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(71) Applicant: **SWEDISH ORDNANCE - FFV/BOFORS AB**

S-691 80 Karlskoga(SE)

(72) Inventor: **Walde, Erik**
Jordanstigen 3
S-633 69 Eskilstuna(SE)

(74) Representative: **Nydell, Peder et al**
Nydells Patentbyra Hägnen 2573
S-380 30 Rockneby(SE)

(54) An ignition device to ignite an explosive charge in a projectile.

(57) An ignition device for a projectile (1) having two charges in tandem relationship, i.e. a pre-penetrator (3) and a main charge (4) for action against a target (11) which is protected by a so-called reactive armour (12-17). A piezo-crystal (8) is arranged to sense a first shockwave in the projectile as a result of an impact in the target, and to sense a second shockwave as a result of any collision between the projectile and a plate or the like expelled from the reactive armour. A delay circuit (9) is provided to delay the detonation of the main charge (4), and an inhibition circuit (10) is provided to automatically inhibit said delay if said collision will occur.

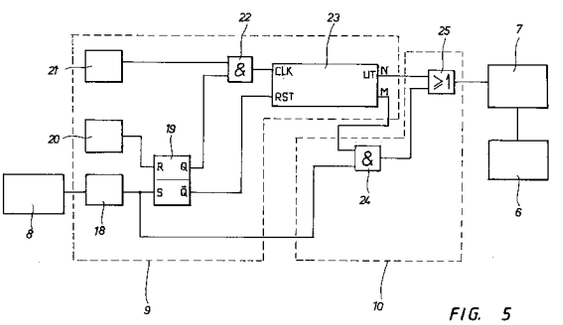

FIG. 5

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FIELD OF THE INVENTION

The present invention relates to an ignition device to ignite an explosive charge in a projectile, such as a shell or a robot missile, in responsive to shockwaves appearing in the projectile as a result of the impact of the projectile in a target or as a result of a detonation of any supplementary explosive charge in the projectile. A piezo-electric generator is responsive to any shockwaves in the projectile to initiate an electric ignition circuit via an electric time delay circuit which is dimensioned to accomplish said initiation of the ignition circuit at a predetermined time delay after the generation of the shock-waves.

The invention relates particularly, but not exclusively, to projectiles for attacking targets protected by reactive armour, said supplementary charge being a front shaped-charge, a so-called pre-penetrator to initiate the reactive armour in order to uncover the target, the first mentioned explosive charge being a rear shaped-charge, a so-called main charge, to penetrate the uncovered target.

BACKGROUND ART

The prior art concerning reactive armour was summarized in a lecture at the "Eight International Symposium on Ballistics" on the 23rd to 25th October, 1984, in Orlando, Florida, USA. The title of the lecture was "Interaction of Shaped-Charge Jets with Reactive Armor", and the lecture was published in a public available report from said symposium.

Reactive armour of the kind mentioned has been put into practice, and has been fitted to various tanks. In order to destroy reactive-armour tanks by means of shaped-charge effects, the explosive shell must have two shaped charges arranged in a tandem-relationship. The first shaped charge will penetrate and initiate the reactive armour structure in order to uncover the underlying main armour structure, whereas the second shaped charge will penetrate the uncovered main armour structure.

The function is as follows. A sensor device in the anti-tank explosive shell will indicate any presence of a target and will initiate the pre-penetrator which forms a shaped-charge jet which will penetrate and initiate the explosive substance of the reactive armour. Upon detonation of the reactive armour, the main armour of the tank will be uncovered. The sensor device of the anti-tank explosive shell, which has indicated the presence of the target, activates the initiator device of the main charge which, after a certain time interval, usually between 0.4 and 3 thousandth parts of a second, will initiate the main charge, which will form a jet and penetrate the uncovered main armour of the armoured vehicle.

The function of the reactive armour is based upon the principle that two or more steel plates are to be expelled by one or more interposed explosive charges. The plates are expelled - in the direction of the "normal" angle to the plates - with a velocity between 200 and 1500 m/sec. The reactive armour consists of panels having an area of 1-10 square-dm and are mounted on the outer surface of the armoured vehicle, substantially in one and the same surface area. The expelled plates may become more or less deformed or fragmentized.

