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(54) **Measurement apparatus**

(57) Measurement apparatus 20, in particular for measuring structures alongside railway tracks, comprises a vehicle 22 preferably in the form of a portable trolley movable relative to a structure to be measured, structure illumination means 24 for illuminating a region of

the structure to be measured, and image capturing means 26 for capturing an image of the region of the structure illuminated by the structure illumination means 24. An illumination arrangement for inspecting a structure is also disclosed.

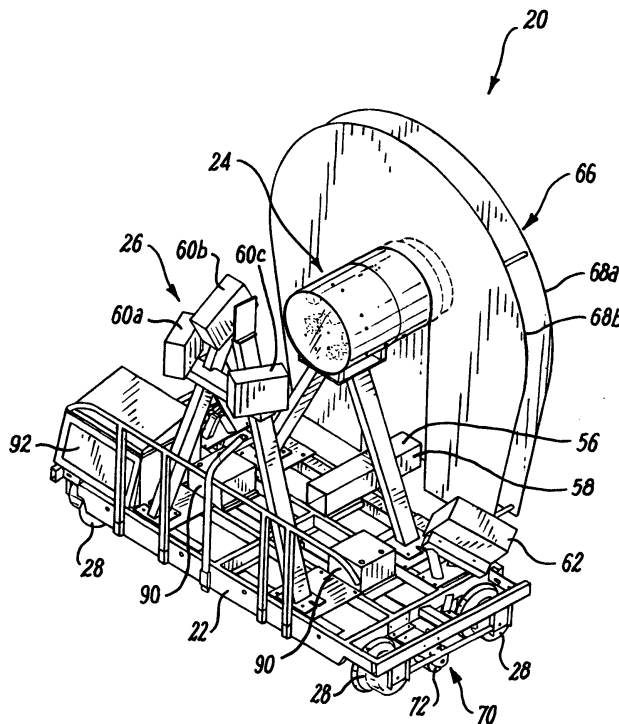


Fig. 1

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Description

[0001] The present invention relates to measurement apparatus, and particularly but not exclusively to measurement apparatus for determining the profile of structures along a rail network. The invention also relates to an illumination arrangement for inspecting a structure.

[0002] In order for rolling stock to operate safely on a rail network, it is important that there is sufficient clearance between all structures which may be present along a particular route on the network and rolling stock which travels along that route. Such structures may typically include overhead line equipment, tunnels, platforms, line-side structures, overbridges and underbridges, although it will be appreciated that many more structures may present a clearance issue.

[0003] Traditionally, knowledge of the structures present along rail networks has been limited, meaning that the exterior dimensions of new rolling stock has been based largely upon the dimensions of existing rolling stock already running along a particular route.

[0004] In order to address this problem, measurement apparatus has been developed to determine the profile of a structure in relation to the rails along a conventional, above ground, rail network. However, this apparatus is not suited for use in areas where access is restricted, such as on an underground rail network.

[0005] According to a first aspect of the present invention, there is provided measurement apparatus comprising a vehicle movable relative to a structure to be measured, structure illumination means for illuminating a region of the structure, and image capturing means for capturing an image of the illuminated region of the structure, wherein the structure illumination means and the image capturing means are removably mountable on the vehicle.

[0006] The structure illumination means and the image capturing means are preferably removably mountable on the vehicle whereby to provide for accurate and repeatable repositioning of the structure illumination means and the image capturing means on the vehicle.

[0007] The vehicle is preferably a trolley.

[0008] The vehicle may be manually movable relative to a structure and may be manually propelled along the ground surface. The vehicle may be arranged to be coupled in use to external tractive means to move the vehicle relative to a structure. The vehicle may be arranged to be coupled to a further vehicle. Alternatively, the vehicle may include propulsion means to move the vehicle relative to a structure.

[0009] The vehicle is preferably portable and is desirably of a weight such that the vehicle and/or its component parts may be lifted by two persons. The vehicle is preferably movable relative to a structure along a ground surface, and may include a plurality of wheels. Each of the wheels may be configured to run along tracks installed on the ground. Each of the wheels may be configured to run along rails and may be configured

to run along railway tracks. The spacing of the wheels may be adjustable so that the vehicle can run along rails of different track spacing.

[0010] The structure illumination means may comprise a narrow light source and means to present illumination across a greater portion of the region of the structure. The means may present illumination across the whole of the region of the structure.

[0011] The structure illumination means may comprise a plurality of lasers. The structure illumination means may comprise an array of lasers and may additionally comprise a further laser. The lasers of the array are preferably circumferentially spaced. Preferably the apparatus includes a deflector arrangement, and the deflector arrangement is preferably arranged to deflect the light emitted by the lasers of the array in a plane perpendicular to the direction in which the light is emitted by the lasers. The deflector arrangement may include a plurality of deflectors and one deflector may be associated with each laser of the array. The lasers and deflectors may present a continuous arc of illumination.

[0012] Each deflector is preferably arranged to deflect the light beam emitted by each laser of the array in a plane perpendicular to the direction in which the beam is emitted by each laser. Each deflector may comprise a reflective surface for deflecting the beam emitted by each laser. The reflective surface is preferably arranged to circumferentially scatter an incident laser beam around a circumference of 360 degrees. The reflective surface is preferably conically shaped and may form part of a conical mirror.

[0013] The deflector arrangement may include shielding means to prevent light scattered by any one of the plurality of deflectors interfering with light scattered by any of the other of the plurality of deflectors. The shielding means may comprise a plurality of shields and the shields are preferably circumferentially spaced. Preferably a shield is located between adjacent deflectors. The shielding means are preferably arranged so that the light scattered by each of the plurality of deflectors illuminates a predetermined region of a structure in use. The shielding means preferably comprises means for absorbing laser light.

[0014] The array of lasers preferably comprises six lasers and the deflector arrangement preferably comprises six deflectors.

[0015] The structure illumination means may include a cylindrical housing and the array of lasers is preferably located in the housing. The cylindrical housing is preferably in the form of a protective drum for protecting the array of lasers. The cylindrical housing may comprise a material which is preferably lightweight and impact resistant. The material may for example comprise aluminium or may comprise a composite material. The housing may additionally comprise rubber for cushioning.

[0016] The further laser may be arranged to illuminate a lower region of a structure being measured, and preferably the ground along which the vehicle is movable.

The further laser is preferably arranged to emit a beam of light in its direction of orientation and a deflector is preferably associated therewith to deflect the beam of light emitted by the further laser generally downwardly. The deflector may also be arranged to scatter the beam of light emitted by the further laser. The further laser is preferably located in a housing, and the housing may be detachably mountable on the vehicle. The housing is preferably arranged to prevent scattering of the beam of light emitted by the further laser in a direction generally upwardly away from the ground.

[0017] The image capturing means preferably comprises a plurality of cameras and each camera is preferably arranged to capture an image of a different region of the structure illuminated by the structure illumination means. Each of the plurality of cameras is preferably orientated so that the captured images of different regions of the illuminated structure together represent an image of the entire region of the structure illuminated by the structure illumination means. The cameras preferably operate continuously so that images of a structure illuminated by the structure illumination means are captured continuously as the vehicle is moved relative to the structure.

