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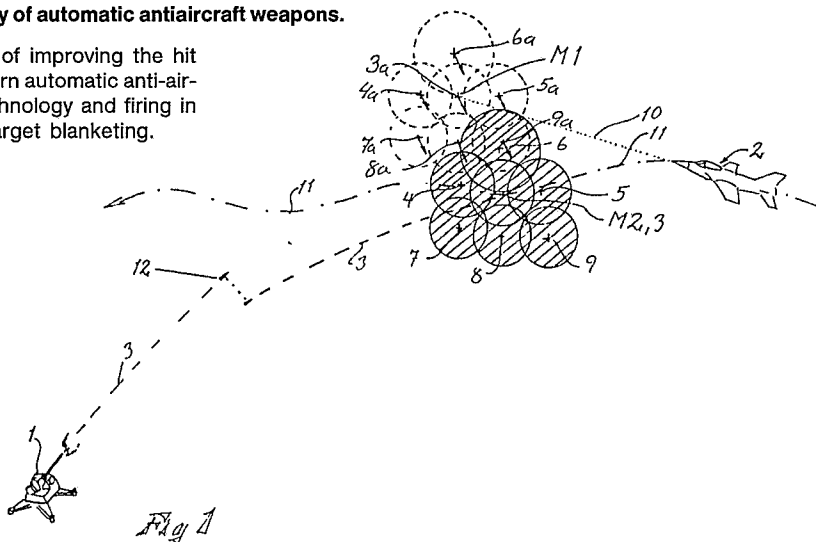
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54 **A method for improving hit probability of automatic antiaircraft weapons.**

57 The disclosure relates to a method of improving the hit probability against evasive targets in modern automatic anti-aircraft weapons, final phase correction technology and firing in kill pattern being utilized for maximum target blanketing.



Description

A METHOD FOR IMPROVING HIT PROBABILITY OF AUTOMATIC ANTI-AIRCRAFT WEAPONS

TECHNICAL FIELD

The present invention relates to a method for improving the hit probability of automatic anti-aircraft weapons, in combating targets taking evasive action, by final phase controlled ammunition discharged in optimum hit patterns in respect of the target type.

BACKGROUND ART

While the capability of modern anti-aircraft defence systems to combat resourceful air-borne targets such as aircraft and missile has increased as a result of access to high-quality tracking and fire control radar, laser range finders and ultrarapid computers combined with quick fire fully automatic AA guns armed with proximity fuse shells, the targets themselves have at the same time become more difficult to combat, in addition to which completely new and extremely difficult target types such as, for instance, the so-called seaskimmers and cruise missiles have entered this arena of warfare. Furthermore, a common denominator for most modern AA target types - irrespective of whether they consist of aircraft, helicopters or missiles, is that they operate tactically in such a manner that the anti-aircraft defence system is given but a brief time for target discovery, target range finding, calculation, gun laying and firing. As a result, it is vital for the anti-aircraft defence system to give fire as rapidly as possible and then to blanket the target with effective fire. Despite the steadily improving technical sophistication of available materials and consequentially increased competence, there remains the risk that minor errors in target range finding and calculations and/or atmospheric fluctuations may result in misses.

Moreover, there is also the problem that the computer-based control systems which are nowadays included in both modern fighting aircraft and missiles are rehearsed to accept the possibility of following, during both flight approach and while under fire, tactically unpredictable snaking trajectories including both rapid changes of direction and oscillatory motion athwart a main course, as well as variations in velocity. Despite the most modern conceivable fire control materials, such "evasive" targets can be very difficult to combat.

Since the killing point in conventional barrelled artillery is determined by the alignment of the gun on the moment of fire, and since the shells subsequently require a certain time to reach the target area, the above-described new possibilities of the object in flight to follow tactical snaking trajectories, combined with the ever increasing flight velocities of such targets entail further problems for anti-aircraft guns.

The best chance of kill on the target with projectiles whose entire direction aiming takes place at the moment of discharge, for instance in the form of normal gun projectiles, will then be by immediately

blanketing the point and the region thereabout where it is calculated that the target will be when the projectiles arrive with a plurality of shells whose blanketing area has its focal point on the previously mentioned point where the target is calculated to be.

