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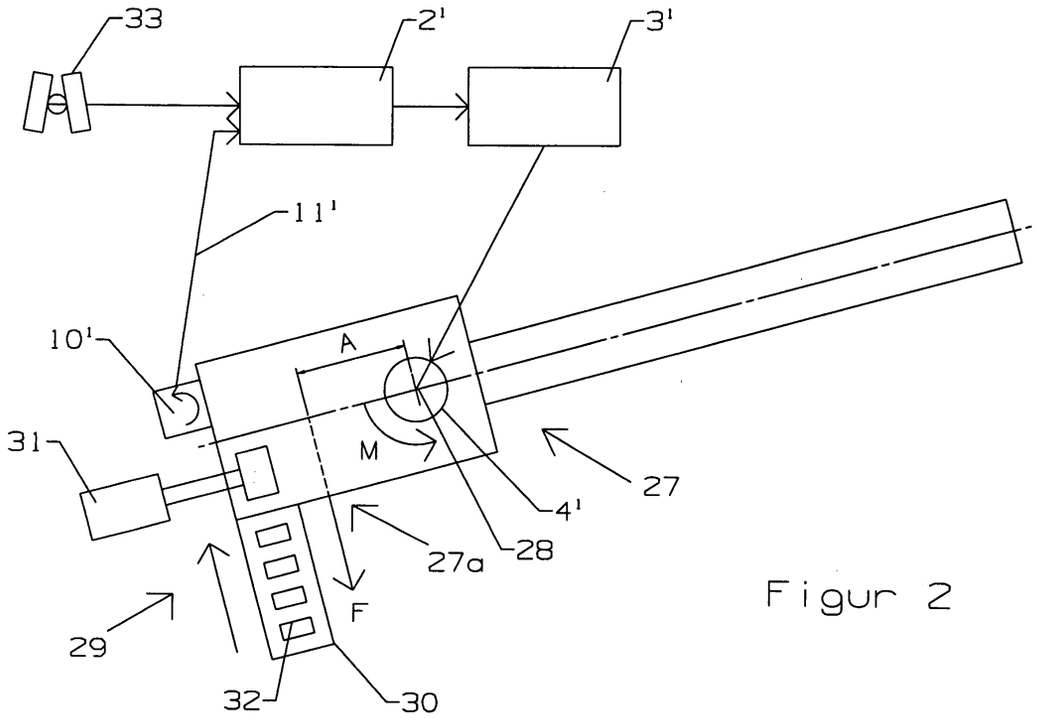
(54) Arrangement for a barrelled weapon with servo system

(57) In an automatically-loaded barrelled weapon (27), information from the barrelled weapon's automatic loading system is used to reduce the interference in the weapon servo that arises when the automatic loading system is set in motion or causes movements in movable parts. The arrangement can comprise or work with a unit (22) that obtains parameter information from, for example, the automatic loading system, which parameter information is representative of a force (F) interfering with the aiming of the weapon and caused by the automatic loading system on the barrelled weapon. The unit is arranged to produce a command (i6) to the servo motor (4), by means of the parameter information, that essentially or completely eliminates the said force. In this way, turning moment interference on the weapon that is caused by the activation of the automatic loading system is counteracted and the accuracy of the barrelled weapon when firing can be improved.



Figur 2

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Description

[0001] The present invention relates to an arrangement for a barrelled weapon, for example a gun, that can be aimed towards a target by means of a servo system which, in response to controls, generates control commands to a servo motor comprised in the servo system. The servo system carries out or assists in the aiming of the barrelled weapon. In addition, the barrelled weapon is able to be fired with ammunition that is arranged to be able to be transferred from an automatic loading system associated with the barrelled weapon.

[0002] In connection with barrelled weapons, the use is already known of a weapon servo, here called a servo system, for carrying out aiming and stabilizing of the weapon. The barrelled weapon can be arranged to be able to be stabilized in both the lateral direction and vertical direction and the servo systems for the respective directions can be implemented in principle in the same way and with similar construction and functions. The present invention will be described primarily in connection with the vertical function, but can also be used in connection with lateral functions. The barrelled weapon or gun can be arranged in association with a turret arrangement and the utilization is already known of a servo system that can be selected to stabilize the weapon relative to the turret in so-called "non-stab mode" or stabilize the weapon relative to space in so-called "stab mode". These modes differ principally in that a tachometer or angle sensor is used as the feedback element in "non-stab mode", while a gyro is used as the feedback element in "stab mode". The use is already known of an automatic loading system in connection with a weapon or a turret supporting this.

