28, in place of the input from the manual handle 27. This detail does not form part of the invention, but advantageously completes the combination described. Similarly, the illuminator 12 may, if desired, also carry out a range-finding function.

In the embodiment in Fig. 3, an optical reflector, e.g. a gyrostabilised flat mirror 40, disposed on the trajectory of the beams of the illuminator 41 and of the sight 42 returns the light of the illuminator returned by the target, by reflection, to the ADM device 43. An optical deflector 44 and a separator 45 are disposed on the trajectory of the light emitted by the illuminator, upstream of the mirror 40. The control or error signals delivered by the ADM device 43 act on the deflector 44 via a suitable amplifier 46 comprising a switch 47 switchable to an "off" position when desired, to interupt transmission of these signals from the amplifier to the deflector. The separator 45 acts to maintain the beam emitted from illuminator 41 separate from rays following trajectory 49 from the target to the sight 42. The rays following trajectory 49 are reflected by a semi-transparent mirror 53 through which passes rays following trajector 51 from a reticle generator 50. Thus at sight 42 the image of the reticle is superimposed on the image of the target.

The functioning of the device will be readily understood from Fig. 3. In the first phase, with the switch 47 in the "off" position so the deflector 44 is in a predetermined position, the optical axes of the illuminator 41, ADM device 43 and reticle generator 50 are harmonised. Then using a control stick 48, the gun-layer acts on the gyrostabilised mirror 40 via amplifiers 34 and 35 and torque motors 36 and 37 connected to a gyroscope 38 for stabilising the mirror, in azimuth and in elevation, and causes the image of the point on the target he is aiming at to coincide at the sight 42 with the image of the reticle which arrives from the reticle generator 50 (trajectory 51).

Now the gun-layer can commence the second phase by placing the switch 47 in an "on" position so that any control or error signals from the ADM device 43 actuate the optical deflector 44 to ensure that the maximum of reflected light energy from the target is reflected from the point aimed at.

This embodiment is suitable for a day-sight. In particular, it has the advantage of being attainable by applying a simple modification to a known day-sight.

The embodiment in fig. 3 may be modified to include a night-sight.

Such a modified embodiment is shown in Fig. 4 which illustrates a device taking part of the device in Fig. 2 and part of the device in Fig. 3.

The device in Fig. 4 comprises a day-sight 42, a night-sight 30, an illuminator 41 and an ADM device 31.

The day-sight and the illuminator are part of an assembly similar to that of Fig. 3, this assembly comprising in particular a gyrostabilised reflector, for example a mirror 33 which sends the beams from the illuminator towards the target and the image of the target towards the day-sight.

The night-sight 30 and the deviation measuring device 31 are mounted on a gyroscopic platform 32 as in the embodiment in Fig. 2.

The deflector is constituted by the mirror 33 and means known per se are provided for the movements of the platform 32 to be reproduced by the mirror 33.

Trunnions 16 and 17, motors 18 and 19, amplifiers 20 and 21, the gyroscope 22 and its torque motors 23 and 24, the amplifiers 25, 26 associated therewith, the control stick 27′ are found again in Fig. 4. But in this case the amplifiers 34, 35 control the torque motors 36 and 37 connected to the gyroscope 38 of the stabilised mirror 33 and adapted to rotate that mirror in a traversing movement and in an elevating movement by corresponding precession of the gyroscope 38.

This device functions as follows:

In the first or "direct" phase (designated by connections A in the switch box 28) the optical axes are first harmonised and then, by acting on the control stick 27, the gun-layer aims the sight 30 or 42 on the target as has already been described above. The gyrostabilised mirror 33 reproduces directly the movements of the platform carrying the ADM device 31 and night sight 30, except for relative deformations between the structures (which are not rigidly connected) mounting the illuminator 41 and mirror 33 on the one hand and the platform 32 on the other hand. Thus the mirror 33 directs the beam of illuminating light towards the target. The ADM device 31 then detects any deviation symbolised at 39 between the point sighted on the target and the point from which maximum light energy is reflected.

By switching the switch box 28 to "corrected", the gun-layer passes to the second or "corrected" phase, by substituting the ADM device-mirror 33 connection designated by B for the platform 32-mirror 33 connection A.

The deviation signal from the ADM device 31 then pilots the mirror 33 to swing the beam of illuminating light in the direction annulling the said deviation, consequently the direction of the maximum light reflected back by the target coincides with the reticle of the sight 30 and thus the point aimed at coincides with point on the target from which the maximum light is reflected. The advantageous role of the mechanical filtering introduced by the gyroscopes 22 and 38 will be noted.

The arrangements described are particularly applicable to the case of the sighting system and illuminator being mounted on a helicopter.