It has previously been proposed in the art to establish a predetermined kill pattern about the calculated position of the target by minor angular corrections of the gun between the different rounds fired in a salvo. This may be effected, for instance, by modifying the aim of the gun during fire about its line of sight. This method is, for example, often practiced in older types of manually aimed machine guns and small-calibre automatic anti-aircraft weapons with simple sights. Naturally, the method can also be employed for a predetermined automatic displacement of an AA gun during fire. The same result can also be achieved by embodying a certain displacement into the gun between the killing points of the different rounds and the calculated line of sight of the gun. For example, this method has been tested on today's multi-barrelled gatling guns which are provided with a plurality of barrels rotating about a shaft disposed in the direction of fire of the gun and in which the individual barrels are fired in mutual sequence according as they reach a determined firing position, while the remaining portion of the travel about the central axis is used for ejecting empty cartridges and reloading the different barrels. In these gatling guns, the desired spread has been realized in that certain barrels are obliquely inclined somewhat in relation to the axis of the gun. In gatling guns, this procedure generally gives a satisfactory result, but at the cost of extremely high ammunition expenditure which is a distinguishing feature of this type of weapon.

However, both the latter method, according to which the different barrels shoot around the aiming point according to a certain firing plan, and the previously mentioned method in which the gun moves in accordance with a predetermined program during fire, give kill patterns which are exclusively dependent on angle in which the spread between the different shots will be wholly dependent upon the range to the target. Hence, using these methods it is only possible to achieve the optimum kill pattern at a single standard range.

Swedish patent application No. 8404403-1 (U.S. application No. 772.520) discloses a further method of improving hit probability in machine-aimed automatic anti-aircraft guns. According to this method, it is necessary that the gun be provided with a modern, rapidly operating and preferably computer-controlled aiming system of high capacity which is interconnected with a reliable range finder, the method also requiring access to proximity fuse-activated bursting shells. The reason for this is that the method according to this application is based on the fact that the aiming system of the gun is utilized for realigning the gun between each round so that all rounds included in one and the same salvo at a

calculated target range together form a predetermined kill pattern in which, on establishment of the kill pattern, attention had been paid to the varying sensitivity of the proximity fuses to different altitudes which, in turn, entails that the shells are more bunched in pattern closer to the surface of the earth than at higher altitudes. At the same time, it is possible to preprogram in the aiming system different kill patterns relating to both different target types such as aircraft, missiles etc. and to the altitude and general behaviour of the target. Since this firing method requires a realignment of the gun between each round, the gun may not be of excessively rapid fire, but firing rates of up to 500-700 rounds/minute should not constitute any obstacle as regards guns which are otherwise modernly equipped with aiming and controlling systems.

According to the method briefly outlined above, the kill pattern is, hence, selected on the basis of an executed target identification and with reference to the altitude of the target. The number of shells per salvo may either be determined once for all or be adapted to the executed target identification and thus selected killing pattern. For this type of killing pattern, it further applies that the regions of activation of the proximity fuses for adjacent shells in the salvo must partly overlap one another so that the killing pattern will be completely dense, at the same time as the areas of activation of the proximity fuses should not approach ground level so closely that the target cannot possibly be so low. In hedge-hopping targets, this will give a killing pattern which is flattened downwardly towards ground level, at the same time as the killing pattern may, by means of a few rounds, be built up vertically in that the proximity fuses are automatically allocated a larger sensitivity area. This is valuable, since a hedge-hopping target can only jink upwardly or laterally. Furthermore, the killing pattern may, in conjunction with target identification, be adapted such that more rounds are placed closer to the calculated position of the target when the target is large and hard and, therefore, easier to range find than when the target is small and difficult to range find and possibly also approaches so close to ground level that the sensitivity area of the proximity fuses will be clearly restricted and, as a result, more shells are required beside one another to form a killing pattern of sufficient lateral blanketing. By such means, there will always be obtained a killing pattern adapted in respect of target type and altitude about the target where the distance between the different shells in the salvo is always the same calculated in metres, irrespective of range, but, on the other hand, wholly dependent upon the killing pattern which was selected on the basis of the executed target identification.

Nevertheless, the new capabilities for aircraft and missiles - as briefly described above - for unpredictable evasion manoeuvres entail that not even this highly sophisticated round-for-round aim firing system is always completely satisfactory, not least because allowance for such evasive manoeuvres entails that such a large target area may need to be

blanketed for an adequate kill probability that the available time for firing is insufficient, or alternatively that the expenditure of ammunition will become unacceptably high. After all, proximity fuse ammunition is extremely expensive and a complete blanket killing pattern requires that the spread within the killing pattern is not greater than that permitted by the operative area of the proximity fuse.