[0003] The function of the servo comprises comparing a required angular velocity, the "desired velocity", with an actual speed measured by the gyro, that is the "actual velocity". The difference is used as the input signal to a servo amplifier with a characteristic that provides a stable system with the required aiming performance. The calculation results in a measurement of a suitable turning moment or in a turning moment command that is obtained as a result of the turning moment and is applied to the weapon in order to counteract interference. The turning moment command is then used as the input signal for a motor control with power amplifier and a servo motor connected in such a way that it provides a turning moment to the weapon. If, for example, the case is considered in which the weapon is required to be stationary, the desired value is zero and the turning moment command given is such that it counteracts any interference moment, for example imbalances and friction. As a result, the weapon/gun is stationary in space. A sudden change in the interference moment is compensated for by the weapon changing angle, which causes a signal to be received from the gyro which goes into the servo amplifier and gives the relevant command, for example a moment command, in order to return the weapon to the starting position. Instead of the said comparison being carried out between angular velocities, it can be carried out between angles. In addition, the turning moment itself can be considered to be represented by the motor current.

[0004] With weapons of this type, there is a desire that they should be able to be provided with an automatic loading system where the loading procedure can be controlled by a motor, the propulsion motor, which conveys or pushes ammunition into the weapon. There is also a desire for the automatic loading system to be completely or partially attached to the barrelled weapon, preferably to its rear parts. The automatic loading system can comprise ammunition belts that are mounted onto the rear parts or lower parts of the barrelled weapon in a known way. With this type of barrelled weapon, the weapon is therefore subjected to a turning moment interference which constitutes a function of the characteristics of the propulsion motor. The propulsion motor draws the ammunition feed and causes a tractive force in the ammunition belt and, in the case when the automatic loading system is in the said required position, this force will act on the weapon at its rear part, that is the firing as such affects the stabilization. The interference is dynamic and is largest in association with the breach opening, but is present during the whole firing phase. The conventional servo system is not able to compensate fully for these interferences. In this way, the ammunition feeding with the said automatic loading system causes a deterioration of the weapon's accuracy when firing. The present invention aims to solve this problem.

[0005] The present invention is based on the fact that the interference has a character that is partially deterministic and, in addition, is a function of the tractive force that originates in the characteristics of the ammunition motor and its loads. According to the invention, in a preferred embodiment, measurements are carried out in the automatic loading system and form a model of how this feeding will cause moments that affect the weapon. The interference moment calculated in this way is added to the weapon servo, preferably as a moment command for the motor control.

[0006] The principal characteristic of an arrangement according to the invention is, among other things, that it is arranged to utilize parameter information emanating from the automatic loading system and/or produced previously, which information is representative of a force interfering with the aiming of the weapon and caused by the automatic loading system. In addition, the invention is characterised in that the arrangement is arranged, by means of the parameter information, to produce a command (moment command) to the servo motor that essentially or completely eliminates the said force.

[0007] In one embodiment, the automatic loading system is completely or partially attached to the barrelled weapon at its rear parts and the interfering force causes a moment around the centre plate bearing axis of the barrelled weapon in connection with the activation of the

automatic loading system. Upon activation, by means of the parameter information, a unit comprised in the arrangement initiates a moment command that can be fed to the servo system. The parameter information is completely or partially related to a feeding motor comprised in the automatic loading system. Parameter information can comprise or consist of a voltage across the feeding motor. Alternatively or in addition, the parameter information can comprise or consist of a current arising in the feeding motor upon firing. Alternatively or in addition, the parameter information can comprise or consist of information relating to the speed of the propulsion motor during one or more stages of the firing. The parameter information can also, alternatively or in addition, comprise or consist of load commands and/or control commands sent to the propulsion motor in the barrelled weapon and the automatic loading system. The parameter information can also, alternatively or in addition, comprise or consist of data obtained by experience in tests and varying experiences of behaviour during the use of the automatic loading system.

