Office de la Propriété Intellectuelle du Canada
Un organisme d'Industrie Canada

Canadian Intellectual Property Office
An agency of Industry Canada

CA 2470119 C 2008/01/29

(11)(21) **2 470 119**

(12) **BREVET CANADIEN**
CANADIAN PATENT

(13) **C**

(86) **Date de dépôt PCT/PCT Filing Date:** 2002/10/24
(87) **Date publication PCT/PCT Publication Date:** 2003/07/03
(45) **Date de délivrance/Issue Date:** 2008/01/29
(85) **Entrée phase nationale/National Entry:** 2004/06/10
(86) **N° demande PCT/PCT Application No.:** EP 2002/011894
(87) **N° publication PCT/PCT Publication No.:** 2003/054472
(30) **Priorité/Priority:** 2001/12/12 (DE101 60 946.9)

(51) **Cl.Int./Int.Cl.** *F41G 3/26* (2006.01), *F41A 17/08* (2006.01)

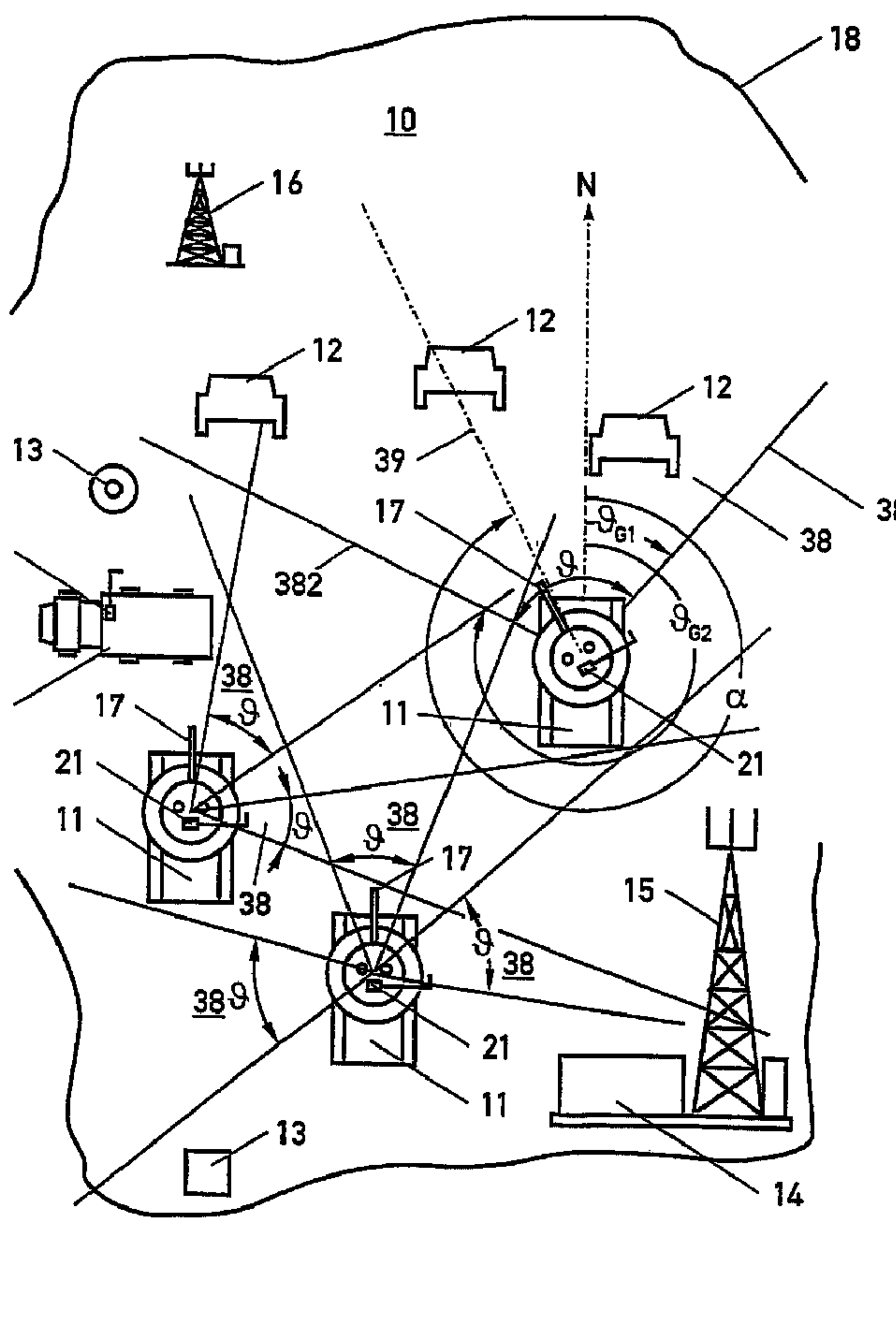
(72) **Inventeurs/Inventors:**
SCHMEDEMANN, HELLMUTH, DE;
JUNGE, MANFRED, DE

(73) **Propriétaire/Owner:**
RHEINMETALL DEFENCE ELECTRONICS GMBH, DE

(74) **Agent:** FETHERSTONHAUGH & CO.

(54) **Titre :** PROCEDE VISANT A ASSURER LA SECURITE DES PARTICIPANTS DANS LE CADRE D'EXERCICES DE TIR A BALLES REELLES

(54) **Title:** METHOD FOR ENSURING SAFETY DURING FIRING WITH LIVE AMMUNITION



(57) **Abrégé/Abstract:**
The invention relates to a method for guaranteeing safety during firing with live ammunition, by mobile combatants (11) practicing under battle conditions in a defined manoeuvres area (10), whereby, for protection of all combatants (11), the instantaneous

(11)(21) 2 470 119

(13) C

(57) Abrégé(suite)/Abstract(continued):
position of the combatants (11) is continuously monitored and reported to a monitoring centre (14). In the monitoring centre (14) currently permissible firing sectors (38) are calculated from the reported positions and the movement ranges of all combatants (11), derived therefrom, optionally stationary objects (13) and by taking into account the boundary (18) of the manoeuvres area (10), for all combatants (11) and transmitted individually to the shooting combatants (11). For each shooting combatant (11), the position of the weapon alignment (39) is compared with the provided firing sectors (38) and a firing trigger for a firing sector (38) only permitted when the weapon alignment lies within said firing sector (38).