WHAT WE CLAIM IS:–

1. A method for correcting the aiming

of target aiming apparatus that includes an optical illuminator directed at a target observed by means of a sighting system, wherein the aiming correction is in response to a difference between the direction of the reflected light and an optical axis of the sighting system, the method comprising harmonising the optical axis of the sighting system with an optical axis of the illuminator, electro-optically detecting the direction of maximum light of the illuminator reflected by the target, measuring the angle formed by this direction and the optical axis of the sighting system and utilising the result of this measurement to control deflecting means acting on the orientation of the optical axis of the illuminator or of the optical axis of the sighting system with the result that the direction of maximum light of the illuminator reflected by the target coincides with the optical axis of the sighting system.

2. A method as claimed in claim 1 in which an angular deviation measuring device adapted to receive the light from the illuminator reflected by the target is used as detector.

3. A method as claimed in claim 2, in which the angular deviation measuring device suppies a deviation signal characterising the angle existing between an optical axis of said device and the direction in which it receives the maximum of reflected light.

4. A method as claimed in claim 3, in which the deviation signal is used for controlling an orientation of the optical axis of the illuminator so that the direction of the maximum of reflected light coincides with the optical axis of the sighting system.

5. A method as claimed in claim 3, in which the deviation signal is used for controlling an orientation of the optical axis of the sighting system so that the direction of the maximum of reflected light coincides with the optical axis of the sighting system.

6. A method as claimed in claim 1, in which the direction of the maximum reflected light originates from a first target point different than a second target point corresponding to the point of intersection of the optical axis of the illuminator and the target.

7. A method as claimed in claim 1, in which initially the optical axis of the illuminator is harmonised with the optical axis of the sighting system and an optical axis of the angular deviation measuring device, subsequently the initially harmonised optical axes of the illuminator and sighting system become de-harmonised due to uncontrolled relative movement between those axes caused by uncontrolled external factors, and the angular deviation measuring device supplies an error signal characterising the angle existing between the optical axis of the angular deviation measuring device and the direction of the maximum reflected light.

8. An apparatus for correcting the aiming of a target aiming system in combination with the target aiming system that includes an optical illuminator to be directed at a target observed by means of a sighting system, optical axes of the illuminator and the sighting system being capable of being harmonised, and the aiming correcting apparatus comprising:

an angular deviation measuring device having an optical axis harmonised with the optical axis of the sighting system, said angular deviation measuring device being adapted to receive the light from the illuminator reflected by the target and to supply signals corresponding to the angular deviation existing between the optical axis of said sighting system and the direction of maximum reflected energy; and

deflecting means being associated with said angular deviation measuring device said deflecting means acting on the direction of the optical axis of the illuminator as a function of the signals from said angular deviation measuring device, in order to orientate the optical axis of the sighting system or of the illuminator so that the direction of maximum light of the illuminator reflected by the target coincides with the optical axis of the sighting system.

9. A combination as claimed in claim 8, in which the deflecting means, the angular deviation measuring device, the illuminator and the sighting system are mounted on a gyrostabilised platform.

10. A combination as claimed in claim 8, in which a gyrostabilised optical reflector is disposed on trajectories of light beams corresponding to the illuminator, the sight, and said angular deviation measuring device for directing towards the target or receiving therefrom the respective light beams, and the deflecting means is positioned between an observable sighting position of the sighting system and the optical reflector.

11. A combination as claimed in claim 8, in which the sighting system is a day sighting system, said deflecting means comprises a gyrostabilised optical reflector controllable by the deviation signals from said angular deviation measuring device and sending the beam from the illuminator to the target and the image of the target toward the sight of the day sighting system, said apparatus further comprising

first means mounting said day sighting system, said gyrostabilised optical reflector and said illuminator, and

second means including a gyrostabilised platform mounting said angular deviation measuring device and a night sighting system, said first and second mounting means not being rigidly connected together, and said reflector reproducing movements of said gyrostabilised platform.

12. A combination as claimed in claim 8, in which the deflecting means comprises a plurality of prisms rotatable relatively one to another.

13. A method for correcting the aiming of target aiming apparatus, substantially as hereinbefore described with reference to Fig. 1 or Fig. 2, or Fig. 3, or Fig. 4 of the accompanying drawings.

14. An apparatus for correcting the aiming of a target aiming system in combination with the target aiming system, substantially as hereinbefore described with reference to Fig. 2, or Fig. 3, or Fig. 4 of the accompanying drawings.