[0008] The unit as such can be comprised in or constitute part of a barrelled weapon system that comprises barrelled weapon, turret arrangement for the barrelled weapon and aiming and firing system for the barrelled weapon. Such a barrelled weapon system normally comprises a computer or processor function, which can have free capacity and can also handle the said interference-reducing or interference-eliminating aiming and firing functions associated with the barrelled weapon. The servo system comprises preferably a first circuit with servo function and filter which, in response to the received desired value, produces the moment command given to the servo motor, and a second circuit with motor control with filter acting as a servo amplifier which, in response to the commanded value and to the moment command produced by the unit, controls the loaded servo motor which thereby produces an angular velocity that can be sent to the barrelled weapon. In addition, there is an angular velocity detecting device, for example a gyro, which is comprised in a feedback circuit that feeds back information about the actual angular velocity or actual value to the input of the first circuit. The signal representing the moment deviation is sent to the second circuit via an adding or subtracting device, to which the said moment command sent to the servo motor is also connected. Additional embodiments are described in the following subsidiary claims.

[0009] In an alternative embodiment, the functions of the said unit can be implemented by additional software in the existing computer function of the tank or barrelled weapon. The computer function can comprise one or more computers or processors with input devices, buses and memories of a known type. The computer function can work with weapon-controlling functions and analysis and simulation functions and it is recognized that the said parameters can be found on the said buses and/or in the said memories, from where they are retrieved alternatively or in addition.

[0010] By means of what is described above, stabilization of automatically-loaded barrelled weapons can be arranged in such a way that information from the automatic loading system or the loading mechanism is utilized to reduce the interference in the weapon servo that arises when the loading mechanism is put in motion or when it is in motion. The model simulated or based in the computer unit can utilize measurements of parameters in the ammunition feeding that determine the size of the tractive force, cf. the parameters described above. By means of the invention, the weapon servo can be given a moment command that is a model of the ammunition feeding and its interfering effect and is based on information from the motor for the ammunition feeding which includes at least one of the parameters described above.

[0011] A currently preferred embodiment that has the significant characteristics of the invention will be described below with reference to the attached drawings in which

Figure 1 shows in outline form a servo system which is supplemented by control signal functions from an ammunition handling system or automatic loading system, and/or the barrelled weapon's own computer-based control system, and

Figure 2 shows from the side and in outline an example of a barrelled weapon utilizing the new ideas, in the form of a gun mounted on a centre plate bearing, to the rear part of which gun is attached an automatic loading system for feeding ammunition.

[0012] Figure 1 shows a servo system for a barrelled weapon/gun represented by 1. The servo system comprises a first circuit 2 with servo amplifier which is provided with a filter. A second circuit is represented by 3 and works with the motor interference function and has a filter and acts as a power amplifier in a known way. A servo motor with an applied load is represented by 4. A control signal is represented by i1 and the gun's velocity deviation or desired value velocity is sent to the input of the servo amplifier. The input is represented by 5. The circuit 2 is intended, in response to the velocity deviation, to generate a moment command to the servo motor, which moment appears at the output 6. The circuit 3 receives, among other things, the moment command to the servo motor at its input 7 and carries out a power amplification of the moment command. The circuit 3 controls the servo motor via its output 8 and the servo motor receives the amplified moment command at its input 9. A gyro 10 is included in a feedback circuit 11 for the angular velocity appearing on the servo motor at its output 12 which is transferred to a circuit 13 that determines the present angle of the gun. The velocity is connected to the input 5 of the circuit 2 via an adding or subtracting device 14. The velocity deviation for the gun

is represented in Figure 1 by 15, the moment command to the servo motor by 16 and the gun's angular velocity by 17. Alternatively, the comparison can be carried out between angle sizes rather than between the described angular velocities. A tachometer, angle sensor, etc, can be used instead of a gyro.