ABSTRACT

The invention relates to a method for guaranteeing safety during firing with live ammunition, by mobile combatants (11) practicing under battle conditions in a defined manoeuvres area (10), whereby, for protection of all combatants (11), the instantaneous position of the combatants (11) is continuously monitored and reported to a monitoring centre (14). In the monitoring centre (14) currently permissible firing sectors (38) are calculated from the reported positions and the movement ranges of all combatants (11), derived therefrom, optionally stationary objects (13) and by taking into account the boundary (18) of the manoeuvres area (10), for all combatants (11) and transmitted individually to the shooting combatants (11). For each shooting combatant (11), the position of the weapon alignment (39) is compared with the provided firing sectors (38) and a firing trigger for a firing sector (38) only permitted when the weapon alignment lies within said firing sector (38).

Method for Ensuring Safety During Firing with Live Ammunition

The present invention relates to a method for ensuring safety when mobile combatants are firing live ammunition when exercising under battle conditions in a defined training area that is monitored from a monitoring centre.

Gunnery training conducted in training areas when using weapons systems designed for mobile operations, for example, battle tanks, armoured personnel carriers and the like, requires unrestricted possibilities for movement and combat operations over large areas by the combatants in order to provide training that is realistic with respect to danger, as opposed to the trajectories used up to now, which are fixed areas of a training area. When a training area is used in this way, it is essential to ensure both external and internal safety, i.e., specific measures have to be used to ensure that the combatants who are shooting cannot bring down fire beyond the limits of the training area (external safety) or into areas of the training area itself, within which there are other combatants, either shooting or non-shooting, or objects that have to be protected (internal safety).

In one known method, in order to ensure safety, special safety personnel are assigned to each combat unit that is firing; these safety personnel are in radio contact with the monitoring centre and give the individual combat units permission to fire on the spot.

It is the task of the present invention to develop a method for ensuring safety during firing, which complies with the stringent safety regulations for military training areas, permits a significant reduction in the numbers of safety personnel, and grants uninhibited flexibility to all combatants within a training area when combatants who are shooting are doing so with live ammunition.

In accordance with this invention there is provided a method for ensuring the safety of mobile combatants firing live ammunition when exercising under battle conditions in a defined training area that is monitored from a monitoring centre, characterized in that the current position of the combatants is continuously determined and reported to the monitoring centre; in that within the monitoring centre actual permissible firing sectors are calculated for each shooting combatant using the reported, current positions and the movement areas derived therefrom, taking into account the limits of the training area, these permissible firing sectors then being transmitted individually to shooting combatants; and in that for each shooting combatant the current weapon alignment is compared to the firing sector assigned to it, clearance to fire being given only if the current weapon alignment lies within this firing sector.

The method for ensuring safety when firing entails the advantage that when gunnery-training exercises are being conducted in open terrain by moving weapons systems, complete and reliable protection against coming under fire from shooting combatants is provided for all the combatants. Such protection is provided in every combat situation, regardless of the position, and the direction and speed of movement of the combatants. Further to this, it is also ensured that no shooting combatant can fire beyond the limits of the training area, and that stationary objects located within the training area are protected against being damaged by unauthorized fire.

A permissible firing area is defined as an expanse of the training area into which an individual, shooting combatant can fire without endangering other combatants and - optionally - other stationary objects in the terrain that are to be protected against coming under fire.

According to one preferred embodiment of the present invention, a danger area is taken into consideration, either when the current, permissible firing sectors for the shooting combatants are being calculated in the monitoring centre, or when the alignment of weapons is being compared with the transmitted, current firing sectors for each shooting combatant. This danger area is specified as a spatial expanse in the training area for every weapon of a shooting combat unit, and takes into account the type of weapon and the type of ammunition that is fired by the weapon. In the first case, the limits of the permissible firing sector are reduced by this danger area; in the second case, opening fire is only permitted if, with the current weapon alignment, the danger area is also located within the firing sector.

According to an advantageous embodiment of the present invention, system tolerances are also taken into account when the danger area is being calculated; these include error tolerances that can occur when positions are being determined and when weapon alignments are being acquired.

According to an advantageous embodiment of the present invention, the positions of stationary objects that are to be protected within the training area are also considered when calculating the permissible firing sectors, so that such objects can also be protected against coming under fire.

According to an advantageous embodiment of the present invention, the time of their acquisition is associated with the positions of the combatants, and the time of their acquisition and a validity period is associated with the specified firing sectors. In the case of shooting combatants, their current weapons alignments are only compared with the assigned firing sectors if the time of acquisition of the weapons alignments is within the validity period. Because of this, acquisition of the combatants' positions, calculation of the firing sectors, and checking the alignments of the combatants' weapons is conducted on the basis of a common timebase and in a defined chronological cycle, so that the current validity of firing sectors and weapon alignments can be determined, and the movement of combatants is also taken into account.

The present invention is described in greater detail below on the basis of one embodiment of a firing-safety system that is shown in the drawings appended hereto. These drawings show the following:

Figure 1: A diagrammatic plan view of a combat scenario in a training area, showing the combatants, stationary objects, and permissible firing sectors assigned to the shooting combatants;

Figure 2: A block circuit diagram of a monitoring device integrated into a monitoring centre as part of the firing-safety system;

Figure 3: A block circuit diagram of a safety device provided for each firing unit as part of the firing-safety system;

Figure 4: A diagrammatic plan view of a firing sector assigned to a shooting combatant, with its danger area.