Known anti-tank explosive shells having two charges are provided with an initiation device for respective one of the charges. The initiation device of the main charge has usually an electric detonator, which receives electric current from a current source such a capacitor or a battery. In order to avoid electric wires along the anti-tank explosive shell, a piezo-electric crystal may be used for sensing any shockwave generated as a result of an impact on the target or of any detonation of the pre-penetrator. The crystal may be located in or at the vicinity of the initiating device of the main charge and deliver electric energy to the electric detonator. The required time delay will be accomplished by an electric time delay circuit. An example of such an ignition system is shown in DE-A-641.181.

Anti-tank explosive shells designed according to FR-A-2.310.547 have a serious drawback. In order to function properly, the trajectory of the anti-tank explosive shell must not coincide with the "normal" angle to the reactive panel. Otherwise, or if the velocity of the anti-tank explosive shell and the expelled plate is unfavourable, the expelled plate will collide with the main charge.

In case of a collision, the main charge will be deformed and/or crushed before the end of the time delay interval and thus before initiation of the charge. Accordingly, the main charge will have no effect.

If the angle of impact, and if the velocity of the anti-tank explosive shell and of the expelled plates has usual values, there will be substantially no risk of collision.

However, in certain cases when aiming at reactive-armour tanks, where special weapon methods are used, for instance when aiming straight towards the side of the target, an unacceptable number of collisions may appear.

SUMMARY OF THE INVENTION

The object of the invention is to provide a device of the kind mentioned by way of introduction, where any collision between the explosive

charge (i.e. the main charge in the above-identified special embodiment) and any object which is expelled from the target (for instance a steel plate if the target is protected by reactive armour) will not prevent the action of the main charge. This object is achieved by providing the device in accordance with the invention with the characterizing features of claim 1.

Further developments of the invention are set forth in the depending claims.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a central longitudinal section of an anti-tank explosive shell with two shaped charges in tandem relationship for action against targets protectd by reactive armour, the rear charge being provided with a device according to the invention.

Fig. 2 shows an example of a target in the form of a modern tank.

Figs. 3 and 4 show examples of initiation of reactive armour at the front portion of a tank of the kind shown in Fig. 2.

Fig. 5 is an electric circuit diagram for a device according to the invention.

PREFERRED EMBODIMENT

The anti-tank explosive shell 1, see Fig. 1, has a sensor device in the form an elongated stand-off means 2 for sensing any impact in the target, a front shaped charge in the form of a pre-penetrator 3, and a rear shaped charge in the form of a main charge 4. This has an initiation device 5 with an electric detonator 6, which via an ignition circuit 7 (see Fig. 5) receives electric energy from a schematically shown piezo-electric generator in the form of a piezo-crystal 8, which receives mechanical energy from the shock-wave generated by the detonation of the pre-penetrator 3 as a result of an impact in the target by the stand-off means 2. Between the piezo-crystal 8 and the ignition circuit 7 there is an electric time delay circuit 9, see also Fig. 5, which is dimensioned to delay the detonation of the main charge 4 a predetermined time interval after the detonation of the pre-penetrator 3.

The time delay circuit 9 is, according to the invention, provided with an inhibition circuit 10, see Fig. 5, capable of inhibiting the delay of the detonation of the main charge 4 and to instantaneously initiate the ignition circuit 7 when a second shock-wave is detected in the projectile by the piezo-crystal 8, for instance generated as a result of a collsion between the projectile and a plate or the like being expelled from the reactive armour of the target.

The function is as follows, see Figs. 1-4:
When the anti-tank explosive shell 1 impacts in a target, i.e. the tank 11 shown in Fig. 2, the front portion of which has reactive armour plates 12-17, as is shown schematically in Figs. 3 and 4, the sensor device 2 will initiate the pre-penetrator 3, which detonates and forms a penetrating jet which initiates the reactive armour, either in the upper portion (see Fig. 3) or in the lower portion (see Fig. 4) of the front portion of the tank, depending upon where the shell hits. The ignition circuit may in a known manner include an electric capacitor capable of being charged as a result of acceleration forces acting on the projectile 1 upon firing, and capable of being discharged in order to ignite the main charge 4 after a predetermined time delay, see below.

The detonation of the pre-penetrator 3 generates a shock-wave which propagates rearwardly in the remaining portion of the anti-tank explosive shell 1, which portion substantially is the main charge 4. The shock-wave affects the piezo-crystal 8 which starts a time metering in the time delay circuit 9. The reactive armour will detonate during the time delay interval, and plates or plate fragments 14 will be expelled, see Fig. 3. Normally, these will pass by the main charge 4, which after the lapse of the time delay interval in the delay circuit 9 will be initiated and detonate, forming a jet which penetrates the target.