[0018] The image capturing means may transmit captured images to a processor for manipulation and/or analysis to determine the profile of a measured structure.

[0019] The structural measurement apparatus may include means for capturing visual images of a measured structure for subsequent viewing. The means preferably continuously captures visual images of a structure being measured as the vehicle is moved relative to the structure.

[0020] The structural measurement apparatus may include distance measurement means for measuring the distance travelled by the vehicle, and the distance measurement means is preferably mounted on the vehicle. The distance measurement means may comprise a rotatable member engageable in use with the surface along which the vehicle is movable. The distance measurement means may include biasing means for urging the rotatable member into contact with the surface along which the vehicle is movable. The rotatable member preferably comprises a wheel which is preferably engageable with a rail along which the vehicle is movable. The distance measurement means may include a shaft encoder for measuring the rotation of the rotatable member. The distance measurement means may transmit data from the shaft encoder to a processor for determining the distance travelled by the vehicle.

[0021] According to a second aspect of the present invention, there is provided an illumination arrangement for inspecting a structure, the arrangement comprising a light source for projecting light towards a deflector for deflecting and scattering the light towards a structure to illuminate a selective region of the structure for inspection.

[0022] According to a third aspect of the present invention, there is provided an illumination arrangement for inspecting a structure, the arrangement comprising a light source and a deflector, the light source presenting a limited width of light beam to the deflector and the deflector deflecting the light beam to present a wider arc of light to the structure for inspection.

[0023] Preferably the light source projects a beam of light in a first direction and the deflector deflects and scatters the incident beam of light in plane perpendicular to the first direction. The deflector preferably deflects and scatters the incident beam of light around a circumference of 360 degrees. The deflector preferably comprises a reflective surface for deflecting and scattering an incident beam of light. The reflective surface is preferably conically shaped. Desirably the deflector comprises a conical mirror.

[0024] The light source may comprise a laser, and desirably comprises a plurality of lasers disposed in a circumferentially equispaced relationship. The illumination arrangement preferably comprises a plurality of deflectors and the deflectors are desirably disposed in a circumferentially equispaced relationship. Preferably, a deflector is aligned with each of the plurality of lasers to receive a beam of light from a respective laser. The illumination arrangement preferably comprises six lasers and six deflectors.

[0025] The illumination arrangement may include shielding means to prevent light deflected and scattered by any one of the plurality of deflectors interfering with light deflected and scattered by any of the other of the plurality of deflectors. The shielding means may comprise a plurality of shields and the shields are preferably circumferentially spaced. Preferably a shield is located between adjacent deflectors. The shielding means are preferably arranged so that the light scattered by each of the plurality of deflectors illuminates a predetermined region of a structure in use. The shielding means preferably comprises means for absorbing laser light.

[0026] The illumination arrangement may include a cylindrical housing and the light source is preferably located in the housing. The cylindrical housing is preferably in the form of a protective drum for protecting the light source. The cylindrical housing may comprise a material which is preferably lightweight and impact resistant. The material may for example comprise aluminium or may comprise a composite material. The housing may additionally comprise rubber for cushioning.

[0027] An embodiment of the present invention will now be described by way of example only and with reference to the accompanying drawings, in which:-

Fig. 1 is a diagrammatic perspective view of measurement apparatus according to the present invention;

Fig. 2 is a rear view of the apparatus of Fig. 1;

Fig. 3 is a side view of the apparatus of Figs. 1 and 2;

Fig. 4 is a plan view of the apparatus of Figs. 1 to 3;

Fig. 5 is a diagrammatic perspective view of structure illumination means of the apparatus of Figs. 1 to 4;

Fig. 5a is a diagrammatic perspective view of part of the structure illumination means of Fig. 5;

Fig. 6 is a cross-sectional view of the structure illumination means of Fig. 5;

Fig. 7 is an enlarged diagrammatic perspective view of part of the structure illumination means of Figs. 5 and 6;

Fig. 8 is a perspective view of distance measurement means of the apparatus of Figs. 1 to 4;

Fig. 9 is a cross-sectional view of the distance measurement means of Fig. 8; and

Fig. 10 is a view from one end of the distance measurement means of Figs. 8 and 9.

[0028] Referring to Figs. 1 to 4, there is shown generally measurement apparatus 20 which in the embodiment illustrated is adapted for measuring structures present alongside railway tracks. The apparatus 20 includes a vehicle 22 in the form of a portable trolley which is moveable along rails relative to a structure to be measured. The apparatus 20 further includes structure illumination means 24 for illuminating a region of the structure being measured and image capturing means 26 for capturing an image of the region of the structure illuminated by the structure illumination means 24.

[0029] The apparatus 20 is particularly suited for use in environments where access may be limited, for example on an underground rail network, and thus the structure illumination means 24 and the image capturing means 26 are removably mountable on the vehicle 22 in such a manner that accurate and repeatable repositioning of the structure illumination means 24 and the image capturing means 26 on the vehicle 22 can be achieved.

[0030] The vehicle 22 is in the form of a lightweight trolley comprising four wheels 28 each having a profile suitable for running along rail tracks (not shown). The trolley 22 includes a fail safe braking mechanism which is known in the art and has a low height to enable it to be used in confined spaces, such as tunnels of an underground rail network. The vehicle 22 is portable and is sufficiently lightweight so that it can be carried by two persons and easily manoeuvred on and off rail tracks.

[0031] In the embodiment shown, the spacing between each pair of wheels 28 on opposite sides of the

vehicle 22 is fixed so that the vehicle 22 is only able to run on rails having a fixed distance therebetween, this distance commonly being referred to as rail gauge. It is however common for rail gauges to vary, for example between 1050 millimetres to 1650 millimetres. Therefore, in order to obviate the need to provide different trolleys for different rail gauges, it is envisaged that means can be provided to vary the spacing between each pair of wheels 28 so that the trolley may easily be adapted to run along rails of varying gauge.

[0032] The vehicle 22 is manually propelled and is pushed along rails to move the vehicle 22 relative to a structure. If desired, the vehicle 22 can be coupled to a further vehicle (not shown) adapted to tow the vehicle 22 and move it along rails relative to a structure. In an alternative embodiment, the vehicle 22 may be provided with propulsion means, for example in the form of an electric motor, coupled to one or more of the wheels 28, or an additional wheel engaged with a rail, to propel the vehicle 22.

[0033] As highlighted above, the structure illumination means 24 is intended to illuminate a region of a structure to be measured using the apparatus 20. In more detail, and referring to Figs. 5 to 7, the structure illumination means 24 comprises an array of six circumferentially equispaced lasers 30 which are mounted so that they each project a laser beam in use generally horizontally and in a forwards direction in the direction of travel of the vehicle 22. The lasers 30 together provide a sufficient level of illumination of a structure so that the image capturing means 26 can capture images of the structure.

