(12) UK Patent Application (19) GB (11) 2 268 252 (13) A

(43) Date of A Publication 05.01.1994

(21) Application No 9313507.7

(22) Date of Filing 30.06.1993

(30) Priority Data
(31) 9213849 (32) 30.06.1992 (33) GB
9213891 30.06.1992

(71) Applicant(s)
British Aerospace Simulation Limited

(Incorporated in the United Kingdom)

P O Box 87, Lancaster House,
Farnborough Aerospace Centre, FARNBOROUGH,
Hants, GU14 6YU, United Kingdom

(72) Inventor(s)
Simon James Begent
Brian G Braybrooke

(51) INT CL[5]
F41A 3/26

(52) UK CL (Edition M)
F3C CTE

(56) Documents Cited
GB 2260188 A GB 2160298 A GB 2152645 A
EP 0330886 A1 EP 0118604 A2

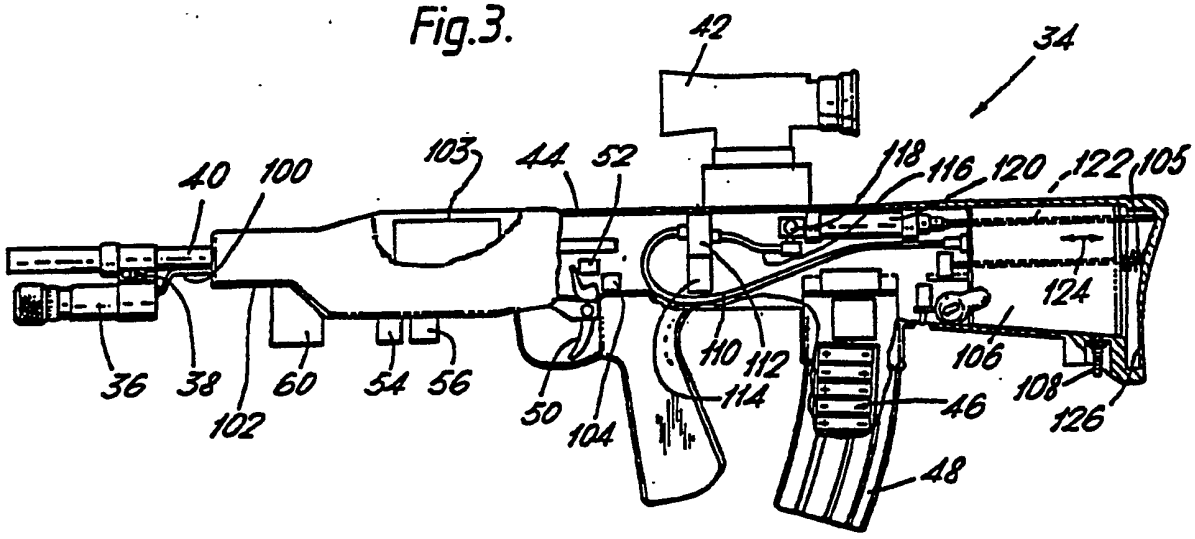
(58) Field of Search
UK CL (Edition L) F3C CTE CTN
INT CL[5] F41G 3/26
ONLINE WP

(74) Agent and/or Address for Service
Ian M Bingham
British Aerospace Public Limited Company,
Corporate Intellectual Property Dept,
Lancaster House, Farnborough Aerospace Centre,
FARNBOROUGH, Hants, GU14 6YU, United Kingdom

(54) Weapon training

(57) Weapon training apparatus comprising a simulated weapon 34, typically a rifle to which is attached a t.v. camera directly along the weapon boresight. The weapon is aimed and fired at a target image with a background scene projected onto a screen. The resulting video signal from the camera is analysed to determine the position of the projected scene within the camera's field of view and given that the target position in the scene is known, the accuracy of the shot can be determined. Signalling between the weapon and fixed parts of the apparatus is by infra-red and microwaves. The weapon may simulate recoil.