[0013] In accordance with the concept of the invention, an automatic loading system or feeding system for ammunition 18 is also included. The automatic feeding system can consist of a known system of this type and will therefore not be described in greater detail here. It is characteristic of the system that, in accordance with what follows, it is mounted on the barrelled weapon and, when it is used, it causes interference to the barrelled weapon's guidance and aiming. In the embodiment, the system 18 comprises a propulsion motor 19 for ammunition in connection with loading and firing the barrelled weapon. The unit 18 comprises equipment 20 for detecting parameters for the motor 19. Thus, the equipment 20 can detect the voltage of the motor 19 upon the starting of the motor in connection with the commencement of firing a salvo. Alternatively or in addition, the equipment 20 can detect the motor current in the said stage. Alternatively or in addition, the equipment 20 can detect the speed of the motor in various feeding stages. Parameters that are based on load data and/or logic can also be used alternatively or in addition. A second piece of equipment for storing and inputting load data and/or logic is represented by 21. In Figure 1, in addition, the parameter for the said motor voltage is represented by i2, the parameter for the motor current is represented by i3 and the parameter for the motor speed or speeds is represented by i4. In addition, the parameter for load data and/or logic is represented by i5. The said parameters can be input into a unit 22 that can consist of a computer or a part of a computer in the barrelled weapon system's other structure. The unit 22 can alternatively consist of a separate unit. The unit 22 comprises an input circuit (1/0) 23 which receives the said parameters and a computer part or processor (for example a microprocessor) 24 that establishes a computer model for estimating moment interferences in the gun servo according to the invention. The processor or the like 24 outputs information, for example a signal i6, that can consist of a moment command, that is sent to the input of the circuit 3 via an adding or subtracting device 26.

[0014] As an alternative or in addition to the equipment described above, the unit 22 together with the first circuit 2 can be arranged to have more of a software implementation, that is the unit function and the function in the first circuit 2 can be implemented together or coordinated in a separate processor or in the barrelled weapon's processor(s) with associated bus or bus system, memories, etc. Such a part is symbolized by a part 25 that can be connected to the output of the automatic loading system and the said second circuit 3. Data/parameters that are sent to the part 25 are executed in the processor function of the part 25 by programs of a known kind. The execution can be based on similarly known control, analyses and simulations carried out in the barrelled weapon relating to the use and testing of the barrelled weapon. Data can relate to control functions, ammunition handling, firing, friction, currents and voltages in the propulsion motor (19), quantity of ammunition, lengths of salvos, firing with single shots, etc. Data can be provided from the system 18 and/or from the processor function of the barrelled weapon system. The parts 18; 2 and 22; and 3 and 4 can be supplied by different suppliers and can be assembled, for example, by a user.

[0015] In Figure 2, a barrelled weapon in the form of a gun is indicated by 27. The gun is mounted on a centre plate bearing and the bearing is symbolized by 28. An automatic loading system 29 is arranged at the rear and lower parts 27a of the gun and is attached to the said parts. The automatic loading system comprises ammunition belts 30 and a propulsion motor 31 (cf. motor 19 in Figure 1) for the belts and the ammunition units 32 contained in these. In connection with the use or activation of the ammunition loading system, there is a reaction force at a distance A from the weapon's centre plate bearing axis 28 or point of rotation in a vertical direction. The force and the distance A cause a moment M that attempts to turn the barrelled weapon primarily upwards in a vertical direction, but opposite (downward) movements can also occur. In Figure 2, the said gyro 10',(cf. the reference numeral 10 in Figure 1) is shown. The first and second circuits 2' and 3', and the servo motor 4' (cf. 2, 3 and 4 in Figure 1) are shown in outline. In addition, there is an aiming handle 33, by means of which the control signal i1 is initiated. The feedback circuit 11' from the gyro 10' to the input of the servo amplifier is also shown. By means of the invention, a moment command (cf. the signal i6 in Figure 1) that counteracts the moment M is introduced in the servo circuit and counteracts the tendency towards the deviation in the aiming described above.

[0016] The motor 19 has a power of 1-10 kW. In an embodiment, the projectiles can weigh approximately 1.5 kg each and the projectiles can be fired one at a time or in salvos of, for example, up to 30 shots. The barrelled weapon can consist, for example, of a tank 90.

[0017] The invention is not limited to the embodiments described above as examples, but can be modified within the framework of the following claims. The parts of the equipment in the figures that are not described in detail can consist of known designs.