[0034] The lasers 30 are mounted within a housing 32 in the form of a cylindrical drum. The housing 32 comprises a first portion 34 and a second portion 36 which may be separated at interface 38 to reduce the weight of the housing 32 for handling purposes. The housing 32 comprises aluminium shrouded in rubber so that the lasers 30 are protected against damage in the event of any impact of the housing 32, which could for example occur if the housing 32 is dropped. It will of course be appreciated that any suitable impact resistant material, such as a lightweight composite material, may be used to fabricate the housing.

[0035] Whilst each of the lasers 30 projects a beam in the direction of travel of the vehicle 22, the measurement apparatus 20 is intended to carry out measurements of structures along the track, in other words structures either side of or above the vehicle 22. The structure illumination means 24 therefore further comprises a deflector arrangement 40 which deflects the beams of laser light emitted by each of the lasers 30 in a plane perpendicular to the direction of orientation of the lasers 30. The deflector arrangement 40 thus causes the light emitted by the lasers 30 to be deflected towards a structure and thereby illuminate that structure.

[0036] The deflector arrangement 40 comprises six deflectors 42 which are circumferentially equispaced and mounted on a flange 44 which is itself removably

secured to the housing 32. A deflector 42 is associated with each of the lasers 30 and each deflector 42 is carefully positioned to be in line with an associated laser so that when a laser beam is emitted by a laser 30 it is transmitted towards its respective deflector 42.

[0037] As best seen in Figs. 5a and 7, each deflector 42 is in the form of a conical mirror and comprises a spherical portion 48 and a conically shaped reflective surface 50. Due to the conical shape of the reflective surface 50, when a beam of light projected by a respective laser 30 is incident upon the reflective surface 50, it is reflected and scattered in a plane generally perpendicular to the direction in which the beam of light is emitted by each laser 30.

[0038] In order to provide an even level of illumination to a structure being measured, it is preferable that light deflected and scattered by any one of the deflectors 42 should not interfere with light deflected and scattered by any of the other deflectors 42. In order to achieve this, the deflector arrangement 40 includes shielding means which are located in appropriate positions relative to each of the deflectors 42. The shielding means comprises a plurality of shields 46, each of which comprises material that absorbs laser light. The shields 46 are circumferentially spaced around the same axis as the lasers 30 and a shield 46 is located between adjacent lasers 30. The shields 46 thus prevent any unwanted interference between light scattered by the deflectors 42 and thereby ensure that the light emitted by each laser 30 and reflected and scattered by each of the deflectors 42 illuminates only a predetermined and defined region of a structure being measured. Hence, an even level of illumination is achieved.

[0039] Referring again to Figs. 1 to 4, in order to illuminate the rails upon which the vehicle 22 is moved, a further laser 54 is provided within a housing 56. Like each of the lasers 30, the further laser 54 is arranged to emit a beam of light generally horizontally in the forwards direction of travel of the vehicle 22. The housing 56 includes an opening 58, and a deflector (not shown) is located inside the housing so that the beam of light emitted by the laser 54 is scattered and reflected out of the housing through the opening 58. The light reflected through the opening 58 thus illuminates each of the rails so that images of the rails can be captured. This is important to provide reference points for measurements carried out using the apparatus 20.

[0040] The image capturing means 26 comprises three battery powered measurement cameras 60a to 60c. Each of the cameras 60a to 60c is orientated so that it points in a different direction and can therefore capture an image of a different region of a structure. Three cameras 60a to 60c are provided so that when the apparatus 20 is located in a fully enclosed structure, such as a tunnel, the two cameras 60a, 60c capture images of the illuminated side regions of the structure, for example the tunnel walls, and the camera 60b captures an image of the top region of the structure, such as the

tunnel roof. Thus, the separate images captured by each of the cameras 60a to 60c represent an image of the entire region of a structure illuminated by the structure illumination means 24.

[0041] In order to capture images of the rails illuminated by the laser 54, further cameras 62, 64 are removably mountable on the vehicle 22, and when mounted for use are orientated so that they each capture an image of one of the rails illuminated by the beam of light emitted through the opening 58 by the further laser 54.

[0042] In addition to the cameras 60a to 60c, 62, 64, a further camera or cameras (not shown) are provided on the vehicle 22 to continuously capture visual images of the structure being measured as the vehicle 22 is being moved. This allows a permanent visual record of the measurement operation to be retained and referred to when necessary.

[0043] In order to prevent a person pushing the vehicle 22 relative to a structure from being directly exposed to light emitted by the lasers 30, 54, the measurement apparatus 20 includes a laser shield 66. The laser shield 66 comprises first and second plates 68a, 68b which are spaced apart and through which light emitted by the lasers cannot pass. The laser shield 66 is located on the apparatus 22 in a position to allow the light deflected and scattered by each of the deflectors 42 to exit the gap around the edge of the plates 68a, 68b and thereby illuminate an adjacent structure. However, the light is constrained in a plane defined by the spaced plates 68a, 68b, and a person standing at the rear of the vehicle 22 and pushing it along is thus shielded from direct laser exposure.

[0044] In order to enable the distance travelled by the vehicle 22 to be determined, the measurement apparatus 20 includes distance measurement means 70, best seen in Figs. 8 to 10. The distance measurement means 70 comprises a rotatable member in the form of a wheel 72 which is engageable with a surface of a rail track along which the vehicle 22 moves. The wheel 72 is rotatably supported in a mounting 74 which is pivotally attached at pivot 76 to a mounting plate 78 which includes brackets 80 for securing the distance measurement means 70 to the vehicle 22.

[0045] In order to ensure that the wheel 72 remains in contact with the rail at all times, the mounting 74 upon which the wheel 72 is rotatably mounted is biased about the pivot 76 towards a rail. Biasing means in the form of a spring 82 acts between the mounting 74 and a lip 84 provided on an edge of the mounting plate 78 so that the mounting is urged away from the plate 78 about the pivot 76.

[0046] The distance measurement means 70 includes a shaft encoder 86 for measuring the rotation of the wheel 72 as the vehicle 22 is moved along rails. Data from the shaft encoder 86 is transmitted to a processor which is able to determine the distance travelled by the vehicle 22 and to relate this to structural measurements based on images captured by the image capturing

means 26, as will be described hereinafter.

[0047] In order to provide power to the lasers 30, 54 and to the cameras 60a to 60c, 62, 64, batteries 90 are mounted on the vehicle 22. Further, in order to enable control of the apparatus and processing of images captured by the cameras 60a to 60c, 62, 64, a processor in the form of a computer 92 is provided on the vehicle 22. The computer 92 is provided with appropriate structural measurement software, and thus if desired, immediate on site structural analysis can be carried out using the measurement apparatus 20.

[0048] When it is desired to carry out measurements of structures using the measurement apparatus 20, the separate components, namely the structure illumination means 24, the cameras 60a to 60c, 62 and 64, the batteries 90 and the computer 92 are transported to the location at which measurement is to take place. The vehicle 22 is also transported to the location and prior to commencing measurement, all of the aforesaid components of the apparatus 20 are mounted on the vehicle 22 so that the apparatus 20 is ready for use. The apparatus 20 is provided with releasable mountings which enable repeated mounting and removal of the components on the vehicle 22, and which provide for accurate and repeatable repositioning when remounted on the vehicle 22.