If the plates and plate fragments 13 of the reactive armour, however, will collide with the main charge 4, see Fig. 4, with sufficient energy, a new shock-wave will be generated in the main charge 4 which propagates rearwardly and reaches the piezo-crystal 8. The inhibition circuit 10 will thereby direct the electric energy received by the piezo-crystal 8 directly to the electric detonator 6 without waiting for the time delay interval to lapse. The main charge 4 will then be initiated and form a jet which penetrates the target.

Modifications of the invention are possible. For instance, there may be a separate piezo-crystal at another location than in the initiation device 5, and which is connected to the electric detonator 6 via an electric wire.

The structure and function of the time delay circuit 9 and the inhibition circuit 10 will be described below.

The time delay circuit 9, see Fig. 5, consists of a voltage detector 18 capable of limiting the pulse amplitude at the output of the piezo-crystal 8 to a level adapted to a RS-flip-flop 19. The output of the detector 18 and of a reset circuit 20 is then connected to a respective input of the RS-flip-flop 19. The Q-output thereof and the output of a pulse oscillator 21 is connected to a respective input of an AND-circuit 22. The output of the AND-circuit 22 is connected to the CLK-input of an electronic pulse counter 23, whereas the $\overline{Q}$-output of the RS-

flip-flop 19 is connected to the RST-input of the counter 23.

The inhibition circuit 10, see Fig. 5, consists of an AND-circuit 24, one output of which is connected to the output of the detector 18, and the other output of which is connected to an output M of the counter 23. A second output N of the counter 23 and the output of the AND-circuit 24 is connected to a respective input of an OR-circuit 25, the output of which is connected to the input of the ignition circuit 7.

Upon powering of the circuits 9 and 10 by the oscillator 21, the reset circuit 20 will deliver a pulse to the RS-flip-flop 19. The $\overline{Q}$-output thereof will then assume a logical "1" level. Thus, the RST-input of the counter 23 is high, and the counter 23 blocked. No counter pulses can pass the gate 19, since one input thereof is a logical "O". When the piezo-crystal 8 is affected by a shock, i.e. upon the impact by the sensor device 2 in a reactive armour plate 11, a high powered pulse will be generated. The amplitude thereof will be limited by the detector 18 to a level which is adapted to the RS-flip-flop 19.

When the RS-flip-flop 19 is activated by the shock against the piezo-crystal 8, Q and $\overline{Q}$ will change their logical levels. The blocking of the counter 23 will cease, and oscillator pulses may now be counted, since one of the inputs of the AND-circuit 22 is positive. Upon counting of N pulses a pulse will be delivered to the ignition circuit 7 such that the electric detonator 6 will be initiated. The time delay τ between the switch over of the RS-flip-flop 19 and the ignition pulse is determined by the frequency f_0 and the number of steps in the counter 23. It is assumed that the counter gives a positive level when N pulses has been received at the CLK-input. Then the relation $\tau = N \cdot f_0$ is valid.

It is, according to the invention, possible to cancel (inhibit) this delay time τ due to the connection of said AND-circuit 24 to the output M of the counter 23, which gives a positive level after M pulses, where M<N. Thereby, the AND-circuit 24 may be activated after a time delay interval T which can be given any value between 0 and τ. Then the relation $T = M \cdot f_0$ is valid.

When a pulse appears for the first time from the piezo-crystal 8, the RS-flip-flop 19 changes to its other state, and the time metering begins. The AND-circuit 24 blocks any signal from the detector 18 so that no ignition pulse will be delivered immediately. After the time $T = M \cdot f_0$ the piezo-crystal 8 will - if it is affected by a second shock derived from a collision between the projectile 1 and a plate or the like which is expelled from the reactive armour of the target - start the ignition circuit 7, since the AND-circuit 24 then goes high at both its input terminals. If, on the contrary, no actuation of the piezo-crystal 8 takes place after the time T, an ignition pulse will be delivered by the ignition circuit 7 only after the preset time delay $\tau = N \cdot f_0$.

The time interval 0 - T is given such a high value that every shockwave from the penetrator 3 having a certain amplitude, has come to a position of rest before the time T. The time interval T is, however, chosen so short that no collision can occur within the interval 0 - T between the main charge 4 and any plate or the like that is expelled from the reactive armour, but instead at a later time, i.e. within the time interval $T - \tau$.