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1594114 COMPLETE SPECIFICATION

3 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 1

Fig:1

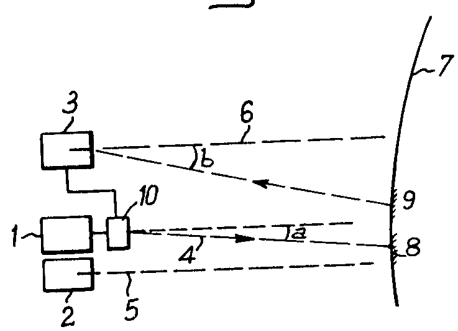


Fig:2

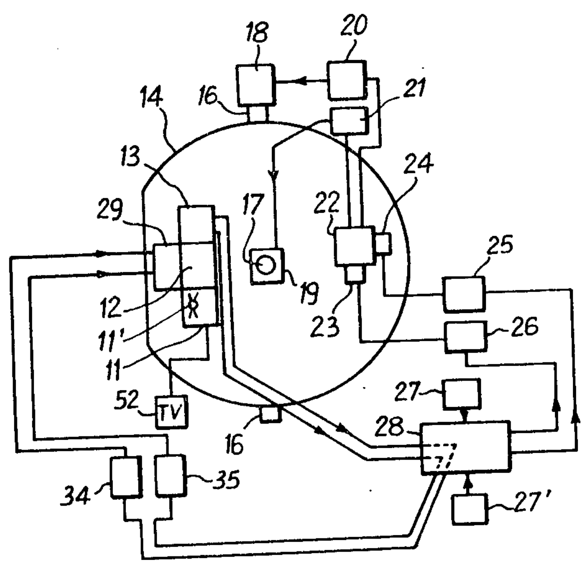


Fig.3

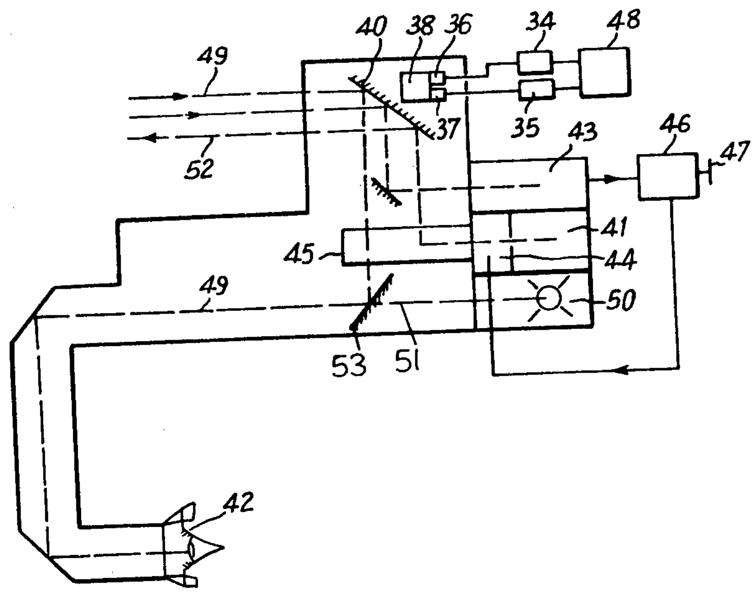
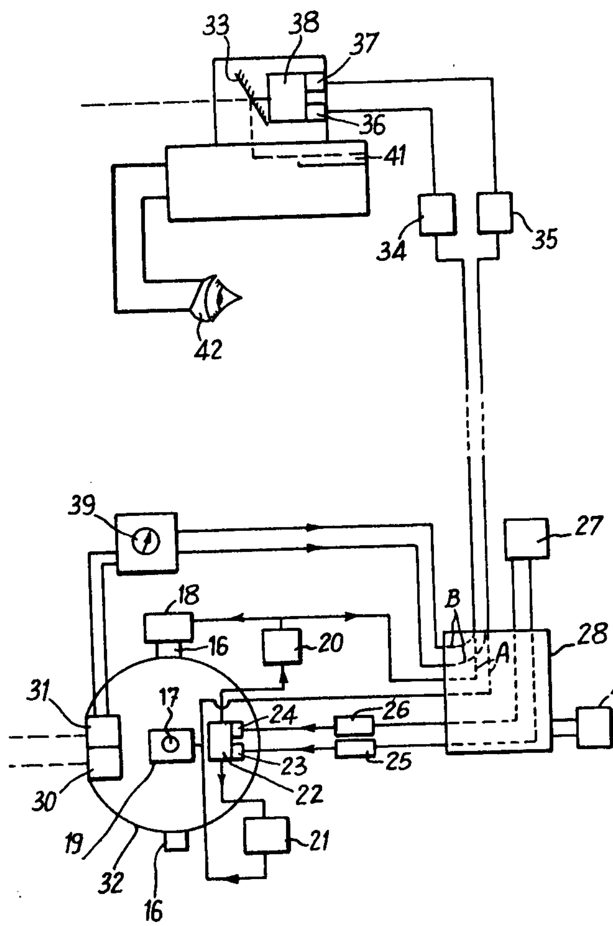


Fig:4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