Figure 1 shows part of a training area 10, delimited by a border line 18, in which mobile combatants 11 are training under combat conditions, with shooting combatants 11 firing live ammunition. In the embodiment that is shown, the shooting combatants 11 are the battle tanks of a combat formation and are firing live ammunition from their weapons 17 at targets 12 set up in the training area 10. In addition to the tanks, or in place of them, there may be other types of shooting combatants 11 involved, for instance, guns, rocket launchers, antitank helicopters, or the like. As an example of a non-shooting combatant 11 moving within the training area 10, Figure 1 shows a vehicle, e.g., of the logistic support services of the combat formation that is undergoing training. Other mobile, non-firing combatants 11 can be reconnaissance and/or observation vehicles. In addition, within the training area 10 there are also isolated, stationary objects 13 that may not be fired upon by the shooting combatants 11.

Combat training is monitored from a stationary monitoring centre 14 by appropriate monitoring personnel, and can be directed from the same facility. The monitoring centre 14 and the combatants 11 are connected to one another by wireless data communications. To this end, there is a main radio station 15 in the monitoring centre 14 and relay stations 16 are set up in the training area and disposed in such a way that seamless radio communications are ensured.

When firing is being conducted it is essential, on the one hand, to ensure the safety of all combatants moving about within the training area so that they do not come under fire and, on the other hand, to prevent the shooting combatants from firing over the border line 18 of the training area 10. In order to ensure this so-called internal and external safety, a firing safety system is installed in the training area 10; this comprises a monitoring device 20 that is disposed in the monitoring centre 14 and a plurality of safety devices 21. One such safety device is carried by each shooting combatant 11. The monitoring device 20 and the safety devices 21 that are carried by the shooting combatants 11 are connected to one another by data links and exchange data that is relevant for ensuring safety during firing by way of said data links. As a minimum, the non-shooting combatants 11 are equipped with a position sensor and a data-link transmitter, so that the non-shooting combatants 11 can transmit their positions and optionally other data acquired on the spot to the monitoring device 20.

Figure 2 is a block circuit diagram showing the components of the monitoring device 20. The monitoring device 20 comprises a radio receiver 22 and a radio transmitter 23, a central computer 24, and a data bank 25 in which are stored the cartography of the training area 10 with the border line 18 and the placement of the stationary objects 13 that are to be protected. Within the central computer 24, the data received from both shooting and non-shooting combatants 11 by way of the radio receiver 22 are processed with respect to position and passed to the radio transmitter 23 as specification data; the radio transmitter 23 then transmits these data to the training area, encoded for the individual, shooting combatants 11.

Figure 3 is a block circuit diagram showing the components of a safety device 21 carried by each shooting combatant. The safety device 21 incorporates a radio transmitter 26, a radio receiver 27, a position sensor 28 for determining the current position $P(t)$ of the shooting combatant 11, a weapon-alignment sensor 29 for acquiring the angle of traverse $\alpha(t)$ of the weapon 17 in azimuth, optionally a weapon-alignment sensor 30 for acquiring the weapon attitude $\varepsilon(t)$ in elevation, an ammunition selector switch 31 with which the type of ammunition to be fired by the weapon is selected, and an optical and an acoustic indicator 34, 35 that indicate that the shooting combatant is cleared to open fire. In addition, the safety device can also incorporate a firing lock 36 that prevents manual firing of a shot by a weapon trigger 37. The processor 32, which activates the optical and the acoustic indicator 34, 35, which identify clearance for firing, deactivates the firing lock 36 when clearance is given, so that the weapon 17 can then be fired by the weapon trigger 37.

Each non-shooting combatant 11 is equipped with a safety device 21' (Figure 1) that comprises fewer components. This comprises only—as indicated—the radio transmitter 26 and the position sensor 28 to determine the current position P(t). The positions of the non-shooting combatants 11 determined by the position sensor 28, like the positions of the shooting combatants 11, are transmitted at intervals to the monitoring centre 14 by the radio transmitter 26. In the embodiment that is described, as in the case of the shooting combatants 11, determination of positions by the position sensor 28 is based on the global positioning system (GPS). Alternative methods for determining position are also possible, of course,.

Using the monitoring device 20 with its components that are installed in the monitoring centre 14, the safety devices 21 with their components that are carried by the individual shooting combatants 11, as well as the safety devices 21' with the radio transmitters 26 and position sensors 28 that are carried by the non-shooting combatants, firing safety can be ensured by the following method:

The current position P(t) of every shooting combatant 11 and non-shooting combatant 11 is determined continuously by the position sensor 28 and reported to the monitoring centre 14 by way of the radio transmitter 26. The position P(t) is determined at time intervals, each position P being assigned to the time t at which it was determined. The length of the time interval between position reports from the combatant 11 is determined by their speed, and decreases as this speed increases and the distance to other combatants

11 becomes less. Within the monitoring centre 14, all the combatants' positions determined in this way are recorded on the site plan of the training area 10 that is available from the data bank. Within the central computer 24, permissible firing sectors 38 (Figure 1) are calculated for each shooting combatant 11, taking into account the position of the particular shooting combatant 11, the positions of all other combatants 11, the positions of the stationary objects 13, the possible areas of movement of all the combatants 11, as well as the border line 18 of the training area 10. Firing can be conducted by the particular shooting combatants 11 to which these firing sectors 38 are assigned within the training area 10, as delineated by the border line 18. These permissible firing sectors 28 are transmitted from the monitoring centre 14 individually to the shooting combatants 11 by data link. When this is done, the permissible firing sectors 38 that have been calculated can additionally be subjected to a plausibility check and excluded from transmission to the shooting combatants 11. Grounds for such exclusion can, for example, be the absence of targets in the particular firing sector, or instructional or tactical reasons. The time at which they were calculated and a validity period for them are assigned to the firing sectors that have been cleared for transmission to the shooting combatants, so that each data message that is transmitted to the shooting combatants by way of the radio transmitter 23 contains the coordinates of the firing sectors 38, the time at which they were calculated, and the validity period.