[0049] Following assembly of the apparatus 20, when it is desired to commence measurement, the lasers 30, 54 and the cameras 60a to 60c, 62, 64 are all activated so that any structure adjacent the vehicle 22 is illuminated by the lasers 30 and the rails along which the vehicle 22 is moveable are also illuminated by the laser 54. For example, if the apparatus 22 is being used in a tunnel, a slice of the entire cross-section of the tunnel wall will be illuminated by the lasers 30 whose light is deflected and scattered by the deflectors 42, as hereinbefore described.

[0050] The vehicle 22 is then manually pushed by a user standing behind the vehicle along rails so that the vehicle 22 is moved relative to an adjacent structure or structures, for example through a tunnel. The cameras 60a to 60c continuously capture images of a structure illuminated by the lasers 30. For example, as the vehicle 22 is pushed through a tunnel, the cameras 60a to 60c continuously capture cross-sectional images of the tunnel wall along the length of the tunnel.

[0051] In use, images are continuously captured by the cameras 60a to 60c, 62, 64 between pre-determined points along the rails. For example, these pre-determined points may be spaced apart at intervals of five metres. Although the cameras 60a to 60c, 62, 64 continuously capture images of an adjacent structure between the pre-determined intervals, the software used to carry out structural analysis using the images captured by the cameras produces a worst case two-dimensional cross-sectional profile between those pre-determined intervals. In the case of a tunnel for example, the cross-sectional profile will vary along the length of the

tunnel between the pre-determined intervals. However, the software with which the captured images are analysed will produce a two-dimensional cross-sectional view of the tunnel which will be made up of those points along the length of the tunnel between the pre-determined intervals where there is least clearance between a reference point and the tunnel wall.

[0052] In order to provide the reference point on which the structural measurements can be based using the images captured by the cameras 60a to 60c, the cameras 62, 64 also continuously capture images of the rails illuminated by the laser 54 between the predetermined intervals as the vehicle 22 is moved along the rails. Images captured by the cameras 62, 64 are thus also utilised by the software when creating cross-sectional profiles.

[0053] In order to enable the apparatus 20 to determine when the vehicle 22 has travelled a pre-determined distance between pre-determined intervals along the rails, the distance measurement means 70 also operates continuously to transmit distance measurement data to the computer 92 on board the vehicle 22.

[0054] There is thus provided measurement apparatus 20 which, due to its modular design allowing removable attachment of all components, can be easily transported and therefore used to measure structures in locations where access is restricted, such as for example on an underground rail network. The use of conical mirrors in the deflector arrangement 40 enables a structure to be fully illuminated whilst using only a small number of lasers 30. This is particularly advantageous since power consumption is minimised and hence this provides added advantages in relation to the modularity and transportability of the apparatus 20. A further and particularly important advantage of the apparatus 20 relates to its ability to take continuous measurements of a structure as the vehicle 22 is moved continuously relative to a structure being measured. This provides for a very significant reduction in the time taken to measure a structure when compared to the time needed to measure the same structure using apparatus which does not operate in such a continuous manner.

[0055] Although embodiments of the present invention have been described in the preceding paragraphs with reference to various examples, it should be understood that various modifications to the examples given may be made without departing from the scope of the present invention. For example, the vehicle 22 may be motorised and may include means for carrying an operator during movement of the vehicle along rails relative to a structure. The vehicle 22 may be of a different design provided that it allows for removable mounting of the various components thereon. Whilst the vehicle 22 has been illustrated for use on rails, the wheels 28 could be replaced with conventional wheels so that the vehicle 22 is able to run along any surface. Thus, the vehicle 22 could for example be used for measuring any structure. The support on which the structure illumination means

24 is mounted may provide for movement of the structure illumination means 24 relative to the vehicle 22, for example so that the height of the structure illumination means 24 may be varied. The apparatus 20 may include further measurement cameras to enable the measurement of larger structures.

[0056] Whilst endeavouring in the foregoing specification to draw attention to those features of the invention believed to be of particular importance it should be understood that the Applicant claims protection in respect of any patentable feature or combination of features hereinbefore referred to and/or shown in the drawings whether or not particular emphasis has been placed thereon.

Claims

1. Measurement apparatus comprising a vehicle movable relative to a structure to be measured, structure illumination means for illuminating a region of the structure, and image capturing means for capturing an image of the illuminated region of the structure, wherein the structure illumination means and the image capturing means are removably mountable on the vehicle.
2. Apparatus according to claim 1, wherein the vehicle is a trolley.
3. Apparatus according to claim 1 or claim 2, wherein the vehicle is manually movable relative to a structure.
4. Apparatus according to any of the preceding claims, wherein the vehicle is portable and is of a weight such that the vehicle and/or its component parts may be lifted by two persons.
5. Apparatus according to any of the preceding claims, wherein the vehicle includes a plurality of wheels configured to run along tracks or rails installed on the ground.
6. Apparatus according to claim 5 wherein the spacing of the wheels is adjustable so that the vehicle can run along rails of different track spacing.
7. Apparatus according to any of the preceding claims, wherein the structure illumination means comprises a narrow light source and means to present illumination across a greater portion of the region of the structure.
8. Apparatus according to claim 7, wherein the means is arranged to present illumination across the whole of the region of the structure.
9. Apparatus according to any of the preceding claims, wherein the structure illumination means comprises an array of lasers, the lasers of the array being circumferentially spaced.
10. Apparatus according to claim 9, wherein the structure illumination means additionally comprises a further laser for illuminating a lower region of a structure being measured.
11. Apparatus according to claim 9 or claim 10, wherein the apparatus includes a deflector arrangement comprising a plurality of deflectors one of which is associated with each laser of the array, and the deflector arrangement is arranged to deflect the light emitted by the lasers of the array in a plane perpendicular to the direction in which the light is emitted by the lasers.
12. Apparatus according to claim 11, wherein the lasers and deflectors are arranged to present a continuous arc of illumination.
13. Apparatus according to claim 12, wherein each deflector comprises a reflective surface arranged to circumferentially scatter an incident laser beam around a circumference of 360 degrees.
14. Apparatus according to claim 13, wherein the reflective surface is conically shaped and preferably forms part of a conical mirror.
15. Apparatus according to any of claims 11 to 14, wherein the deflector arrangement includes shielding means to prevent light scattered by any one of the plurality of deflectors interfering with light scattered by any of the other of the plurality of deflectors, the shielding means being arranged so that the light scattered by each of the plurality of deflectors illuminates a predetermined region of a structure in use.
16. Apparatus according to any of claims 10 to 15, wherein the further laser is arranged to emit a beam of light in its direction of orientation and a deflector is associated therewith to deflect and scatter the beam of light emitted by the further laser generally downwardly.
17. Apparatus according to any of the preceding claims, wherein the image capturing means comprises a plurality of cameras and each camera is arranged to capture an image of a different region of the structure illuminated by the structure illumination means.
18. Apparatus according to claim 17, wherein each of the plurality of cameras is orientated so that the captured images of different regions of the illuminated

structure together represent an image of the entire region of the structure illuminated by the structure illumination means.