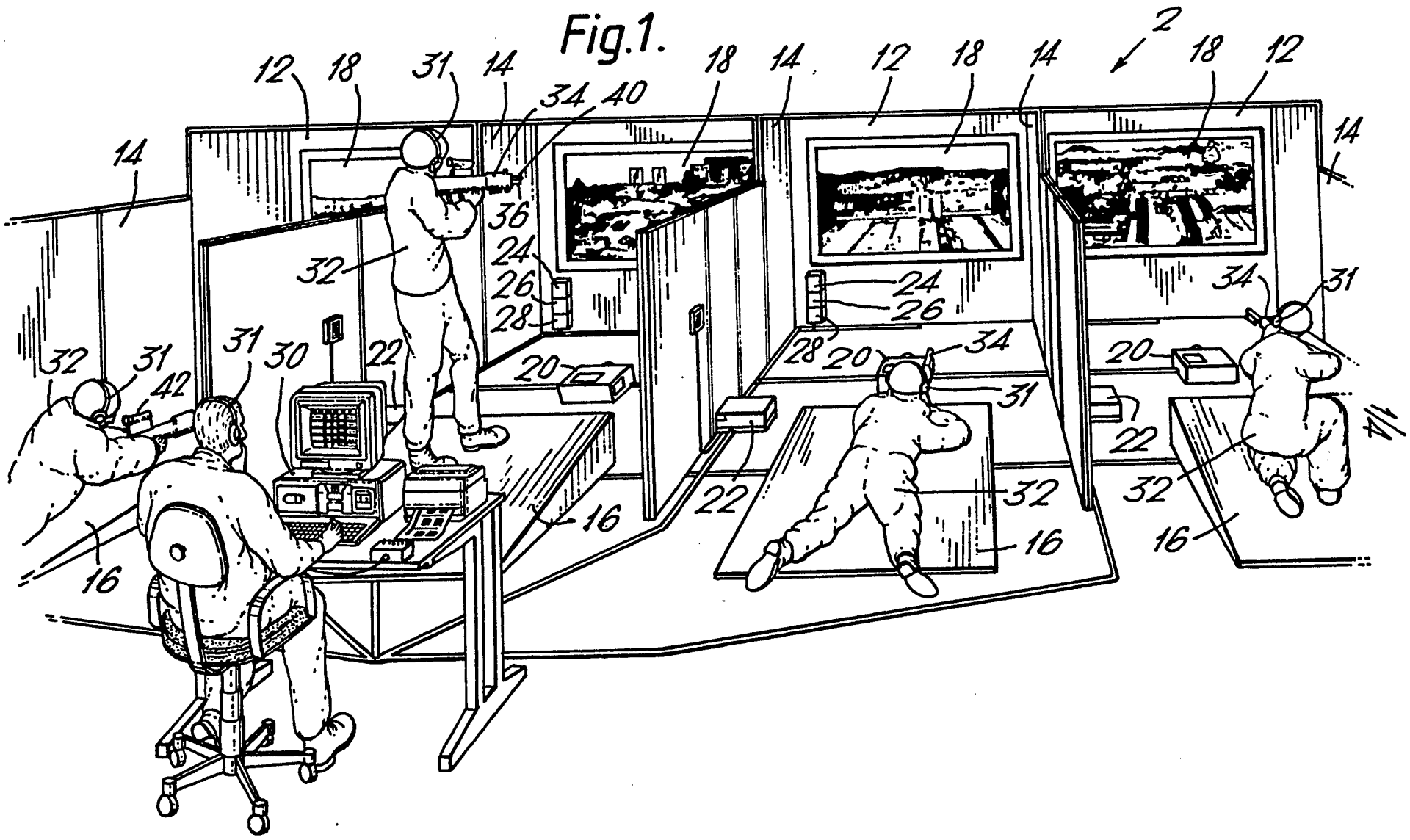
Fig.3.



GB 2 268 252 A

At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

Fig.1.