Figure 1 shows diagrammatically the permissible firing sectors 38 calculated by the monitoring device 20 and assigned to the three shooting combatants 11. Only a single permissible firing sector 38 has been authorized for the uppermost shooting combatant 11 shown in Figure 1. Two firing sectors 38 have been authorized for the shooting combatant 11 on the left-hand side in Figure 1, whereas three possible firing sectors 38 have been authorized for the shooting combatant 11 that is the lowest in Figure 1. Each firing sector 38 is defined, for example, by an azimuth angle δ that is in each instance related to the individual position of the particular shooting combatant 11. The azimuth angle δ is established, for example, by a north-related, lower angular limit δ_{G1} and a north-related upper angular limit δ_{G2}, as is shown in Figure 1 for the firing sector 38 of the uppermost shooting combatant 11.

The data messages that are broadcast in coded form from the radio transmitter 23, which contain the firing sectors 38 that have been established for the time t and their validity period, for example, the angular limits $\delta_{G1}(t)$ and $\delta_{G2}(t)$, are received by the radio receiver 27 of the shooting combatant 11 addressed by the coding, decoded, and then passed to the processor 32. Within the processor 32, a check is made as to whether or not the current weapon alignment39 of the shooting combatant's weapon 17 that, in the exemplary embodiment, is passed to the processor 32 through the azimuth angle $\alpha(t)$ of the weapon 17, agrees with the assigned firing sector 38 with respect to time, i.e., whether or not the time at which the alignment of the weapon was determined is within the validity period of the assigned firing sector 38. If this is the case, then a check is conducted in the processor 32 as to whether or not the current weapon alignment 39 of the shooting combatant 11 is within a firing sector 38 assigned to said shooting combatant. Otherwise, if the validity period for one or several firing sectors 38 does not include, cover, or bridge the time at which the alignment of the weapon was determined, this firing sector or sectors are eliminated and are no longer considered. If the current alignment 39 of the weapon is within a firing sector 38, then the shooting combatant 11 is cleared to fire in this firing sector 38, and the processor 32 generates a fire-release signal that triggers the optical indicator 34 and/or the acoustic indicator 35 in order to signal firing clearance and optionally deactivates the firing lock 36 for the weapon trigger 37. The shooting combatant 11 is now able to fire a shot at the target 12 that is in its sight, using the current weapon alignment 39.

In order to clarify this procedure, Figure 1 shows, by way of example, the north-related angular limits δ_{G1} and δ_{G2} of the azimuth angle δ of a firing sector 38 permitted for the upper shooting combatant 11; these amount to 40° or 295°, respectively. The north-related, azimuth angle of traverse α of the weapon 17 amounts to 333°, for example. In this case, the angle of traverse α is much greater than the upper angular limit δ_{G2}, and is smaller than the upper angular limit δ_{G1}. The current weapon alignment 39 thus lies within the firing sector 38. If the shooting combatant 11 does not change its position, then it can engage all three targets 12 within this permitted firing sector 38. If this same shooting combatant aims its weapon17 at the right-hand target 12 in Figure 1 then, even though the north-related azimuth angle of traverse α of the weapon 17 will become much smaller, it will still lie within the angular limits δ_{G1} and δ_{G2}, so that the conditions for obtaining clearance to fire are still fulfilled with the weapon 17 traversed into this position.

Since, in the usual course of events, it cannot be assumed that the shot fired by the shooting combatant 11 with the current weapon alignment 39 will move in the vertical plane that passes through the barrel axis of the weapon 17, but will deviate from this laterally to a greater or lesser degree, a danger zone 33 is established as a spatial expanse for the type of weapon fired by the shooting combatant 11 and the type of ammunition that is fired by this type of weapon. An example of such a danger zone is shown in Figure 4. The geometric shape of such a danger zone may vary greatly as a function of weapon type and type of ammunition. The established danger zone 33 is taken into account when the current weapon alignment 39 is compared with the permissible firing sector 38, in that a check is made as to whether or not the danger area 33 at the current weapon alignment 39 lies within one of the permissible firing sectors 38. Only if this is so is firing clearance given for this firing sector 38.

As an alternative, the danger area 33 can also be examined in the central computer 34 of the monitoring device 20, to which end it is necessary that the shooting combatant 11 transmit the type of ammunition it is using to the monitoring device 20 by way of a data link. The sector limits δ_{G1} and δ_{G2} of the firing sector 38 are reduced by including the danger area 33 in calculation of the permissible firing sector 38, so that the angular width of the permissible firing sector is made much narrower.

So-called system tolerances can also be included in calculation of the permissible firing sector 38; these tolerances result because, for example, error tolerances can occur in the safety device when the position of the shooting combatant 11 and the current alignment 39 of the weapon are being determined.

A permissible firing sector 38 that has been calculated for a shooting combatant 11 is always of a depth or length that is greater than the range of the projectile fired by the weapons being used by the shooting combatant 11. Alternatively, it is possible effect a range reduction for the shooting combatant 11, by specifying a maximal angle of elevation φ for the shooting combatant 11 in every permissible firing sector 38, this angle of elevation φ being transmitted to the processor 32 by radio 27.The current angle of elevation $\varepsilon(t)$ of the weapon is passed to the processor 32 by the weapons-alignment sensor 30, and the processor 32 compares the previously specified maximal angle of elevation $\varphi(t)$ with the current elevation $\varepsilon(t)$ of the weapon 17 being used by the shooting combatant 11. If the latter is smaller than the previously specified maximal angle of elevation $\varepsilon(t)$, then firing is permitted; it this is not the case, then firing is blocked.

21712-275

CLAIMS:

1. Method for ensuring the safety of mobile combatants (11) firing live ammunition when exercising under battle conditions in a defined training area (10) that is monitored from a monitoring centre (14), characterized in that the current position of the combatants (11) is continuously determined and reported to the monitoring centre (14); in that within the monitoring centre (14) actual permissible firing sectors (38) are calculated for each shooting combatant (11) using the reported, current positions and the movement areas derived therefrom, taking into account the limits (18) of the training area (10), these permissible firing sectors then being transmitted individually to shooting combatants (11); and in that for each shooting combatant (11) the current weapon alignment is compared to the firing sector (38) assigned to it, clearance to fire being given only if the current weapon alignment (32) lies within this firing sector (38).