SUMMARY OF INVENTION

According to the present invention, use is now made of a combination of firing in kill patterns and final phase control of the discharged shells at a late point in time along their trajectory in order, first, to allow for a broadening of the blanket cover of the killing pattern with an unchanged number of shells, and, secondly, to increase the kill probability within the target region blanketed by the killing pattern.

Final phase control or final phase correction of projectiles may be effected in different manners, but arguably the most economical method is the so-called gas impulse method in which the direction of the projectile is modified in that one or more gas impulse rocket motors act at right angles to the trajectory of the projectile. According to Newton's Third Law, there will be obtained by such means a change in direction of the projectile. However, the invention is not restricted to that type of final phase control, any type of final phase control being employable. A plurality of different types of final phase corrected shells are previously known in the art or are still in the planning stage. The majority of these are in the planning or experimental stage and are, as a rule, intended for anti-tank purposes and are, therefore, fitted with their own target seekers which activate the final phase correction only after their own target identification. Such a shell as contains both an active target seeker and a final phase correction facility will, however, be extremely expensive and, in addition, the target seeker requires such large space that it cannot be accommodated in, for example, a 40-mm anti-aircraft shell.

According to the present invention, which is primarily intended for medium-calibre AA artillery, for example 40 or 57 mm, the shell should not contain its own target seeker but only a conventional proximity fuse for triggering the bursting charge of the shell, suitable means for final phase correction of the shell and a receiver which receives an order from the fire control instrument of the AA gun in question to activate the final phase control in one or the other direction.

Hence, the fundamental principle of the present invention is, fully in accordance with the previously-discussed Swedish patent application No. 8404403-1, to form, by redirection round-for-round, a killing pattern, predetermined in view of target identification, target trajectory type and altitude, of shells about that point which the target is calculated to have reached when the shells reach the target area. Moreover, according to the present invention, the killing pattern will, by final phase control of the shells during the final portion of their trajectory towards the target, be corrected in accordance with supplementary target parameters

made during the trajectory of the projectiles towards the target. The method according to the present invention hence makes it possible, as was mentioned in the foregoing, to bunch up the killing pattern and to displace this in one direction or the other, or to execute both operations. Correspondingly, the killing pattern can also be spread out.

The final phase correction of shells, introduced in accordance with the present invention on the basis of target parameters executed late in the projectile trajectory, will radically reduce the possibilities of the target to deceive the gun sight by evasive flight or other unpredictable manoeuvres.

The practical design of target tracking and fire control instruments, calculators and transmitters on or at the gun, as well as receivers, activators and final phase control means in the shells as required for reducing the method according to the present invention into practice are based on prior-art technology and will not, therefore, be dealt with in detail in this context.

BRIEF DESCRIPTION OF THE ACCOMPANYING DRAWINGS

The nature of the present invention and its aspects will be more readily understood from the following brief description of the accompanying Drawings, and discussion relating thereto.

In the accompanying Drawings..

Fig. 1 generally outlines one variation in which the entire killing pattern has been displaced,

Fig. 2 shows one example of a partial bunching of a killing pattern, and

Fig. 3 shows a further example of a killing pattern.

Referring to the drawings, Fig. 1 shows shows an AA gun 1 fitted with its own radar fire control, calculators etc. The AA gun 1 has opened fire on a target 2 and, in this instance, discharges seven shells 3-9. These are aimed and fired individually with mutual aiming differences, with the intention of forming the killing pattern 3a-9a, in which each ghosted circle marks the effective activation area of the proximity fuse and payload of each respective shell. The skilled reader of this specification will know that the sensitivity of the proximity fuses increases with altitude, for which reason the uppermost shell 6 has been allocated the largest marking circle. On the drawing figure, only the projectile trajectory for shell designated 3 has been marked. The placement of the killing pattern has been selected to have its point of gravity in the point M1, since the fire control calculator of the gun 1 indicates, on the basis of the course and velocity of the target 2 at the point of time of fire, that the target would have reached the point M1 when the shells arrive at the target area. However, in reality the target does not follow the dotted course towards the point M1 but instead follows the dash-dot snaking trajectory 11. When the shells have reached point 12 in each respective projectile trajectory, course correction takes place of all shells by means of final phase control such that the entire killing pattern will instead be gathered about point M2 which the fire control calculator of the gun has now established will lie in

the immediate proximity of the target when the projectiles reach there. All shells are thus final phase corrected in the direction marked by arrows, which gives a blanket killing pattern 3-9 about the target.