19. Apparatus according to any of the preceding claims, wherein the image capturing means is arranged to transmit captured images to a processor for manipulation and/or analysis to determine the profile of a measured structure. 5
20. Apparatus according to any of the preceding claims, wherein the apparatus includes means for continuously capturing visual images of a measured structure for subsequent viewing as the vehicle is moved relative to the structure. 10
21. Apparatus according to any of the preceding claims, wherein the apparatus includes distance measurement means for measuring the distance travelled by the vehicle. 15
22. Apparatus according to claim 21, wherein the distance measurement means comprises a rotatable member engageable in use with the surface along which the vehicle is movable. 20
23. Apparatus according to claim 22, wherein the distance measurement means includes biasing means for urging the rotatable member into contact with the surface along which the vehicle is movable. 25
24. Apparatus according to claim 22 or claim 23, wherein the rotatable member comprises a wheel which is engageable with a rail along which the vehicle is movable. 30
25. An illumination arrangement for inspecting a structure, the arrangement comprising a light source and a deflector, the light source presenting a limited width of light beam to the deflector and the deflector deflecting the light beam to present a wider arc of light to the structure for inspection. 35
26. An illumination arrangement according to claim 26, wherein the light source is arranged to project a beam of light in a first direction and the deflector is arranged to deflect and scatter the incident beam of light in plane perpendicular to the first direction, preferably around a circumference of 360 degrees. 40
27. An illumination arrangement according to claim 26 or claim 27, wherein the light source comprises a plurality of lasers disposed in a circumferentially equispaced relationship and the illumination arrangement comprises a plurality of deflectors disposed in a circumferentially equispaced relationship. 45
28. An illumination arrangement according to claim 27, 50

wherein a deflector is aligned with each of the plurality of lasers to receive a beam of light from a respective laser.

29. An illumination arrangement according to claim 27 or claim 28, wherein the illumination arrangement includes shielding means to prevent light deflected and scattered by any one of the plurality of deflectors interfering with light deflected and scattered by any of the other of the plurality of deflectors. 55
30. An illumination arrangement according to claim 29, wherein the shielding means are arranged so that the light scattered by each of the plurality of deflectors illuminates a predetermined region of a structure in use. 60