2. Method as defined in Claim 1, characterized in that the calculated firing sectors (38) are defined by an azimuth angle (δ) that is applied to the position of the shooting combatant (11).

3. Method as defined in Claim 2, characterized in that each angle of azimuth (δ) is fixed by a lower and an upper angular limit (δ_{G1}, δ_{G2}), each being north-related.

4. Method as defined in any one of Claims 1 - 3, characterized in that when the permissible current firing sectors (38) are being calculated for each shooting combatant (11), a defined danger area (33) based on weapon type and type of ammunition fired by this particular weapon

is taken into account as a spatial expanse within the training area (10).

5. Method as defined in any one of Claims 1 - 3, characterized in that, based on weapon type used by the shooting combatant (11) and type of ammunition fired by this particular weapon, a defined danger area (33) is determined as a spatial expanse within the training area (10); and in that, when comparing the weapon alignment (39) with the predetermined, current firing sectors (38), the danger area is so taken into account that firing clearance is only given if, with the current weapon alignment, the danger area (33) lies within the permissible firing sector (38).

6. Method as defined in Claim 4 or Claim 5, characterized in that, in addition, possible error tolerances are taken into account when calculating the permissible firing sectors (38).

7. Method as defined in Claim 6, characterized in that the error tolerances that are taken into account are those that can occur when determining position and weapon alignment.

8. Method as defined in any one of Claims 1 - 7, characterized in that the positions of stationary objects (13) that are within the training area (10) and are to be protected are included when calculating permissible firing sectors (38).

9. Method as defined in any one of Claims 1 - 8, characterized in that the time at which determinations were made is associated with the positions of the combatants (11), and the time at which determinations were made is associated with the calculated firing sectors (38), and a validity period is also assigned to these; and in that

in the case of the shooting combatants (11), only assigned firing sectors whose assigned validity periods to include the time that the weapon alignment (39) was acquired are used for comparison with the current weapon alignment (39).

10. Method as defined in any one of Claims 1 - 9, characterized in that of the calculated, permissible firing sectors (38), firing sectors (38) selected by applying specified criteria are excluded from transmission to the shooting combatants (11).

11. Method as defined in Claim 10, characterized in that the absence of one or more targets, instructional or tactical reasons are specified as criteria.

12. Method as defined in any one of Claims 1 - 11, characterized in that a visual or acoustic indicator is activated when clearance is given for firing.

13. Method as defined in any one of Claims 1 - 12, characterized in that for every shooting combatant (11), firing is permanently blocked, this blocking being deactivated when firing clearance is given.

14. Method as defined in any one of Claims 1 - 13, characterized in that the positions of the combatants (11) are reported, and the shooting combatants (11) are informed of permissible firing sectors (38) by data link between the combatants (11) and the monitoring centre (14).

15. Method as defined in any one of Claims 1 - 11, characterized in that a visual and acoustic indicator is activated when clearance is given for firing.

16. Method as defined in Claim 15, characterized in that for every shooting combatant (11), firing is

permanently blocked, this blocking being deactivated when firing clearance is given.

17. Method as defined in Claim 15 or 16, characterized in that the positions of the combatants (11) are reported, and the shooting combatants (11) are informed of permissible firing sectors (38) by data link between the combatants (11) and the monitoring centre (14).