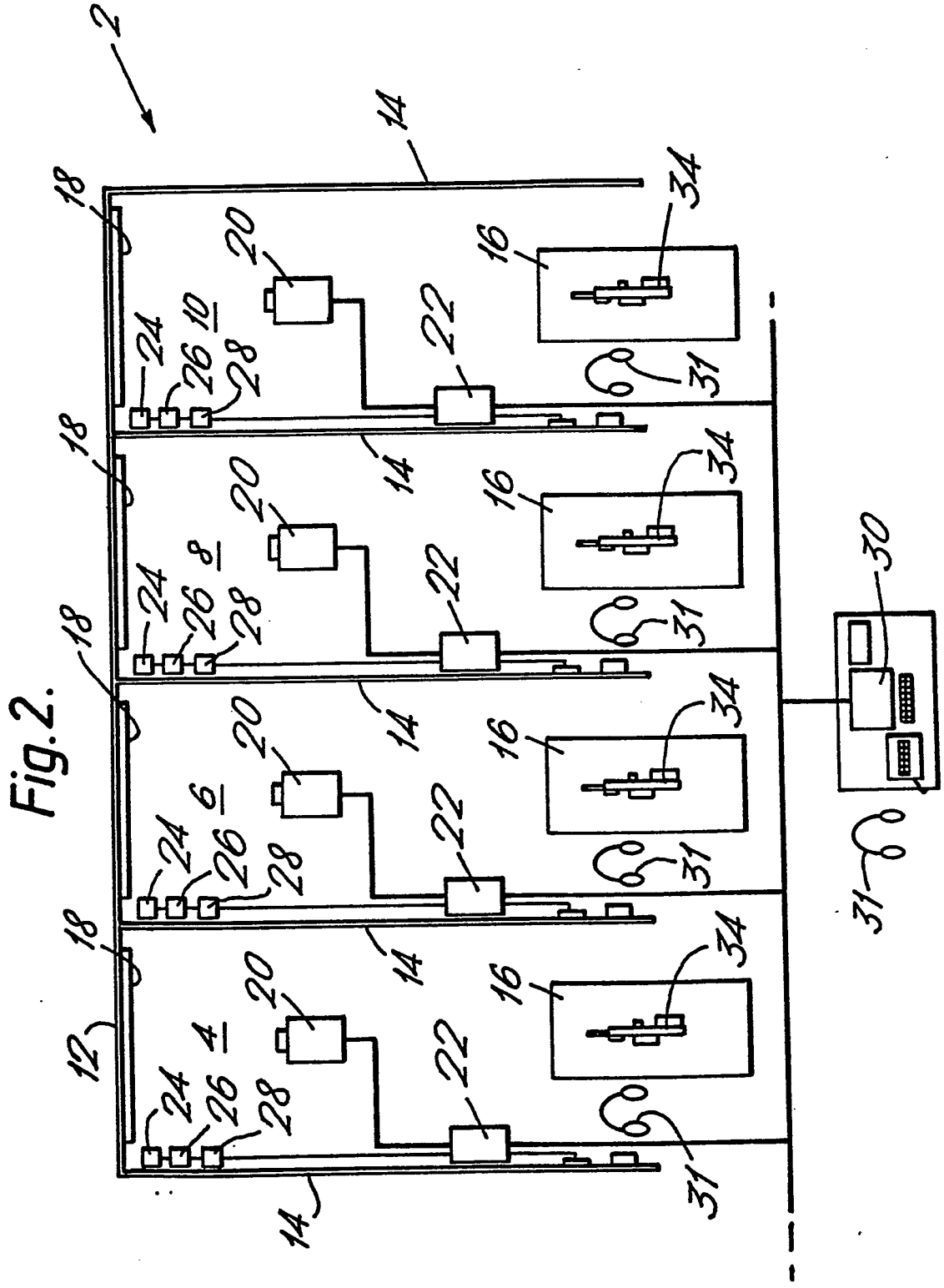


Fig.2.