Claims

1. An arrangement for a barrelled weapon (gun) (27) that can be aimed towards a target by means of a servo system (1) which, in response to controls (i1), generates control commands (16) to a servo motor (4) comprised in the servo system, which servo sys-

tem carries out or assists in the aiming of the barrelled weapon, and, in addition, that can be fired with ammunition (32) that can be transferred from an automatic loading system (29) associated with the barrelled weapon, **characterized in that** it is arranged to utilize parameter information (i2, i3, i4, i5) emanating from the automatic loading system and/or produced previously, which information is representative of a force (F) interfering with the aiming of the weapon (1) and caused by the automatic loading system (29), and **in that** it is arranged, by means of the parameter information, to produce a command (i6) to the servo motor that essentially or completely eliminates the said force.

2. An arrangement according to Claim 1, **characterized in that** the automatic loading system (29) is completely or partially attached to the barrelled weapon (27) at its rear parts (27a) and **in that** the interfering force (F) causes a moment (M) around the centre plate bearing axis (28) of the barrelled weapon in connection with the activation of the automatic loading system (29), and **in that**, upon activation, by means of the parameter information, the unit (22) initiates a moment command (i6) that can be fed to the servo circuit.

3. An arrangement according to Claim 1 or 2, **characterized in that** the parameter information is completely or partially related to a propulsion motor (31) comprised in the automatic loading system.

4. An arrangement according to Claim 3, **characterized in that** parameter information comprises or consists of a voltage arising in the feeding motor upon firing.

5. An arrangement according to Claim 3 or 4, **characterized in that** the parameter information comprises or consists of a current arising in the feeding motor upon firing.

6. An arrangement according to Claim 3, 4 or 5, **characterized in that** the parameter information comprises or consists of information relating to the speed of the propulsion motor during one or more stages of the firing.

7. An arrangement according to any one of Claims 3-6, **characterized in that** the parameter information comprises or consists of load and/or logic functions sent to the propulsion motor in the barrelled weapon and the automatic loading system.

8. An arrangement according to any one of Claims 3-7, **characterized in that** the parameter information comprises or consists of data obtained by experience in tests and varying experiences of behaviour during the use of the automatic loading system.

9. An arrangement according to any one of Claims 3-8, **characterized in that** the automatic loading system is located and attached at the rear and lower parts (27a) of the barrelled weapon and **in that** the supply of ammunition is carried out by means of one or more ammunition belts (30) driven by the propulsion motor.

10. An arrangement according to any one of Claims 1-9, **characterized in that** the comparison in the servo circuit is based on detection of angular velocity or angle size.