FETHERSTONHAUGH & CO.
OTTAWA, CANADA

PATENT AGENTS

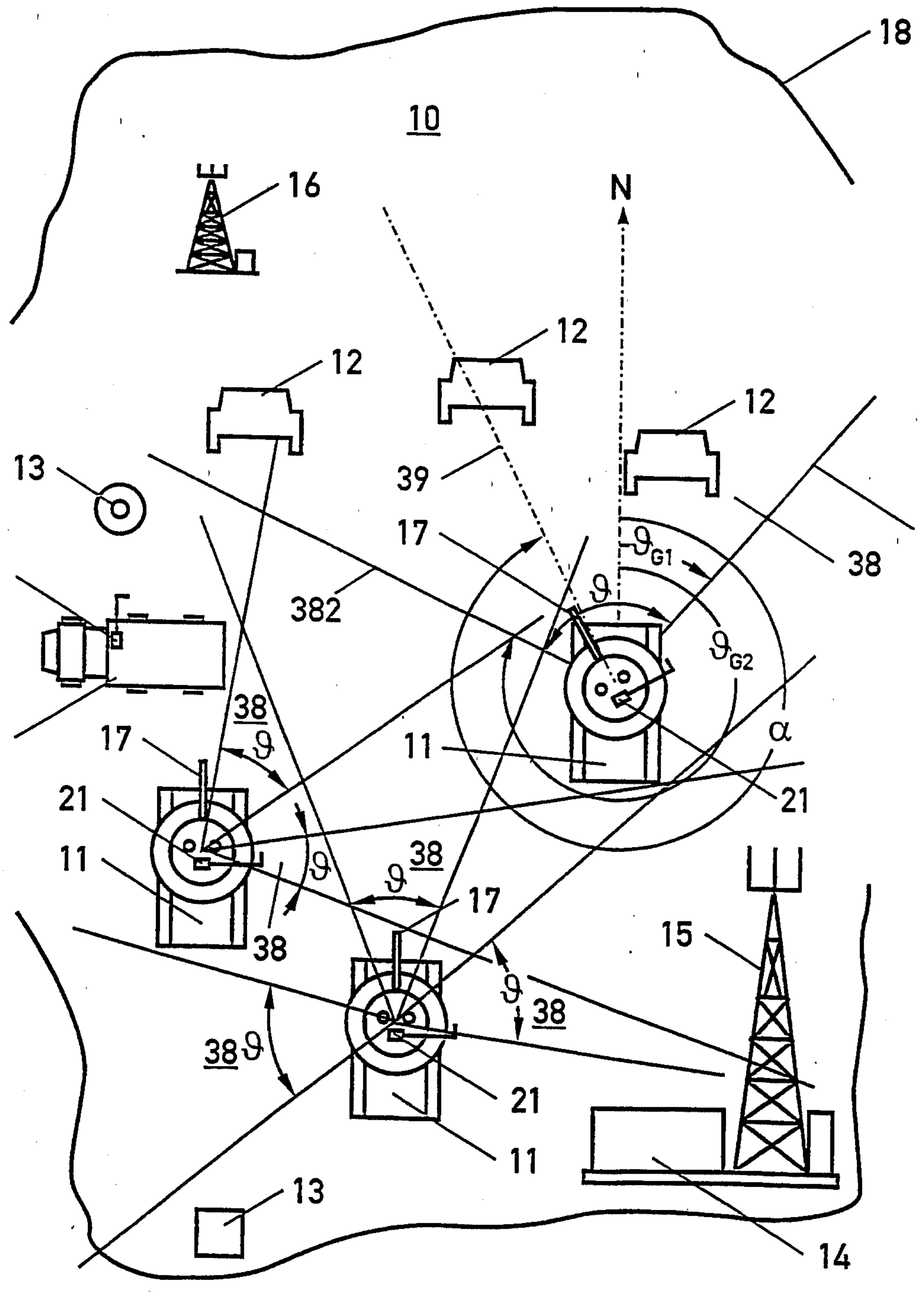

18
10
16
N
12
12
12
13
39
381
17
38
382
ϑ_{G1}
21
ϑ
ϑ_{G2}
38
11
17
ϑ
α
11
21
21
11
ϑ
38
ϑ
38
17
15
38
38
ϑ
38
38
ϑ
21
11
13
14