Another variation is illustrated in Fig. 2. In this figure, the kill pattern is shown for a salvo of 8 shells in which the shells 13-20 have been more widely spaced than the proximity fuse ranges of the shells. At the moment of firing, the target is calculated to have reached the point M3 when the shells have reached the immediate vicinity of the target. However, target tracking shows that the target at this point in time will, in all probability, instead be at point M4. By final phase correction, the shells 14, 16 and 19 are deflected from their original courses so that these together form the ghosted killing pattern region 14', 19', 16' about the point M4. Hence, in this example final phase control was selected of those three shells which lay most proximal the correct position M4 of the target. Naturally, bunching of the entire killing pattern may be effected correspondingly, at the same time as dispersion of the killing pattern may also be effected in a corresponding manner.

Fig. 3 shows, in its turn, a variation of a widely spread killing pattern according to the present invention comprising nine shells 21-29 which were discharged with mutual aiming differences which, if no measures had been taken would, on the same height as the target, have given the killing pattern as shown on the Figure. On the Figure, the positions of the shells are marked by crosses, while ghosted circles indicate the manoeuvreability of the shells with maximum utilization of final phase correction, and the solid line smaller diameter circles show the active effective areas of the proximity fuses and the shells. Thus, the killing pattern is highly dispersed but, at the same time, covers a large area. On firing, the killing pattern has been grouped about point M5 which was then calculated as the actual position of the target when the shells reach the target area. In reality, the position of the target will, however, be at point M6, but, because of the evasive manoeuvres of the target, this position can only be calculated at a very late point in time. In accordance with the present invention, it is now possible to direct the shells which may reach the proximity of the point M6 in this direction. In this case, the shells 21, 23 and 37 are final phase directed towards point M6, but it is only the shell 23 which arrives, this, nevertheless, being fully sufficient, since it will give complete target blanketing. The final positions of the final phase corrected shells are marked 21 b, 23 b and 27 b. The new proximity fuse ranges of shells 23 b and 27 b have been shown as hatched, while the target blanketing shell 23 b has been cross-hatched.

Even if the shells 23 b and 27 b do not finally reach the target, their phasing-in towards the final position of the target can provide an extra security factor. Other shells which have no possibility of making a kill will be disregarded. Coded signals which activate the final phase control correction of each respective shell will ensure that the correct shell is affected.

Claims

1. A method of attaining optimum effect in combating evasive air-borne targets by means of automatic anti-aircraft weaponry which shoots in killing patterns with aiming point differences between the different shells, **characterized in that** the final phase controllable shells are fired at the target with mutual aiming point differences which, on calculated target range, do not exceed the manoeuvring capability of the shells, and the final positions of the shells within the killing pattern being corrected by final phase control in accordance with target parameters prepared while the shells are in their trajectory towards the target.

2. The method as claimed in Claim 1, **characterized in that** the final phase control is utilized for guiding one or more of the shells in a direction towards a point within the killing pattern and thereby densifying the pattern towards this point.

3. The method as claimed in Claim 1, **characterized in that** the final phase correction

is utilized for laterally displacing the entire killing pattern.

4. The method as claimed in one or more of Claims 1-3, **characterized in that** the final phase correction of the shells is activated by coded commands, whereby each shell may be given a specific course correction in accordance with the calculated position of the target on each correction occasion.

5. The method as claimed in any one or more of Claims 1 or 4, **characterized in that** the shells are final-phase controlled away from one another such that the killing pattern is broadened.

6. The method as claimed in any one or more of Claims 1-5, **characterized in that** the shells are provided with proximity fuses whose range is less than the manoeuvring capability of the shells.

7. The method as claimed in any one or more of Claims 1-6, **characterized in that** none of the shells within the uncorrected killing pattern is placed further from its closest shell than corresponds to the manoeuvring capability of the shells and none closer than that the proximity fuse ranges of the shells precisely overlap.