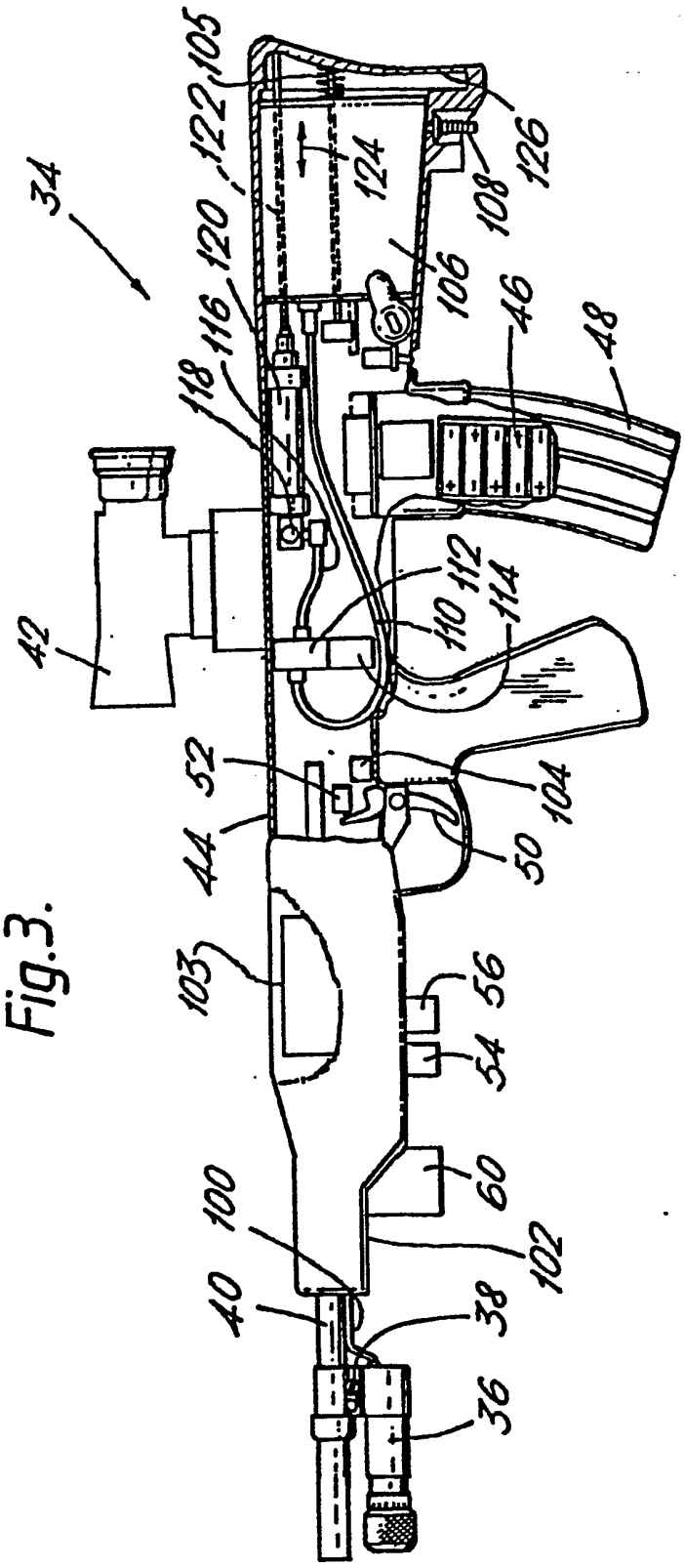

34
105
122
120
116
118
124
126
108
106
46
48
42
112
110
114
52
104
44
50
103
56
54
60
100
102
40
38
36

Fig.3.

Fig.4a.

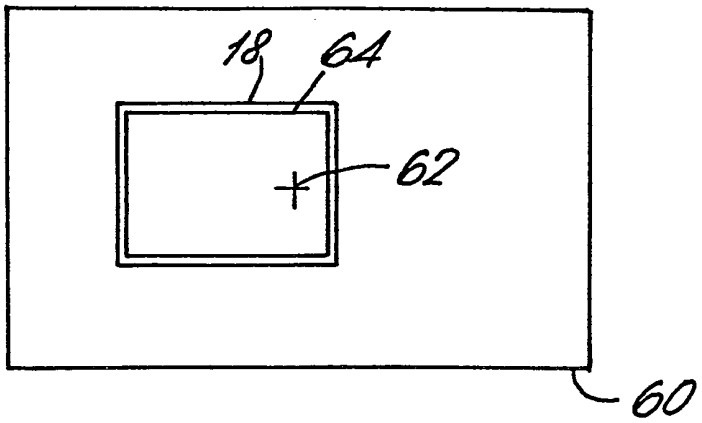


Fig.4b.

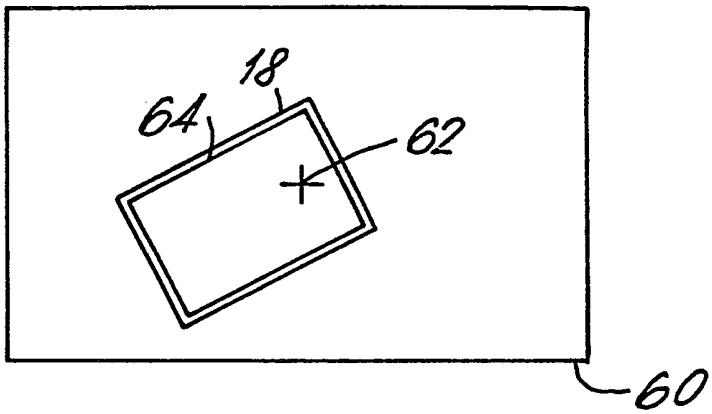


Fig.4c.