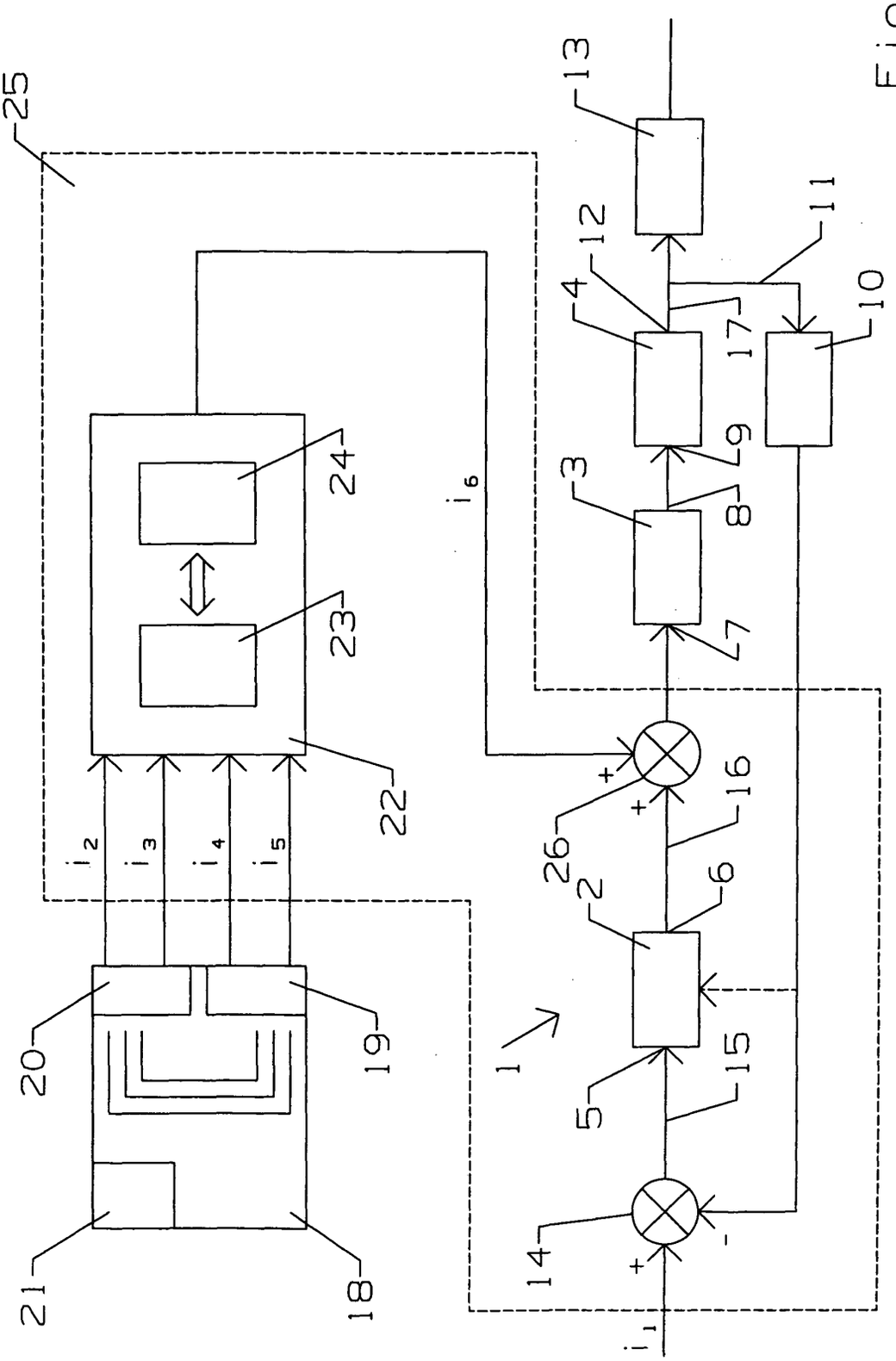
11. An arrangement according to any one of Claims 1-10, **characterized in that** a unit (22) is comprised in or constitutes part of a barrelled weapon system that comprises barrelled weapon, turret arrangement for the barrelled weapon and aiming and firing system for the barrelled weapon.

12. An arrangement according to any one of the preceding claims, **characterized in that** servo system comprises a first circuit (2) with servo amplifier and filter which, in response to the received desired value, produces a moment command that is sent to the servo motor (4), a second circuit (3) with motor control with filter and acting as a power amplifier which, in response to the commanded value and to the moment command (16) produced by the arrangement or unit (22), controls the loaded servo motor (4) which thereby produces an angular velocity (17) that can be sent to the barrelled weapon, and **in that** an angular velocity detecting device, for example a gyro (10), is comprised in a feedback circuit (11) that feeds back information about the angular velocity or actual value to the input of the first circuit (2).

13. An arrangement according to Claim 12, **characterized in that** the unit is computer-based and estimates, using the said parameter information, the moment control (M) in the servo system (1).

14. An arrangement according to any one of Claims 1-11, **characterized in that** it comprises a part (25), implemented by the barrelled weapon's own computer function, arranged to receive or extract parameter information from the automatic loading system and/or from the barrelled weapon's computer function, the barrelled weapon's own computer function comprising bus(es), computer(s), memory/memories, by means of which the computer function carries out the barrelled weapon control, and carries out analyses and simulations, etc., upon which the interference reduction or interference elimination can be based.