Fig. 1

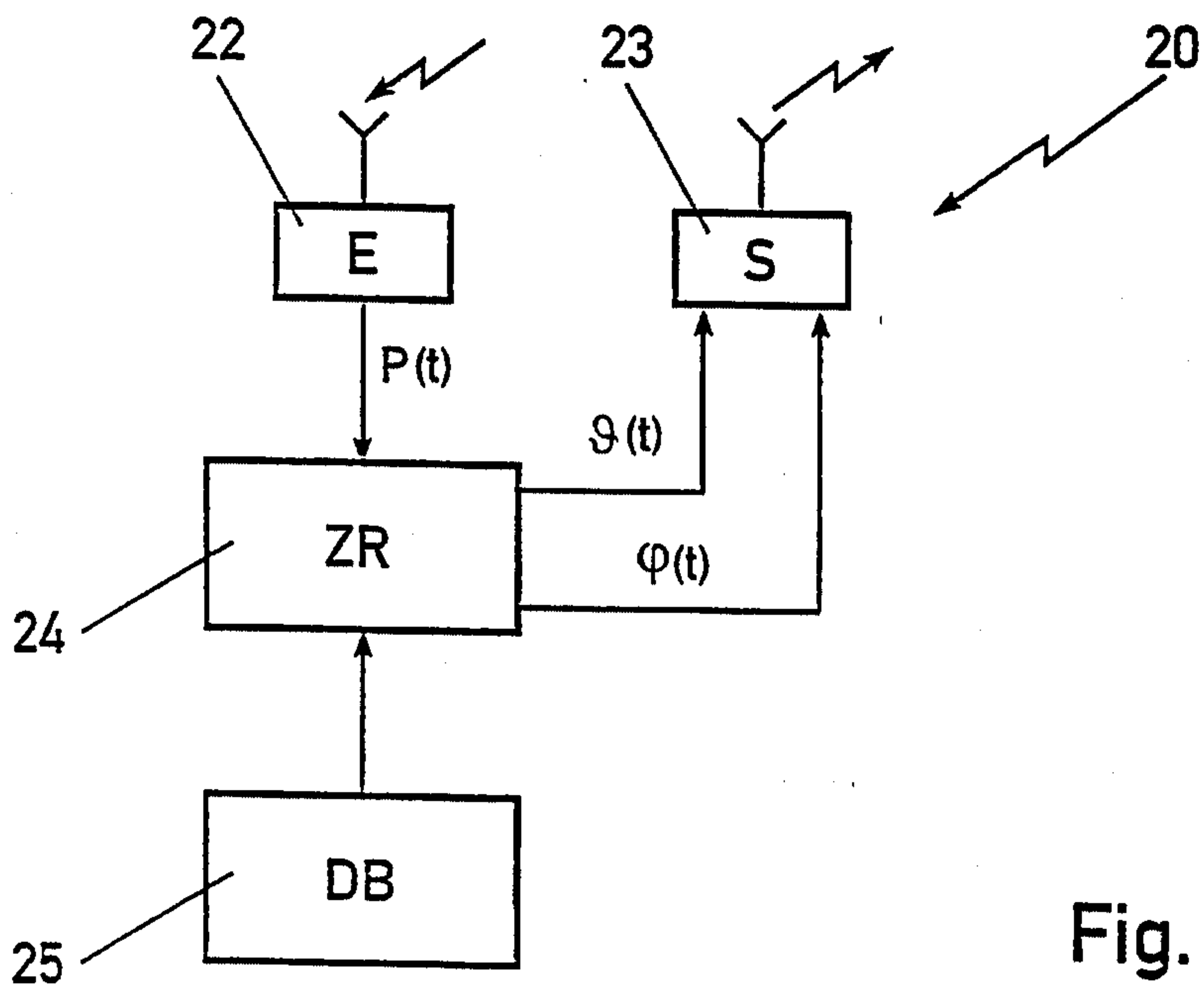

22
23
20
E
S
P (t)
ϑ (t)
ZR
φ(t)
24
DB
25

Fig. 2

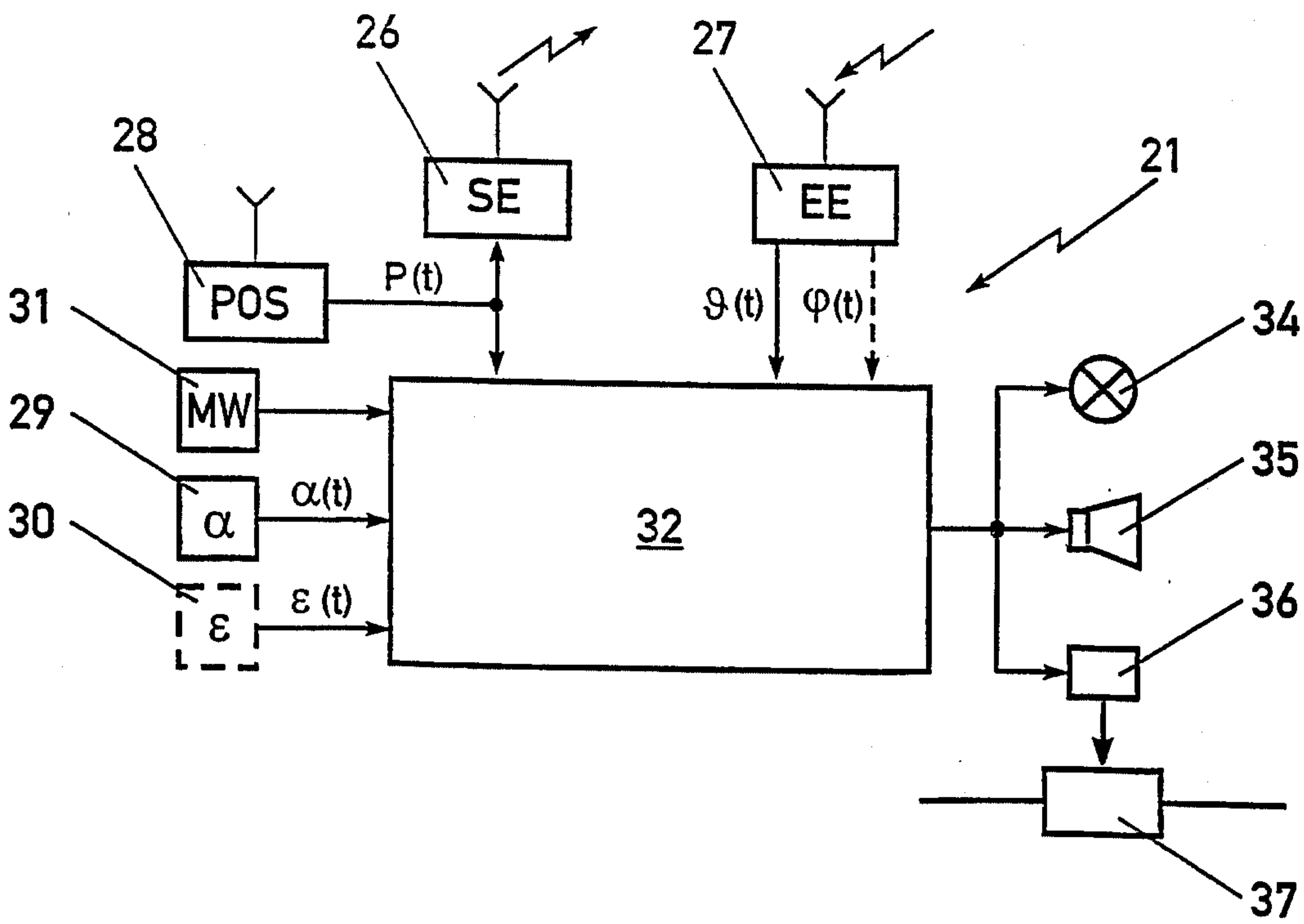

26
27
28
21
SE
EE
POS
P (t)
ϑ (t)
φ(t)
31
34
MW
29
35
α
α(t)
32
30
ε
ε (t)
36
37