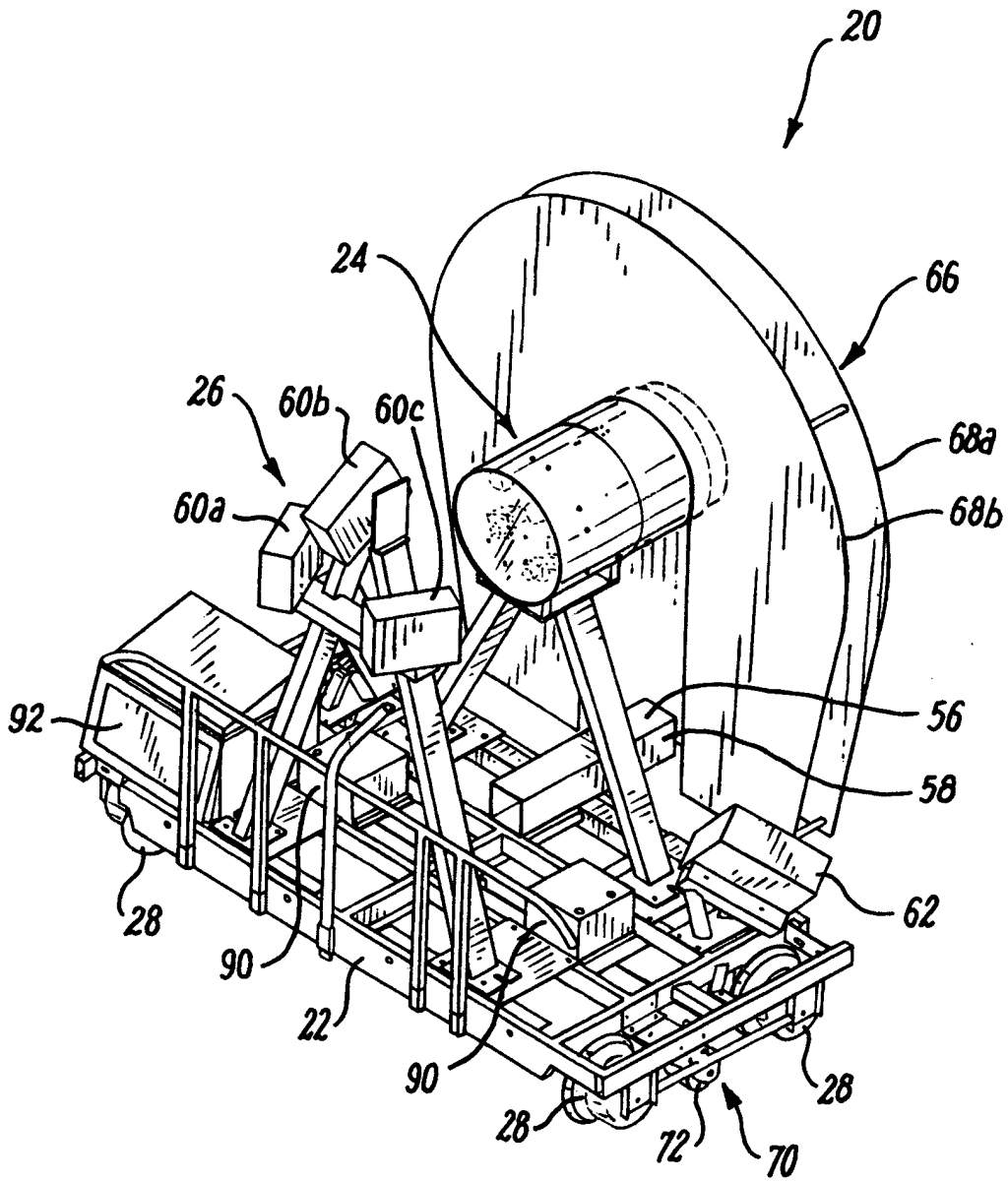


FIG. 1

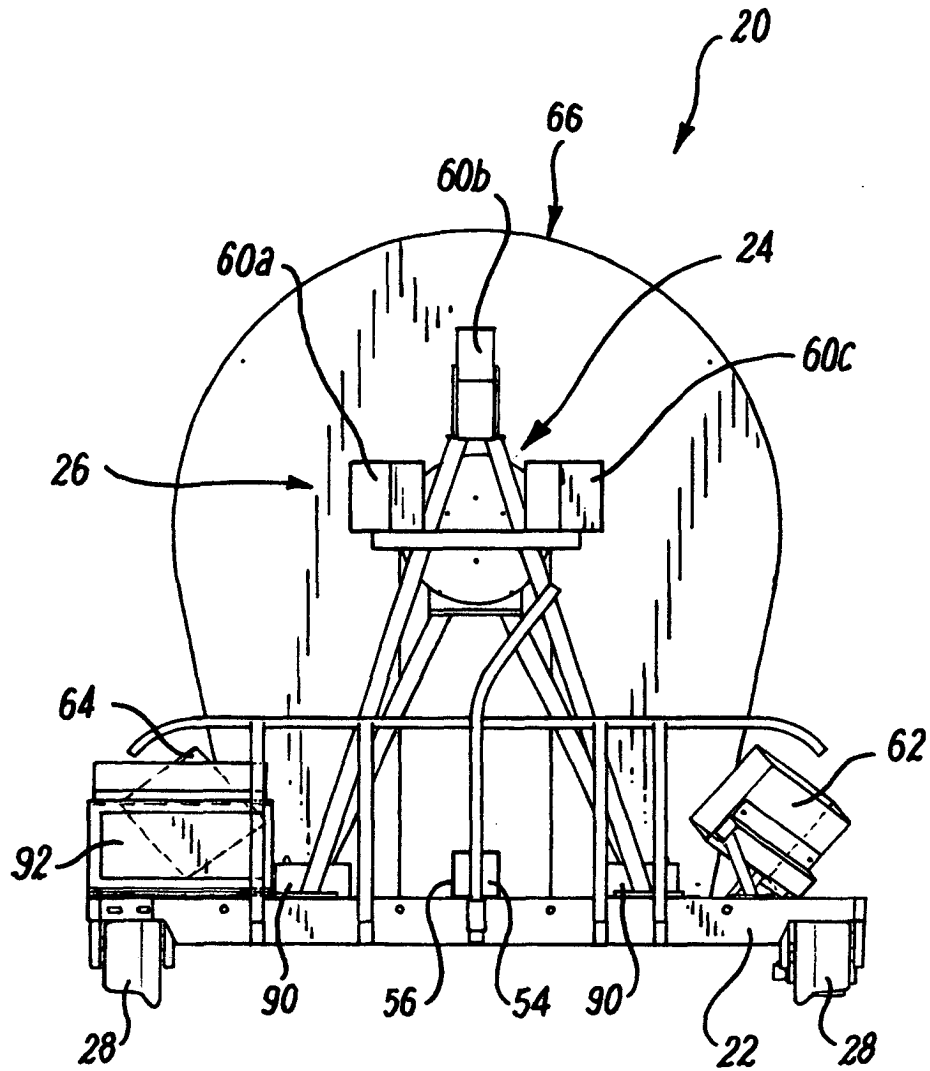
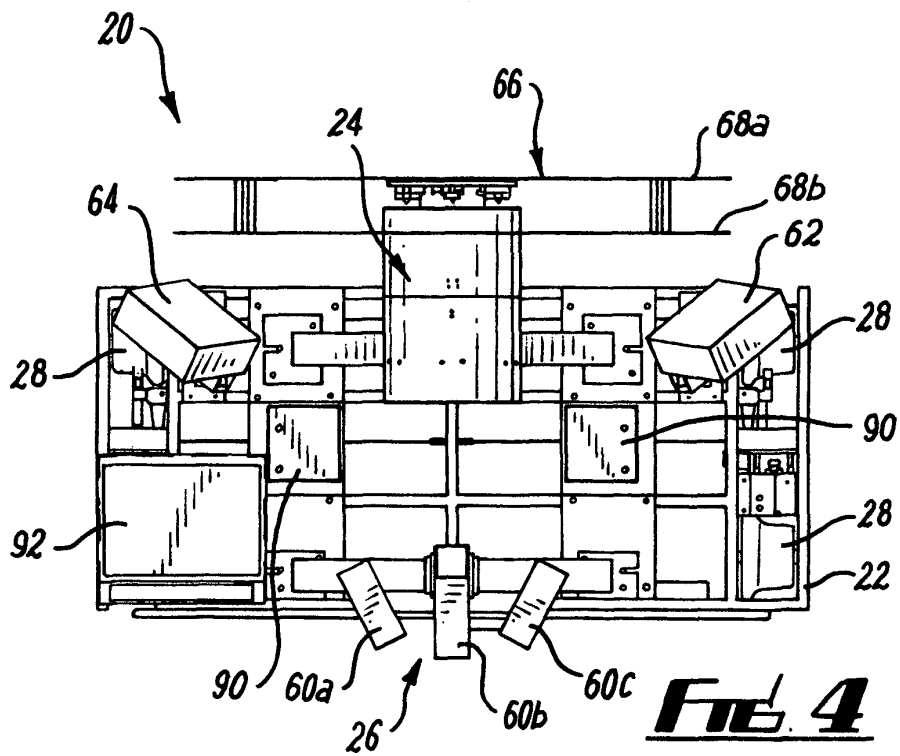
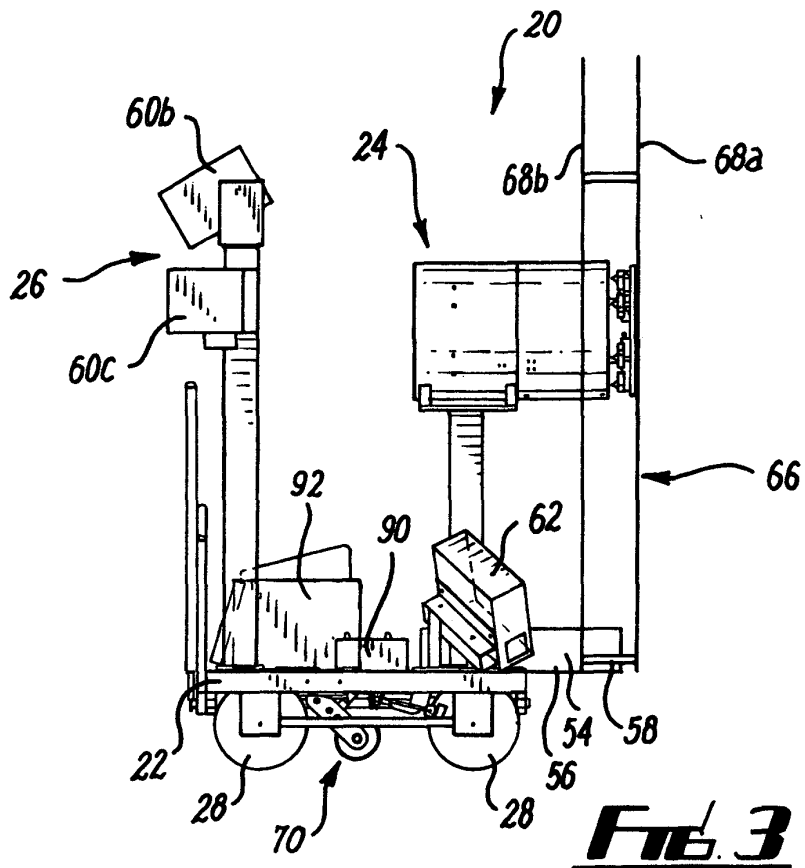