Claims

1. An ignition device to ignite an explosive charge (4) in a projectile, such as a shell or a robot missile, in response to shockwaves appearing in the projectile (1) as a result of the impact of the projectile in a target (11) or as a result of a detonation of any supplementary explosive charge (3) in the projectile, a piezo-electric generator (8) being provided responsive to any shockwaves in the projectile to initiate an electric ignition circuit (7) via an electric time delay circuit (9) which is dimensioned to accomplish said initiation of the ignition circuit at a predetermined time delay (τ) after the generation of the shockwaves, **characterized** by an electric inhibition circuit (10) capable of - after appearance of said shockwaves and after initiation of said time delay - inhibit said time delay and bring about immediate initiation of the ignition circuit (7) if further shockwaves will appear, for instance as a result of a collision between the projectile (1) and any material being expelled from the target.

2. An ignition device according to Claim 1, **characterized** in that the time delay circuit (9) comprises a pulse counter (23) capable of activating the inhibition circuit (10) at a predetermined time before said time delay has been reached.

3. An ignition device according to Claim 2, **characterized** in that the time delay circuit (9) has a first output terminal which is connected to the ignition circuit (7) to initiate this after a counting of N pulses corresponding to said time delay, and a second output terminal which is connected to the inhibition circuit (10) to activate this after a counting of M pulses, where M<N.