Fig. 3

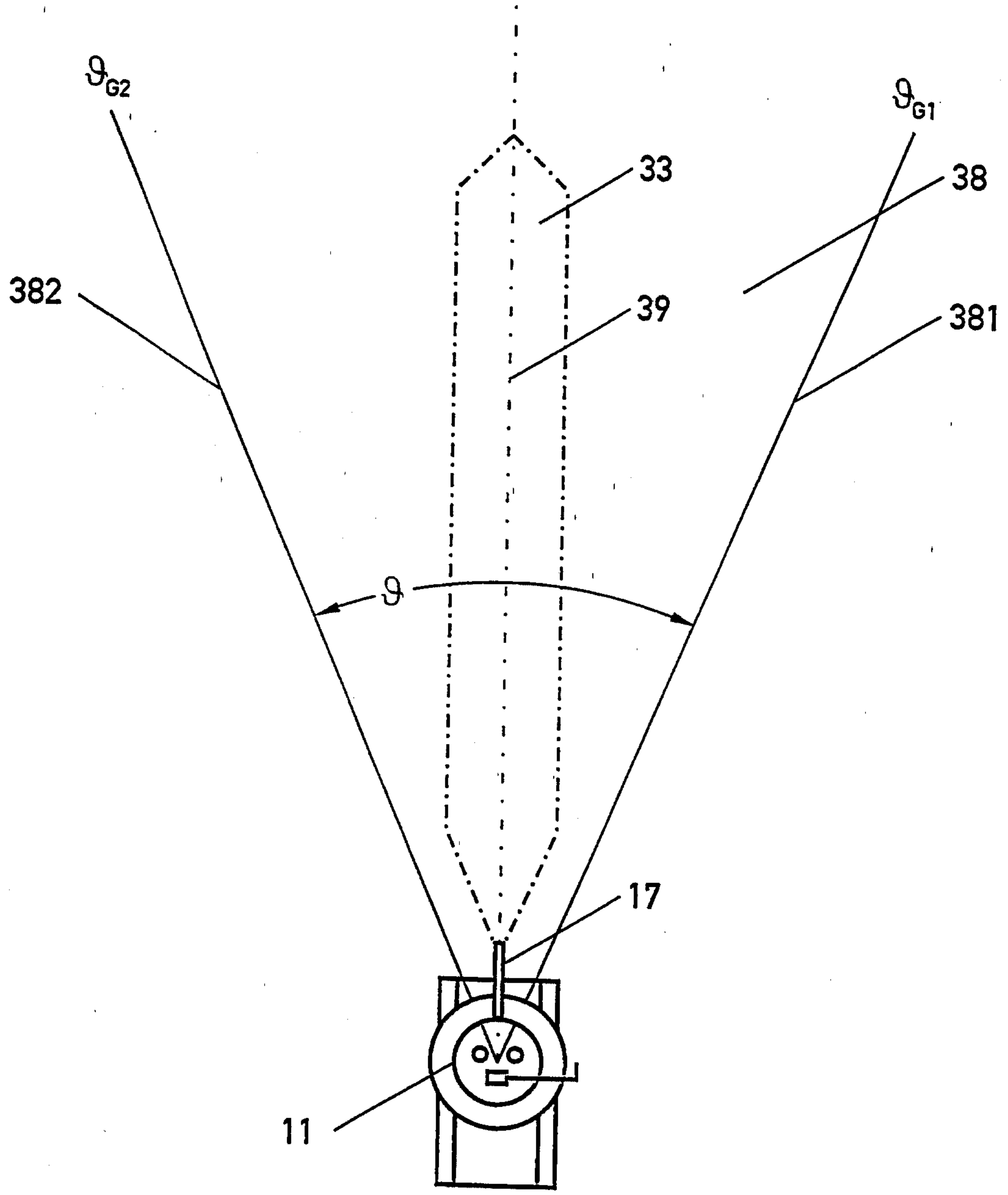
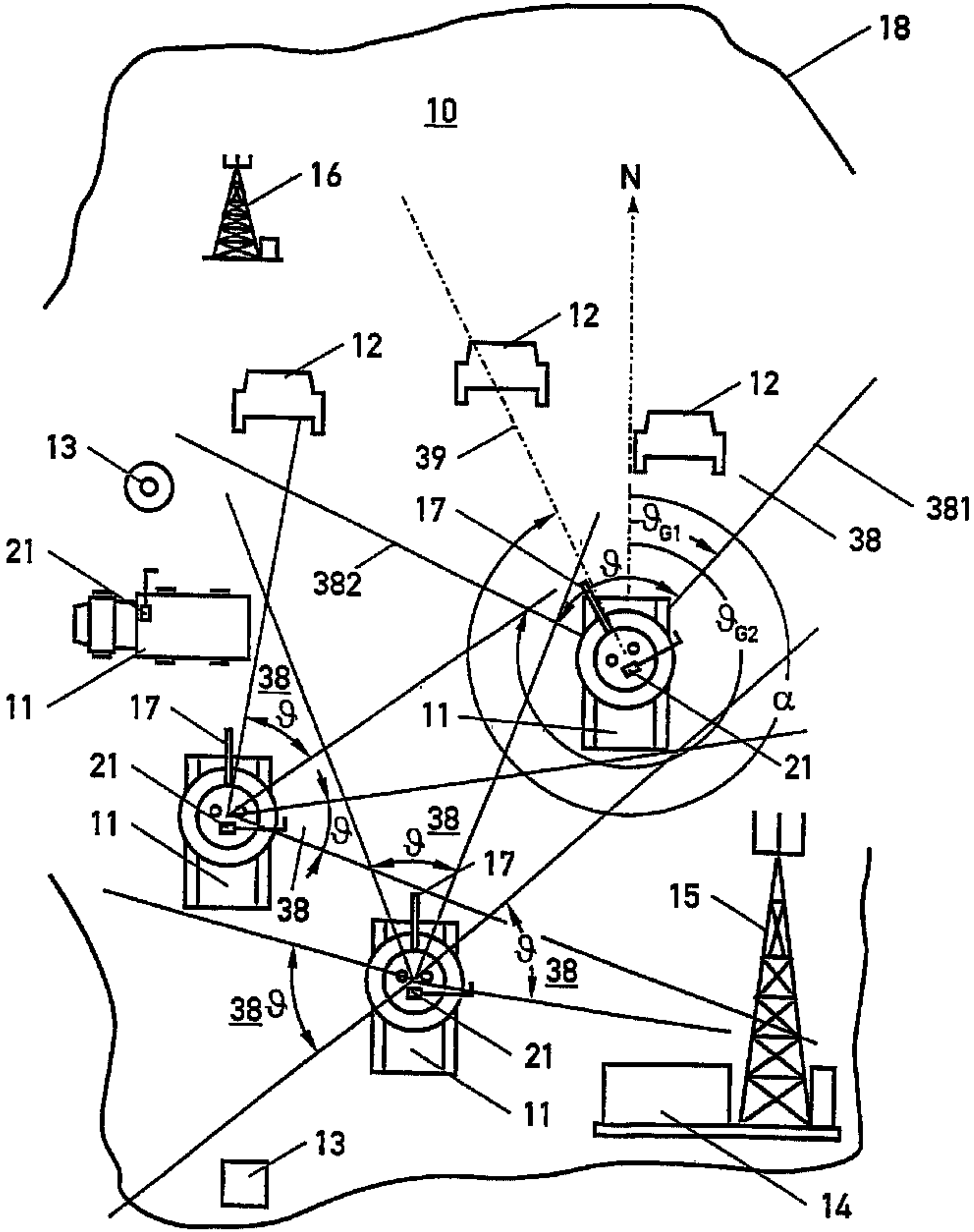


Fig. 4



18
10
16
N
12
12
12
13
39
381
17
38
21
382
ϑ_{G1}
ϑ
ϑ_{G2}
11
38
17
ϑ
11
α
21
21
ϑ
11
ϑ
38
17
38
15
ϑ
38
38 ϑ
21
11
13
14