FIG. 2



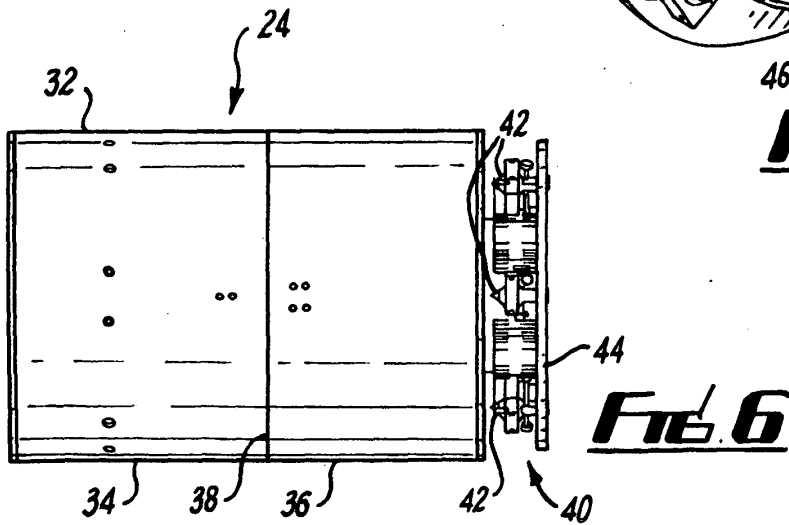
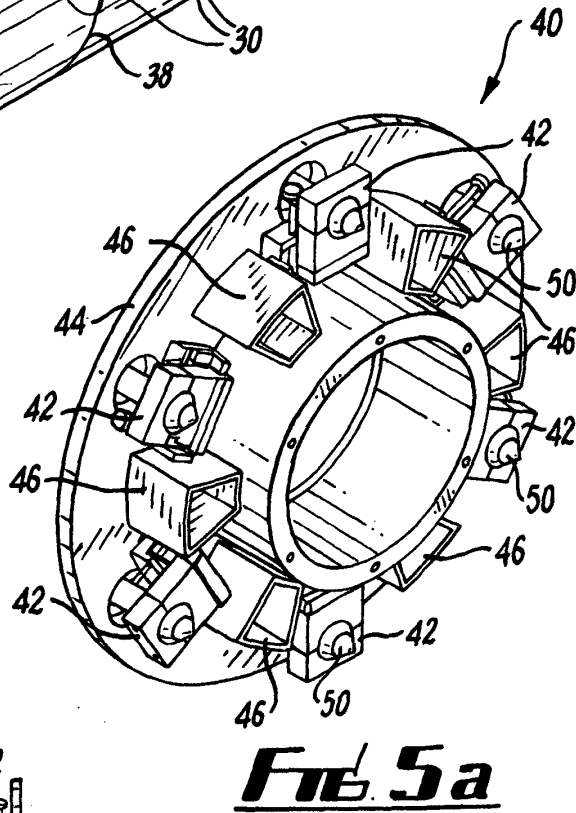
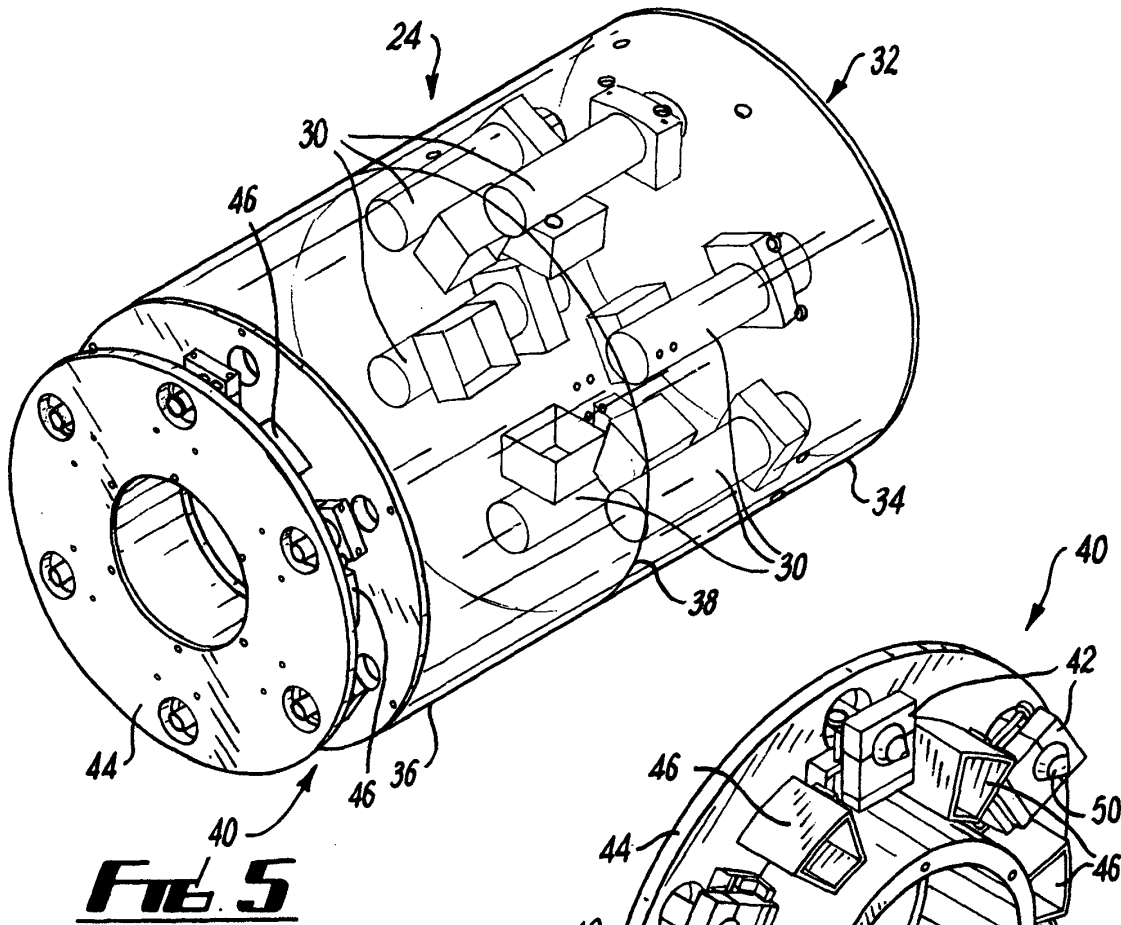
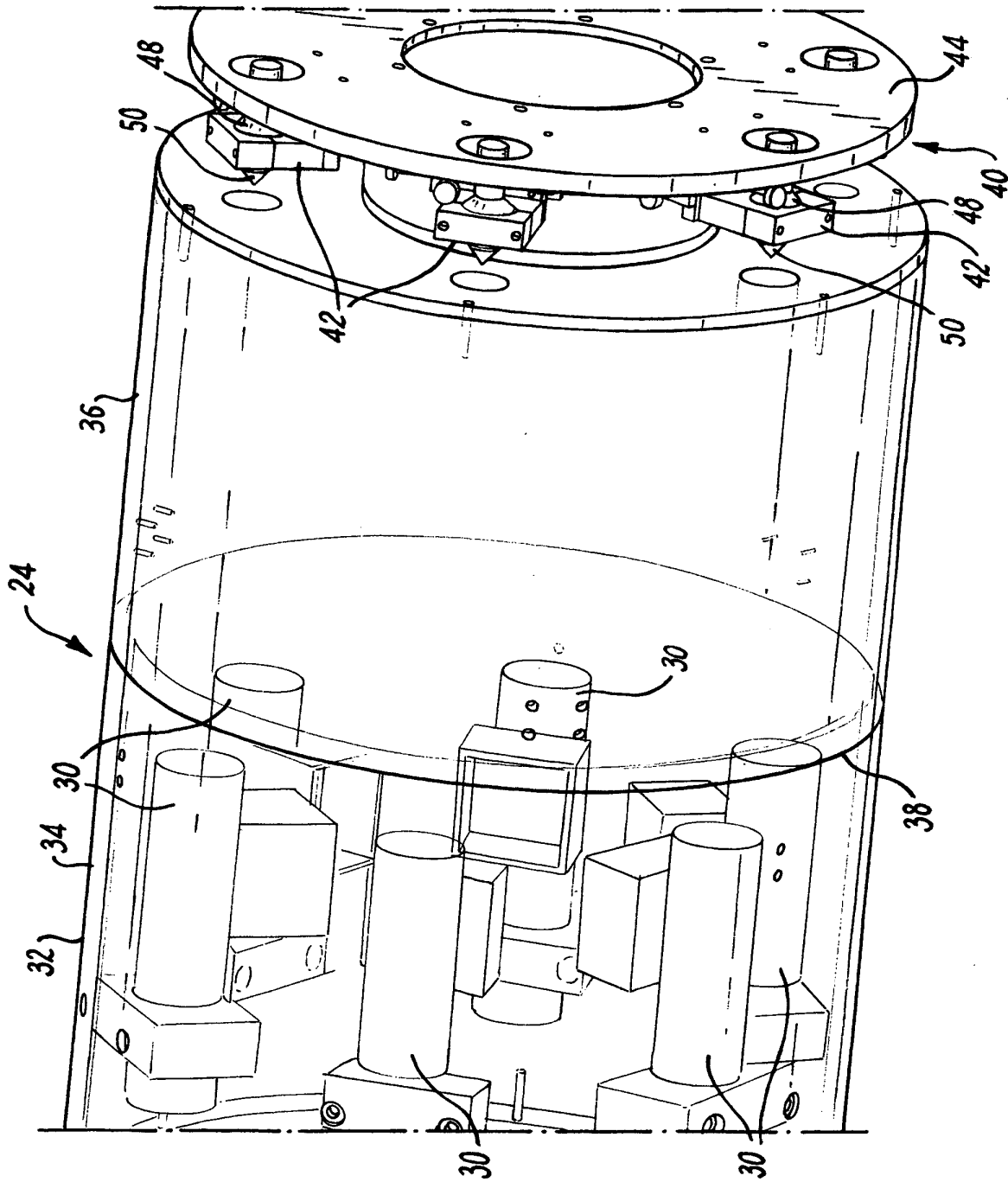