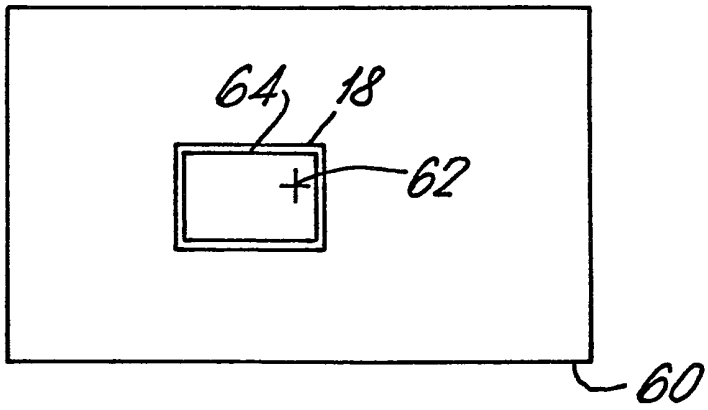
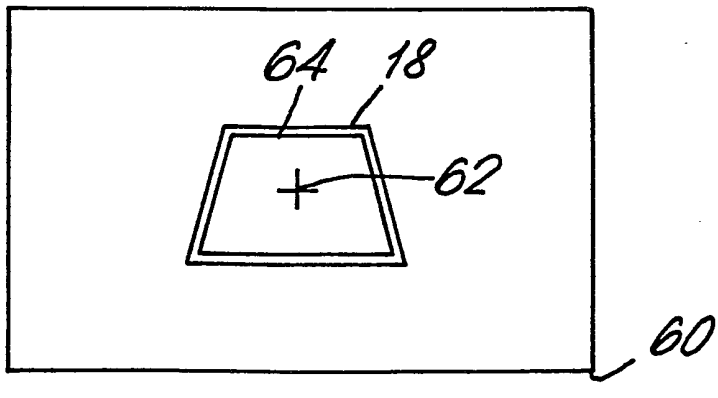


Fig.4d.



2268252

WEAPON TRAINING

For weapon training, video monitors or projectors may be used to display images of background scenes and targets on a screen. The personnel being trained are situated an appropriate distance away from the displayed images and equipped with a simulated weapon. A beam of light, eg from a laser is emitted from an appropriate part (usually the barrel) of the weapon when the operator fires and the point of incidence of the laser beam on the screen is determined by a suitable radiation detector. This point of incidence information can then be analysed to see if the point of incidence coincides with the known position of a target in the projected image.

The result of the analysis will be inaccurate unless the projected image is in exactly the right location on the screen. If the location is not correct, a target hit may be indicated when the weapon was incorrectly aimed and vice versa.

Thus one object of the invention is to provide weapon training apparatus which is not quite so dependent for its accuracy upon the alignment of different items of equipment making up the apparatus.

In addition there usually has to be communication between the simulated weapon and other parts of the training

apparatus for example to indicate to a control computer that the weapon has been "fired". Such communication is by way of electrical cables. These cables detract from the realism of the simulated range and may make the weapon difficult to handle and aim and so a further object is to provide apparatus in which there need not be any physical connection between the simulated weapon and the rest of the apparatus.

According to one aspect of the present invention there is provided apparatus for training personnel in the use of aimable weapons, the apparatus including:

a displayed image having a predetermined shape defined by the image borders and the image including at least one practice target at a known location in said image;

an aimable simulation weapon for being aimed by said personnel at said target;

a camera having a field of view and being movable with the weapon such that the weapon aiming point always occupies the same part of the field of view;

store means for storing the camera image representative of said field of view;

image analysing means for analysing the stored image to determine the locations in said stored image of the borders of said displayed image and thereby forming a signal representative of the distance of the displayed image from

said weapon and the orientation of said displayed image in said stored image;

target position calculation means for receiving said signal and using same in combination with said known location of said target in said displayed image to calculate the location of the target in the camera field of view; and

comparing means for comparing said calculated location of the target with the weapon aiming point.

Thus, the apparatus overcomes the problems of the above-described prior art because determination of the correctness of aiming is done using information from an image representative of the camera's field of view, the camera being a movable with the weapon such that the weapon aiming point always occupies the same part of the field of view, i.e. the image is viewed from the point of aim as is the case when a firer aims in real life and is independent of the position of the displayed image on the screen - thereby eliminating any problems with alignment.

Preferably, said comparing means uses the information in said signal to compensate for effects of the distance from the weapon to the displayed image and the relative orientations of the displayed image and the weapon when comparing said calculated location of said target with the weapon aiming point.

Conveniently, said comparing means uses predetermined weapon-specific data to compensate for the different accuracy characteristics of various weapons when comparing said calculated location of said target with the weapon aiming point.

Advantageously, said image analysing means analyses the relative brightnesses of points in said stored image to determine the locations of said borders.

Optionally, said camera is fixedly attached to said weapon and the centre of its field of view is boresighted with the weapon.

According to a second aspect of the present invention there is provided a simulation weapon for use in a system for training personnel in the use of aimable weapons, the simulation weapon including electromagnetic radiation transmitting means for transmitting signals from said weapon to said system.

Preferably, said weapon includes camera means for forming a camera field of view representative signal, said field of view representative signal being transmitted by said transmitting means.

According to yet another aspect of the invention there is provided a simulation weapon for use in a system for training personnel in the use of aimable weapons, the simulation weapon including electromagnetic radiation

receiving means for receiving at said weapon signals from said system.