15. An arrangement according to Claim 14, **characterized in that** the part (25) comprises parameter-receiving circuit or circuits and circuit (2) or circuits with servo amplifier and filter, and **in that** the circuits can function together with the automatic loading system (18) and circuits (3, 4) for motor control with filter/power amplifier and servo motor.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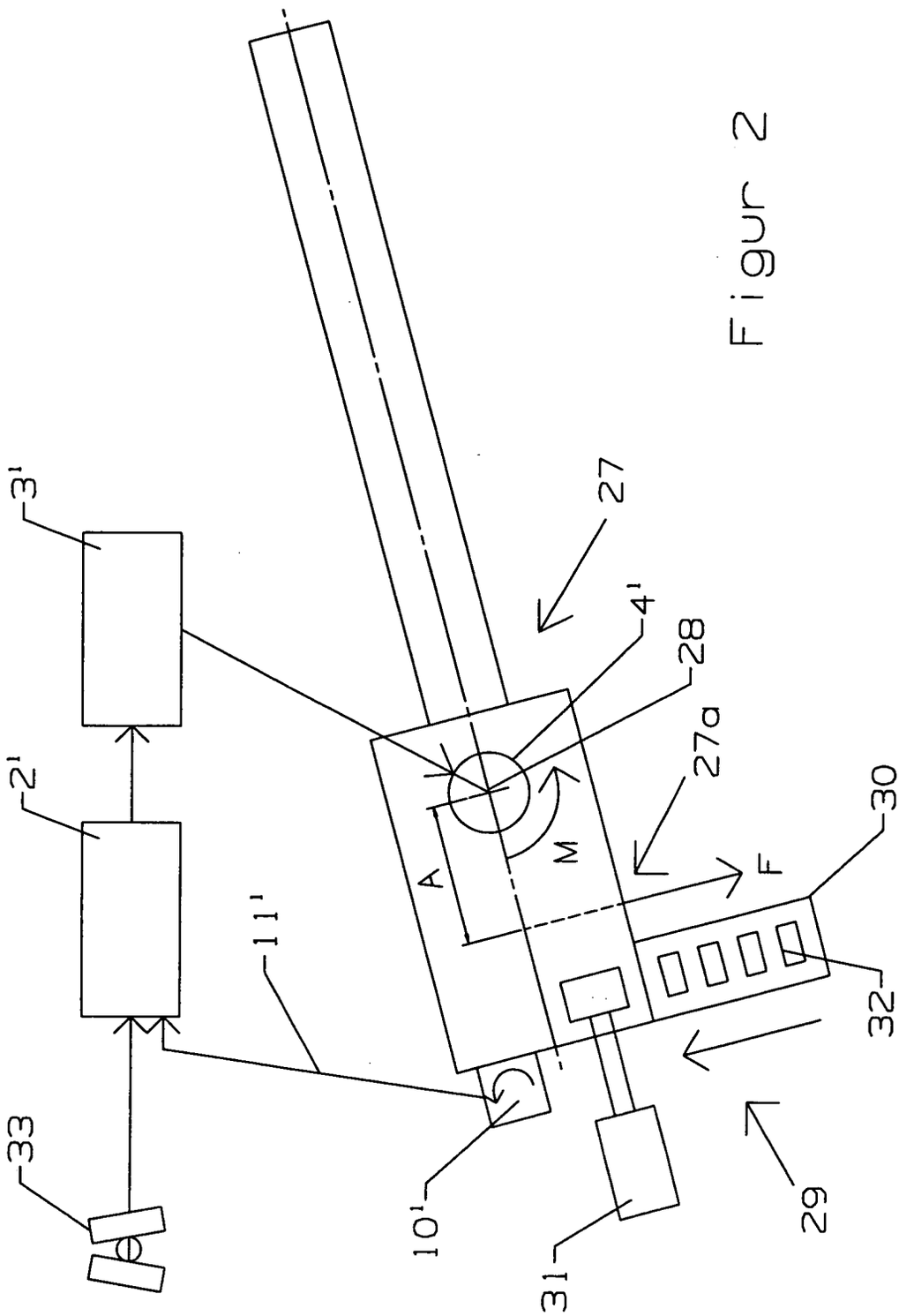
Figur 1



Figur 2

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 04 44 5023

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TECHNICAL FIELDS SEARCHED (Int.Cl.7)

F41G

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	10 June 2004	Blondel, F

CATEGORY OF CITED DOCUMENTS

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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 04 44 5023

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