Fig 1



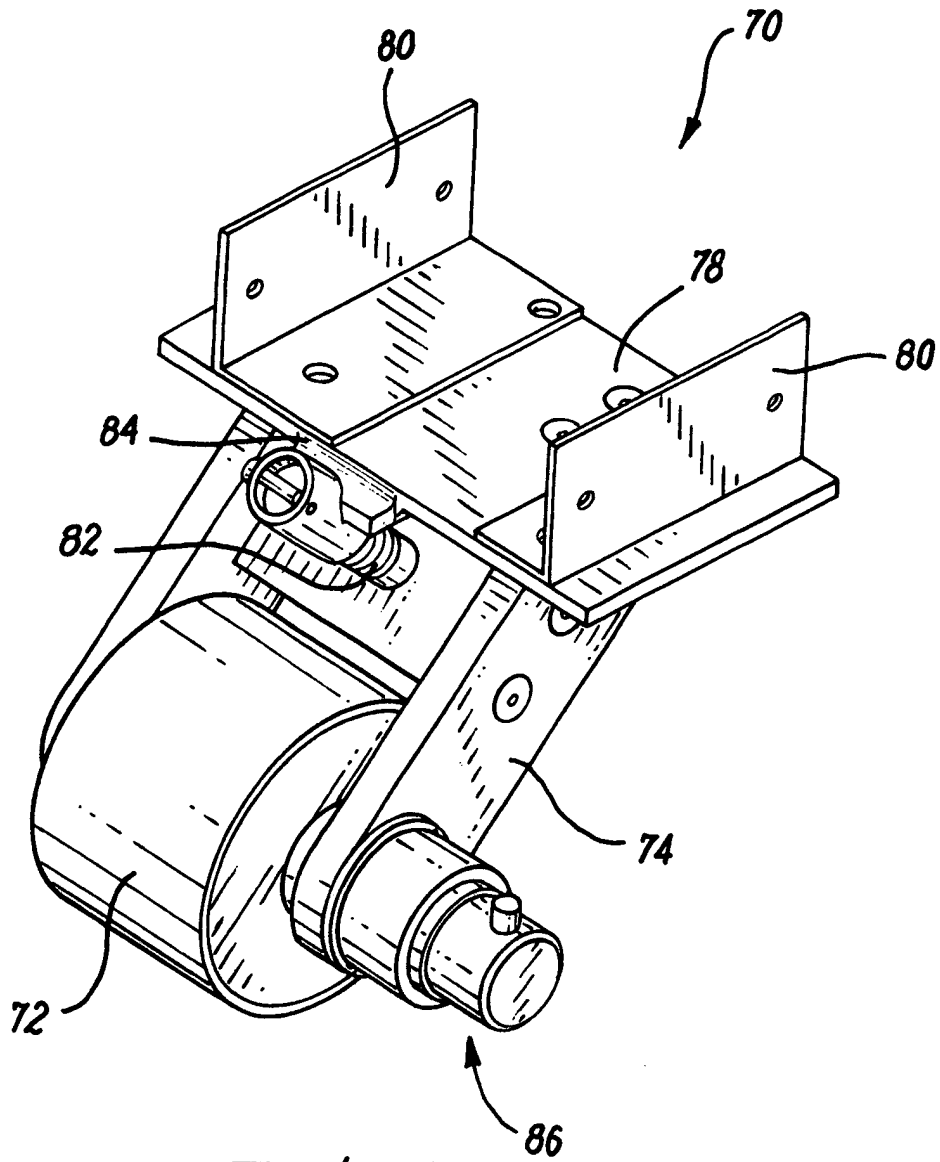


FIG. 8