Preferably, the simulation weapon comprises means for simulating recoil driven by compressed fluid, and the compressed fluid containing means connected to said means for simulating recoil for supplying compressed fluid thereto.

For a better understanding of the invention, an embodiment of it will be described by way of non-limiting example, with reference to the accompanying drawings in which:-

Figure 1 shows a perspective view of a range for training personnel in the use of aimable weapons in accordance with the invention;

Figure 2 shows a plan schematic view of the range of Figure 1;

Figure 3 shows a side elevation in part cross-section of a simulation weapon for use on the range of Figures 1 and 2; and

Figures 4a to 4d show the various orientations of the displayed image (containing the targets) in the camera's field of view.

To improve understanding of the drawings, like elements which appear in more than one figure are designated by the same reference numeral.

Referring initially to Figures 1 and 2, a training range is shown generally at 2. The training range 2 includes four lanes 4-10, each of which comprises a rear wall 12, a side wall or walls 14 and a ramp 16. An image 18 is projected onto the rear wall 12 of each lane by a liquid crystal display (LCD) projector 20, such as the Sayett Mediashow (trade mark) available from Sayett, New York, USA. The displayed images are derived from colour photographs which have been digitised and stored as computer files which are accessed by computers 22. Each computer 22 provides the required image data to its respective LCD projector 20. Target images, which are overlaid on the background scene images, are also digitised, and are stored as separate computer files.

Positioned on the rear wall of each of the lanes is an infra-red detector 24, an infra-red emitter 26 and a microwave detector 28, all of which are connected to the appropriate computer 22 for that lane.

The computers 22 in each lane are all connected to main computer 30 which is operated by an instructor. The instructor can use the main computer 30 to select the general image displayed in each lane and the positioning of target images in the general image. The size of the target images can be adjusted to correspond to their perceived

range, and could be of different types such as stationary, pop-up or moving targets.

Each of the four personnel 32 to be trained, as well as the instructor, is provided with a pair of headphones 31. Apart from the instructor's headset, all headsets are connected to their respective lane computer for receiving digitally stored sound information therefrom for providing sound simulation (such as the sound of gunfire) to the wearer.

Each of the personnel 32 being trained is provided with a simulation rifle such as that illustrated generally at 34 in Figure 3. The rifle 34 is designed to have the same weight and feel as the real weapon of which it is a replica. A CCD camera 36 is attached to the barrel 40 of the rifle by adjustable clamp 38 so that the centre of its field of view is boresighted with the barrel 40 and the sight 42 attached to the main body 44. The gun is powered by rechargeable battery pack 46 housed in the removable magazine 48. The gun is 'fired' in the conventional way by pulling the trigger 50 which operates a microswitch 52 (or microswitches - if more than one level of force applied to the trigger 50 needs to be registered). The microswitch(es) 52 is (are) connected to a processor 103 which in turn is connected to infra-red emitter 54 and infra-red detector 56 which send and receive respectively

signals representing trigger operation, shot-inhibit and any other data required to the infra-red detector 24 and infra-red emitter 26 positioned on the rear wall 12 of each lane. Microwave transmitter 60 transmits the signal from CCD camera 36 to the microwave detector 28 positioned on the rear wall 12 of each lane. In the embodiment shown the video output from the CCD camera 36 is transmitted by co-axial cable 100 to a UHF modulator 102 in the weapon body, the output from which is passed to microwave transmitter 60. The signals transmitted by the weapon of each lane in the range are all set to be at different frequencies to avoid crosstalk between lanes. The signals transmitted/received by the infra-red emitter 54/detector 56 are transmitted as binary data words, using any suitable data protocol.

Depending on the application, the rifle 34 may include additional features. For example, the gun could include a safety catch, the operation of which is detected by microswitch 104; a cocking lever and butt pressure sensor 105, the operations of which are also detected by respective microswitches (not shown); and a magazine catch - also having an associated microswitch. All these microswitches are connected to processor 103, and information therefrom, in addition to trigger operation data, and any other useful information such as type of weapon and number of shots

remaining, may be transmitted serially from infra-red emitter 54. It will be understood, that in some applications it may be advantageous to transmit all the data (i.e. camera field of view information and information from the various microswitches) using a single microwave transmitter.