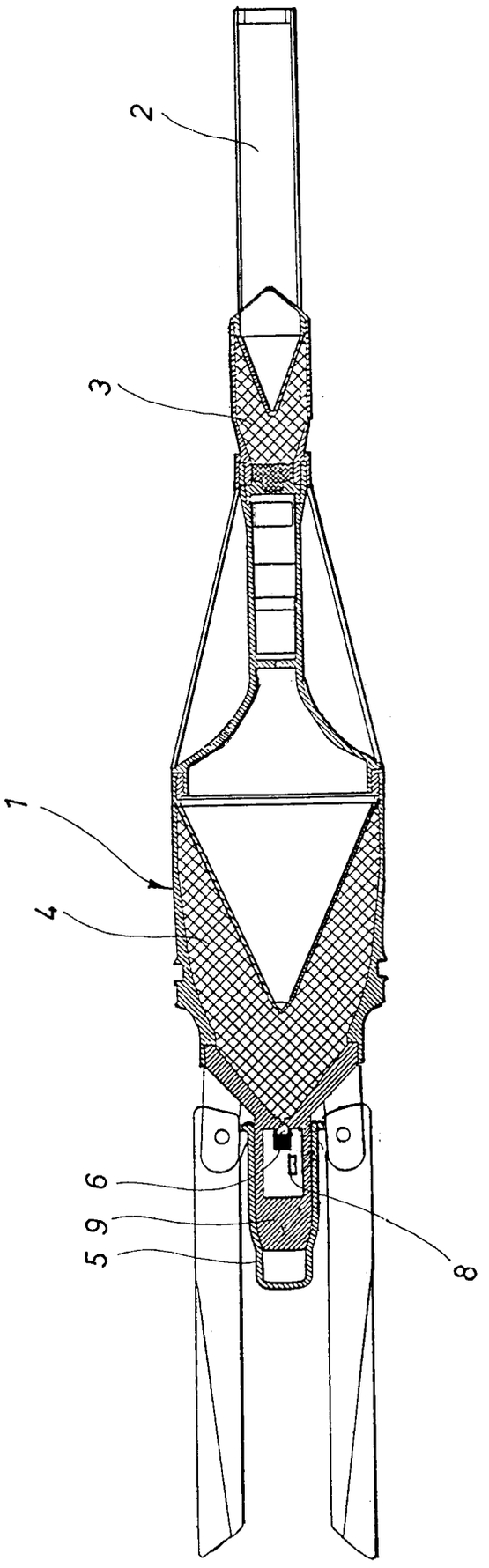

FIG. 1

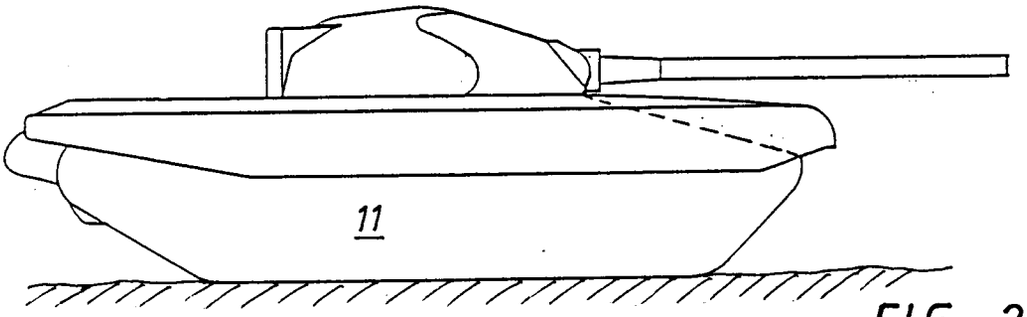

FIG. 2

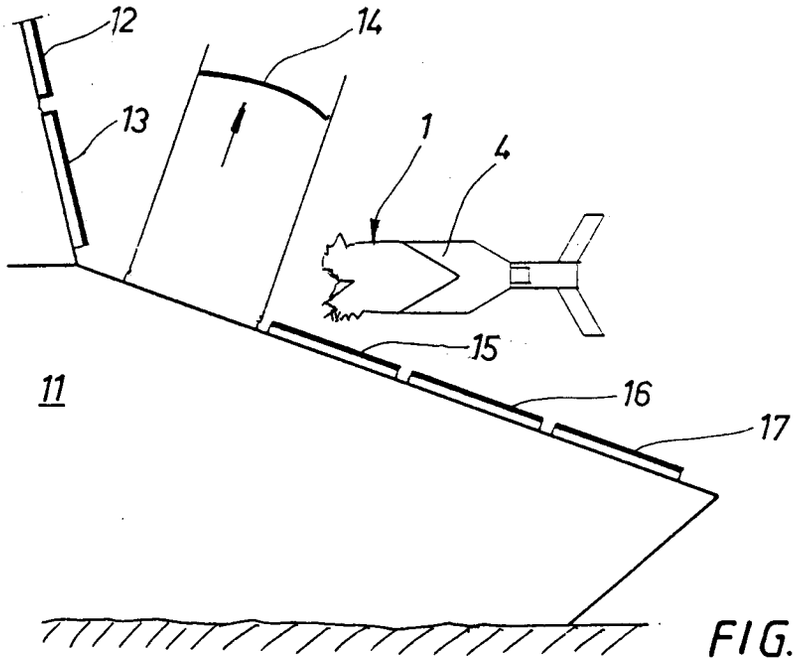

FIG. 3

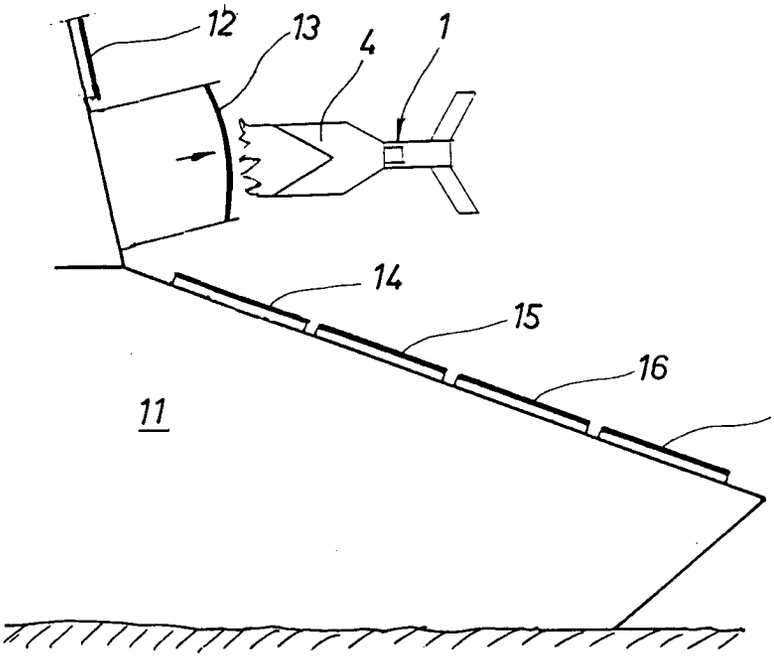

FIG. 4

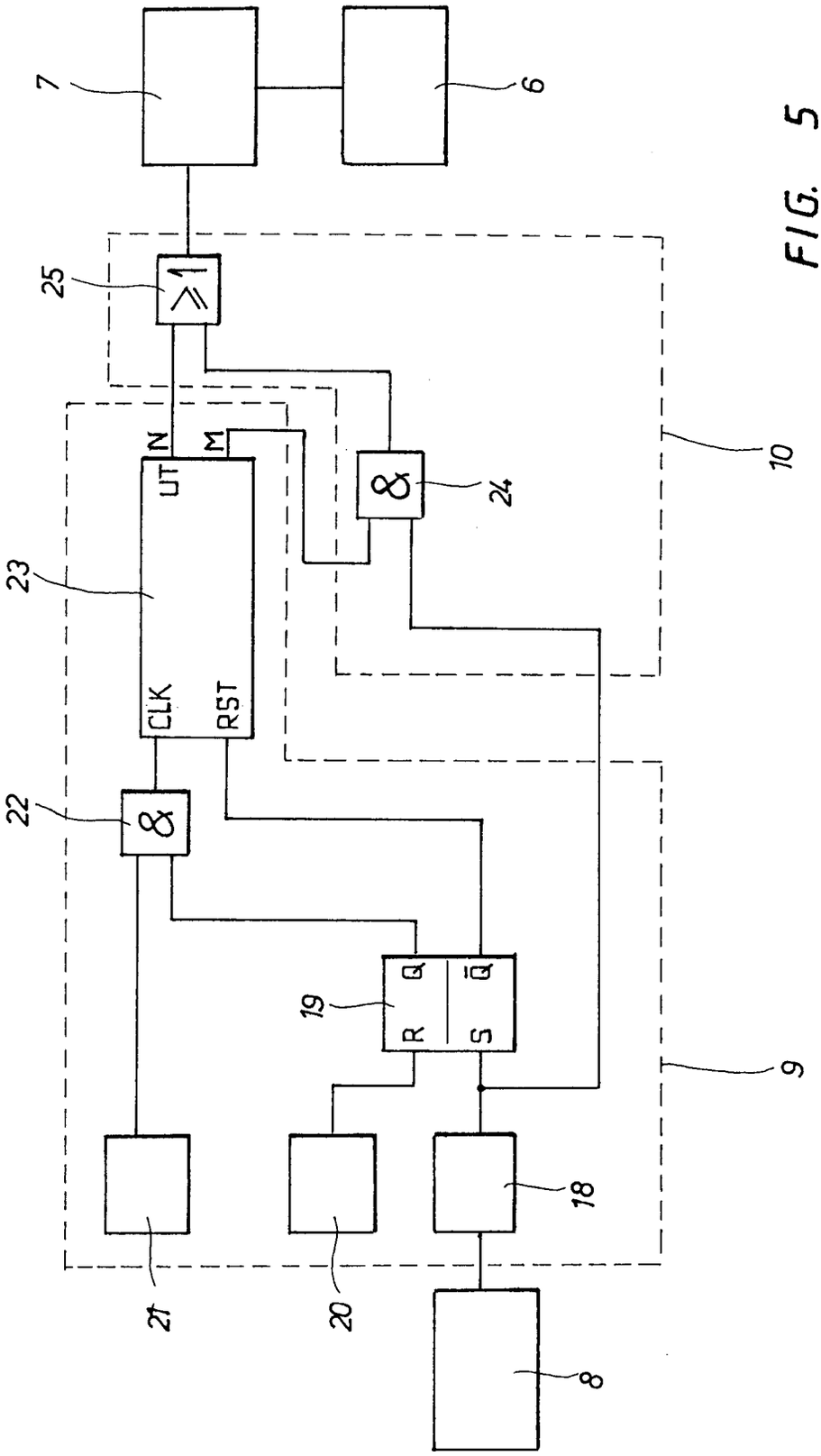

FIG. 5

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EUROPEAN SEARCH REPORT

Application Number

EP 92 20 0066

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
A	EP-A-0 238 715 (MESSERSCHMITT-BÖLKOW-BLOHM GMBH) * page 2, line 4 - page 4, line 4; figure *	1	F42C11/06 F42B12/18
A	GB-A-2 060 837 (DIEHL GMBH) * page 2, line 31 - page 3, line 55 *	1,2	
A	DE-A-3 346 406 (MESSERSCHMITT-BÖLKOW-BLOHM GMBH) * the whole document *	1	
D,A	FR-A-2 310 547 (SOCIETE D'ETUDES, DE REALISATIONS ET D' APPLICATIONS TECHNIQUES)		

TECHNICAL FIELDS SEARCHED (Int. Cl.5)
F42C
F42B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	12 MAY 1992	TRIANTAPHILLOU P.

CATEGORY OF CITED DOCUMENTS

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