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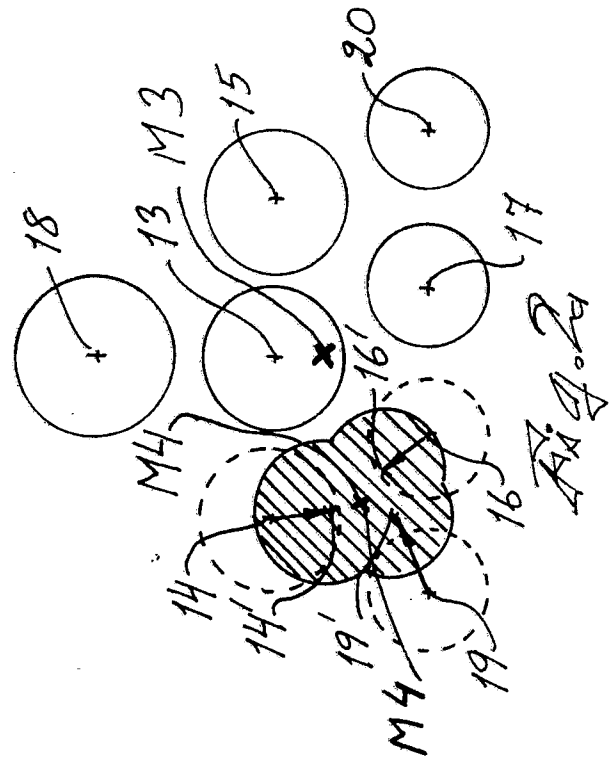
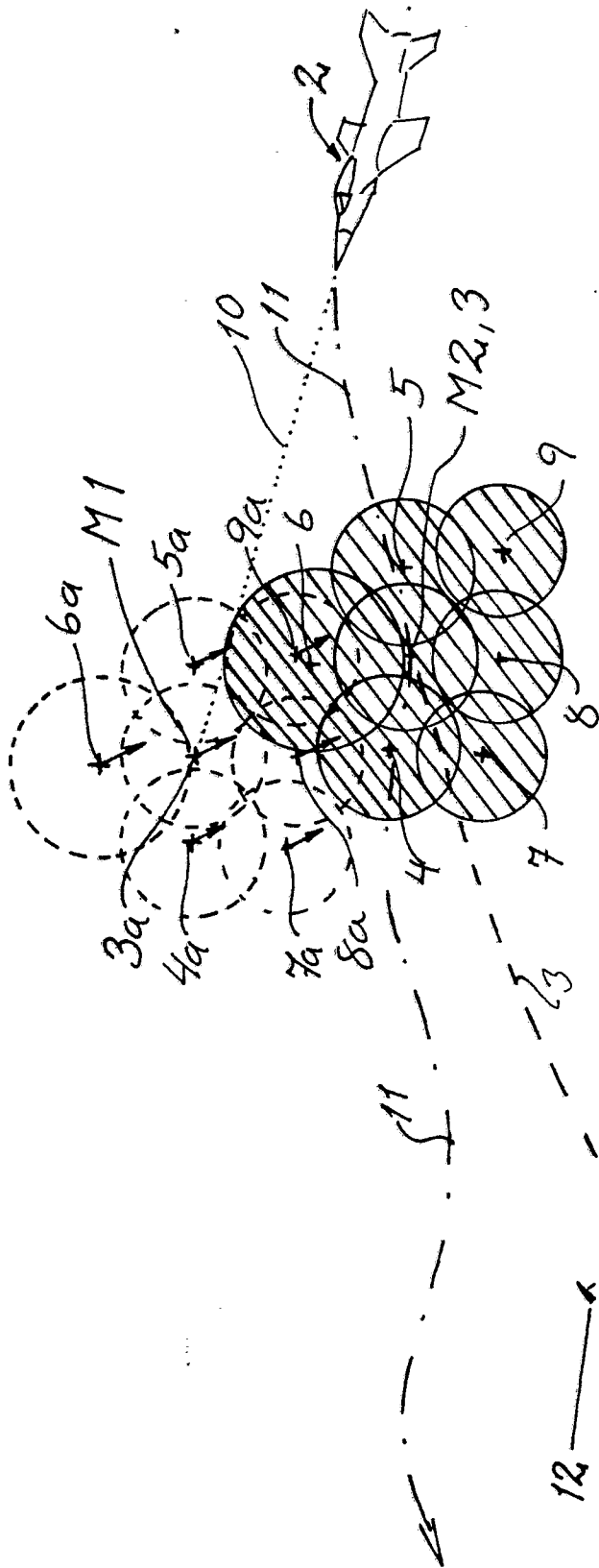
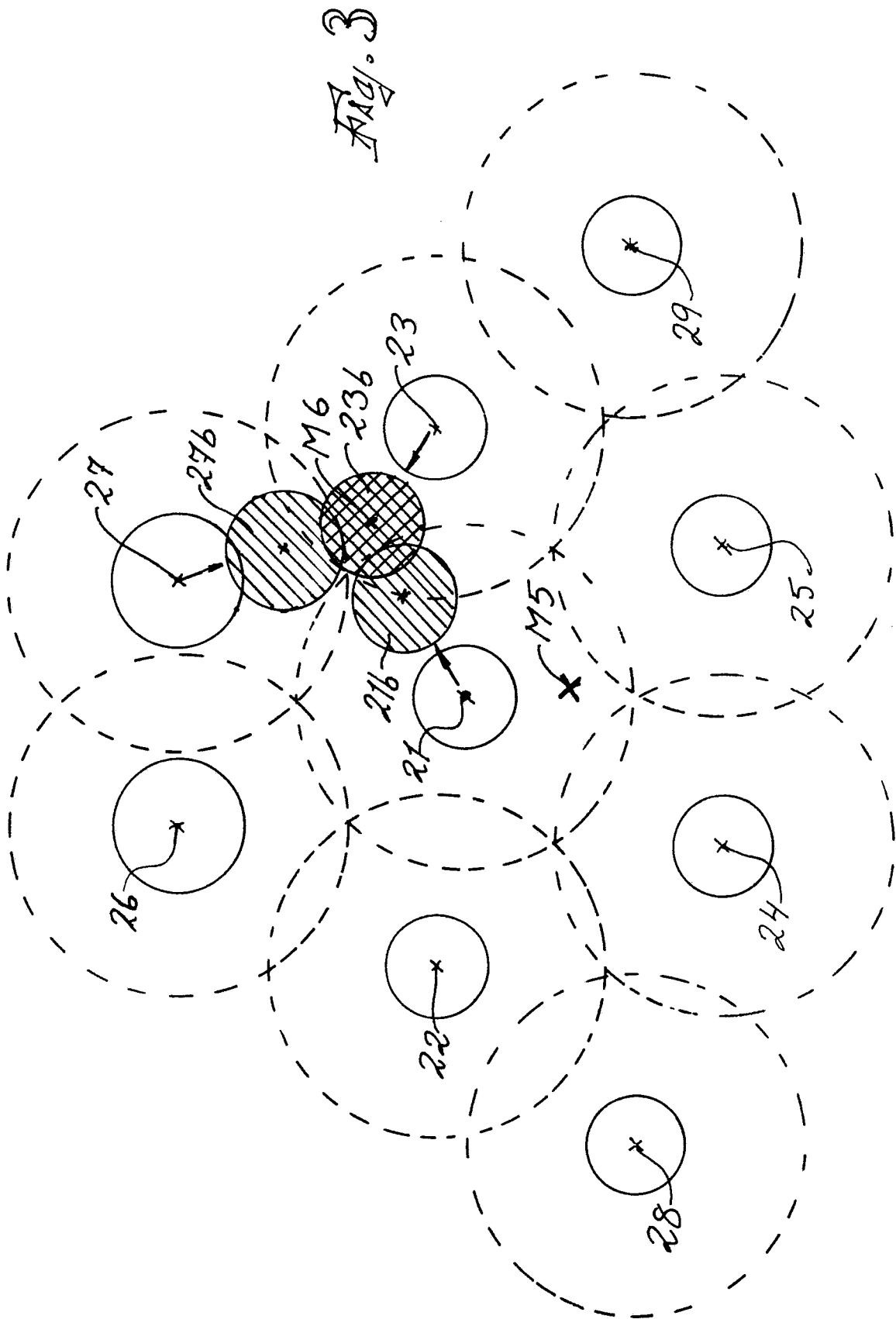


Fig. 1

Fig. 2





DOCUMENTS CONSIDERED TO BE RELEVANT			EP 88850348.9
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.4)
D, A	DE - A1 - 3 531 596 (BOFORS) * Totality * --	1-7	F 41 G 5/08
A	DE - A1 - 2 650 380 (LICENTIA PATENT-VERW.-GMBH) * Totality * --	1-3	
P, A	CH - A5 - 667 523 (OERLIKON) * Totality * --	1,2	
A	GB - A - 2 140 538 (FERRANTI) -----		
The present search report has been drawn up for all claims			TECHNICAL FIELDS SEARCHED (Int. Cl.4) F 41 G 3/00 F 41 G 5/00 F 41 G 9/00 F 42 B 13/00
Place of search VIENNA		Date of completion of the search 18-01-1989	Examiner HEMMELMEIER
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			