The weapon 34 may also include a jump and recoil simulation capability using a compressed air system, for example. The rifle illustrated at 34 in Figure 3 includes such a system, which comprises an air tank 106 which is connectable to an air compressor (not shown) by way of air tank recharging connector 108 (but at other times no connection exists). Air pipe 110 allows the passage of air from the tank 106 to air valve 112, controlled by solonoid 114. When the air valve is opened, air is transmitted via air pipe 116 to end part 118 of air piston assembly 120. The air piston assembly 120 causes movement of rod 122 in the direction of arrow 124. The rod 122 is connected to the rifle butt 126, which is movable relative to the rifle main body 44. Operation of the trigger 50 sends an electrical pulse to the solonoid 114 which causes the valve 112 to release a measured amount of air into the air piston assembly 120. This causes the rod 122 to force the butt plate away from the main body for a short period, thus

simulating weapon jump and recoil. If necessary the jump and recoil system can be de-activated.

For example, the frame grabber could be the VFG 4000 available from Digital Imaging Systems Limited, Newport, UK, and the CCD camera could be the TM-7/TM-6 available from Pulnix of Germany.

For training, each member of personnel 32 is equipped with a headset 31 and a rifle 34. A general image and various target images, selected by the operator, are displayed by LCD projector 20 on rear wall 12 of each lane. Each member of personnel aims the rifle 34 at the target using the sight 42 as he/she would with a conventional rifle. While this process is going on, the signal from CCD camera 36, which has a field of view at least twice the size of the displayed image 18, is transmitted to the appropriate computer 22 via microwave emitter 58 and detector 28. When the trigger 50 is operated, a signal is sent to the computer 22 via infra-red emitter 54 and infra-red detector 24 which causes the computer to store the camera image representative of its field of view on a frame grabber contained in the computer. Figures 4a to 4d show the image stored on the frame grabber. The box 60 represents the boundary of the camera's field of view, in which, provided the rifle is aimed with any reasonable accuracy, is contained the displayed image 18 as seen by the CCD camera 36. The cross

62 represents the centre point of the stored image which corresponds to the aiming point of the rifle 34 due to the boresighting with the CCD camera 36. A computer program in the computer 22 then analyses the grabbed image which is nominally of resolution 768 x 756 pixels but is enhanced by the frame grabber software by more than a factor of 10, each pixel having an associated brightness value ranging from 0 to 255 - 0 representing black and 255 representing bright white. Because the rear wall 12 of each range is painted black the brightness values associated therewith will all be 0, whereas the projected image will have values ranging up to 255. As an advantageous option, the displayed image 18 is given a border 64 which is bright white to help distinguish the displayed image from the background.

The brightness values for each pixel on the grabbed image are used in the program on each computer 22 to determine the exact location of the displayed image in the stored grabbed image. The pixels along a line from the edge of the grabbed image will all be at value 0 until the edge of the projected image is reached, whereafter the pixels will have a higher value, say 100 or more. If the pixels in the stored image do not exactly line up with the location of the displayed image, then the program will compensate for this. To illustrate this assume that a stored pixel for which this is the case has a brightness

value exactly half-way between 0 (representing the rear wall 12) and the border 64. If the brightness value of the border 64 is 100 then the pixel in question will be of brightness value 50, thus indicating that the exact location of the displayed image lies in a position half-way across the pixel. The location of each of the sides of the border is accurately determined in this way. This enables the precise size of the displayed image as seen by the CCD camera 36 to be determined (see Figures 4a and 4c) so that the distance from the rifle 34 to the displayed image 18 can be calculated, as well as the cant angle of the rifle (i.e. whether or not the user is holding the weapon tilted over to the left or right when viewed down the length of the barrel - see Figure 4b) and also the elevation (Figure 4d), or any combination thereof. Using this information, the program is able to calculate the position of a target image displayed in the general image 18 within the image stored on the frame grabber using known geometrical methods. This is possible because the exact location of the target image within the general image 18 is already known because it is set in the training exercise by the instructor on the main computer 30. The calculated target position can then be compared with the centre point 62 of the image stored on the frame grabber (which represents the weapon aiming point) to determine whether there has been a hit or not.

Particular characteristics of the various weapons and ammunitions, the effects of various weapon-to-perceived-target distances, and the relative orientations of the camera 36 and the weapon 34 may be taken into account by the program when determining whether a hit is actually made or not - thus, even though the centre point 62 and the calculated position of the target image correspond in location, an actual hit may not be registered because of some other factor which the weapon operator would have to take into account in a real life situation. The effects of these variables are stored in look-up tables and are accessed as appropriate by the program depending on the particular circumstances. Furthermore, this method can also be employed to allow for the effects of wind speed and the like, as set by the instructor on the main computer 30.

Any errors in the boresighting of the rifle 34 with the CCD camera 36 can be compensated for by an electronic zeroing set-up procedure. In this procedure a cross-hair is displayed at the centre of the displayed image 18. The rifle 34 is aimed at the centre of the cross-hair and fired from a predetermined operator position and distance from the rear wall 12. After the rifle has been fired a suitable number of times, for example five, the program takes into account the various calculated locations of the rifle aiming

point and uses this information to calculate any errors in the boresighting which can be compensated for by the program during subsequent training.

CLAIMS

1. Apparatus for training personnel in the use of aimable weapons, the apparatus including:

a displayed image having a predetermined shape defined by the image borders and the image including at least one practice target at a known location in said image;

an aimable simulation weapon for being aimed by said personnel at said target;

a camera having a field of view and being movable with the weapon such that the weapon aiming point always occupies the same part of the field of view;

store means for storing the camera image representative of said field of view;

image analysing means for analysing the stored image to determine the locations in said stored image of the borders of said displayed image and thereby forming a signal representative of the distance of the displayed image from

said weapon and the orientation of said displayed image in said stored image;

target position calculation means for receiving said signal and using same in combination with said known location of said target in said displayed image to calculate the location of the target in the camera field of view; and

comparing means for comparing said calculated location of the target with the weapon aiming point.

2. Apparatus according to claim 1, wherein said comparing means uses the information in said signal to compensate for effects of the distance from the weapon to the displayed image and the relative orientations of the displayed image and the weapon when comparing said calculated location of said target with the weapon aiming point.

3. Apparatus according to claim 1 or 2, wherein said comparing means uses predetermined weapon-specific data to compensate for the different accuracy characteristics of various weapons when comparing said calculated location of said target with the weapon aiming point.

4. Apparatus according to claim 1, 2 or 3, wherein said image analysing means analyses the relative brightnesses of points in said stored image to determine the locations of said borders.

5. Apparatus according to claim 1, 2, 3 or 4, wherein said camera is fixedly attached to said weapon and the centre of its field of view is boresighted with the weapon.

6. Apparatus substantially as hereinbefore described with reference to and as illustrated in accompanying drawings.

7. A simulation weapon for use in a system for training personnel in the use of aimable weapons, the simulation weapon including electromagnetic radiation transmitting means for transmitting signals from said weapon to said system.

8. A simulation weapon according to claim 7, wherein said weapon includes camera means for forming a camera field of view representative signal, said field of view representative signal being transmitted by said transmitting means.

9. A simulation weapon for use in a system for training personnel in the use of aimable weapons, the simulation weapon including electromagnetic radiation receiving means for receiving at said weapon signals from said system.

10. A simulation weapon according to claim 7, 8 or 9 comprising means for simulating recoil driven by compressed fluid, and compressed fluid containing means connected to said means for simulating recoil for supplying compressed fluid thereto.

11. A simulation weapon substantially as hereinbefore described with reference to and as illustrated in the accompanying drawings.

12. Weapon training apparatus comprising:-

a simulated weapon for being aimed and "fired" at a target image within a background scene;

a t.v. camera fixed to and boresighted to the weapon;

analysis means for receiving the video signal from the camera and determining the position of the background scene

within the field of view of the camera and hence also the accuracy of the weapon aim when the weapon was fired.

Patents Act 1977
Examiner's report to the Comptroller under Section 17 (The Search Report)

Application number
GB 9313507.7

Relevant Technical fields

(i) UK Cl (Edition L) F3C (CTE,CTN)

(ii) Int Cl (Edition 5) F41G 3/26,26B,26B1

Search Examiner
PAUL GAVIN

Databases (see over)

(i) UK Patent Office

(ii) ONLINE WPI

Date of Search
10 SEPTEMBER 1993

Documents considered relevant following a search in respect of claims 1 TO 6

Category (see over)	Identity of document and relevant passages	Relevant to claim(s)
X,P	GB 2260188 A (SHORT BROS) whole document	1 to 5
X	GB 2160298 A (FERRANTI) whole document	1 to 5
X	GB 2152645 A (D HENDRY) whole document	1 at least
X	EP 0330886 A1 (MICROFOX) whole document	1 at least
X	EP 0118604 A2 (BRUNSWICK) whole document	1 at least

Category	Identity of document and relevant passages	Relevant to claim(s)

Categories of documents

X: Document indicating lack of novelty or of inventive step.

Y: Document indicating lack of inventive step if combined with one or more other documents of the same category.

A: Document indicating technological background and/or state of the art.

P: Document published on or after the declared priority date but before the filing date of the present application.

E: Patent document published on or after, but with priority date earlier than, the filing date of the present application.

&: Member of the same patent family, corresponding document.

Databases: The UK Patent Office database comprises classified collections of GB, EP, WO and US patent specifications as outlined periodically in the Official Journal (Patents). The on-line databases considered for search are also listed periodically in the Official Journal (Patents).