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### (54) FLYWHEELSTARTER/GENERATOR FOR I.C.-ENGINES

SCHWUNGRADSTARTER/GENERATOR

MOTEUR-DEMARREUR-VOLANT POUR MOTEURS A COMBUSTION INTERNE

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(56) References cited:  
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• **PATENT ABSTRACTS OF JAPAN vol. 006, no. 267  
(M-182), 25 December 1982 (1982-12-25) & JP 57  
159956 A (NISSAN JIDOSHA KK), 2 October 1982  
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## Description

**[0001]** This invention relates to an electric machine which may act as a (flywheel)-starter-motor, and/or a generator for internal-combustion-engines (called i.c.en-gines or engines hereafter). A planetary gear/brake/clutch arrangement offers two gear-speeds and a free-wheel. Thanks to the freewheel-mode, the machine may be permanently connected to the i.c.engine and is therefore perfectly suited for turbo-compounding, offering a fast shaft to combine a exhaust-turbine with a, preferably, non-turbo compressor. The invention moreover relates to the various practical forms, matching control-devices and auxiliaries which enable the machine to be used in a number of different applications. The electric configuration of the machines used, may differ, depending on the application.

**[0002]** On itself the use of flywheels for starting must be considered as public domain, in W. W.II (hand-driven) flywheels where used for starting aeroplane-engines. For car-starting, patent PCT/NL88/00044 of this author, has many of the features claimed in this patent in common. PCT/NL88/00044 however, describes a double-rotating electrical machine of which the outer-rotor and the inner-rotor are interconnected by the members of a planetary gear. The machine acts as an Electric Differential Torque Converter (called E.D.T.C. hereafter) and the patent describes a number of applications for this machine among which a starter/generator for cars. As turbo-compressors have a narrow speed-bandwidth, the E.D.T.C.'s main-function in PCT/NL88/00044 is to provide a fast turbo-shaft at more or less constant speed to compensate for the constantly alternating speed of car-engines. The fast shaft in the current patent application offers no constant speed and is therefore better suited for non-turbo compressors.

**[0003]** In spite of its common features like the use of a flywheel and a planetary gear, the machine described here is no torque converter, and as a starter/generator much more straight-forward and more flexible. For the purposes described here, this invention is therefore much better suited, as the E.D.T.C. is unnecessary heavy, complicated and expensive. Even in its most basic form, the E.D.T.C. involves an extra set of heavy bearings, a complicated commutation system, a double tacho-system, an inverter and a microprocessor.

**[0004]** Moreover, although with the outer-rotor blocked the E.D.T.C may start as a conventional starter, the system is inefficient as a flywheelstarter. Because of its construction, with the planetary gear integrated in the electrical machine, the E.D.T.C. has no possibility of a free-wheeling flywheel. Instead, to spin up the flywheel/outer-rotor, the inner-rotor has to rotate in the opposite direction. As the speed of the inner-rotor will be at least 3 times that of the flywheel, the inner-rotor and the sun-wheel quickly reach their upper speed-limit, severely limiting the maximum speed of the flywheel. Therefore said flywheel must be bulky to compensate for its low speed.

Also, as the highspeed inner-rotor has considerable inertia, this energy has to be compensated for in the flywheel as it counteracts to the flywheel-movement and its energy will subtract from that of the flywheel once both rotors are connected to the friction-disk.

**[0005]** The E.D.T.C. has no two-speed provision, neither in motor- nor in generator-mode. Also, no practical solution is presented in PCT/NL88/00044 for establishing the need for a flywheel-start on the basis of engine-temperature and/or battery-condition.

As for turbine/compressor operation: Lacking a free-wheeling flywheel, the E.D.T.C. is unable to effectively preserve kinetic energy for the compressor to close the so called "turbine-gap" at low engine-speeds.

**[0006]** The invention provides for an electric machine, according to the features of claim 1.

**[0007]** Unlike the E.D.T.C, the current machine can feed high amounts of surplus turbine power back directly to the crankshaft, independent of powering of the inverter or the electrical machine. With the E.D.T.C, inverter-power and the power of the electrical machine will be considerably higher than necessary for starting alone, like in this patent, as it has to be proportional to the turbine-power handled.

**[0008]** Fig 1 shows the basic arrangement of the machine ( 101 ) where one side of the rotor is connected to sun-wheel ( 104 ) of a planetary gear ( 105 ) and the other side of said rotor is connected to flywheel (102). The ring-wheel (109) of said planetary gear is connected to a brake, preferably of the tape and drum type in which case said ringwheel preferably is encased in a oilcooled drum (112) around which the braketape (110) is positioned. A servomotor, spindlemotor, or solenoid (111) acts upon said braketape. The free running mode permits the accumulation of kinetic energy in said flywheel, while in brake mode said energy may be released, more or less gradually, to start the engine c.q. permitting a conventional direct start when totally blocked.

**[0009]** The outgoing shaft of said planetary gear is connected to planetcarrier (106) and the other side of said shaft is connected to the engine, be it directly or using the usual "Bendix" starter-construction of a splined sheath (113) and solenoid (114) arrangement, moving gear (107) into contact with engine-flywheel (108).

**[0010]** A similar planetary gear/ flywheel construction is used in a re-starting device for automobiles by Nissan Motor Co as described in the Japanese publication no 57159956. The planetary gear is connected to an alternator here and utilises the energy of a running motor, collecting it in the flywheel at the time of deceleration. The outputshaft is connected to the ringwheel instead of the planetcarrier and two electric brakedisks are utilised to manipulate the respective parts of the planetary gear. Said output shaft is connected to a separate starter. Thus said invention involves two separate machines and no provision is made for a cold start and / or the accumulation of flywheel-energy by the starter itself Also, no testing of the battery condition is involved and no provision is made

for different gearratio's as described furtheron in this application.

**[0011]** Fig. 2 shows a construction for the manual operation of the flywheel-starter. Ringwheel-brake (201) is operated using spring (202) and lever (203) whether or not using a bowden-cable. Spring (202) is situated around rod (205) and may, in rest, permanently engage or disengage said brake, depending on the application. Handle (209), acting on lever (203), has a switch (207) connected to it, to activate the starter and eventual glow-plugs. Springloaded securing-pin (206), keeping handle (209) in place once pulled, may be either manually operated or by a solenoid, activated by a centrifugal-switch at max. r.p.m.

**[0012]** As a flywheel-starter-motor the device is very well suited for use with Diesel-engines. Especially at low ambient temperatures these engines demand very heavy starter-motors and big batteries in order to compensate for the combined effects of reduced battery-capacity, low engine-temperature and lower compression-end-temperatures associated with freezing conditions. By storing kinetic energy, discharging the battery with relative low current over a longer period, the device is able to start the i.c.engine immediately. The advantages are clear: Installed battery-capacity may be minimal and is applied much more favourably, while peak-currents are reduced. The latter is especially important with semi-conductor controlled machines i.e. permanent-magnet machines.

**[0013]** Fig. 3A shows a simple electric circuit for Diesel-engines with traditional manually activated glowplugs. (Dashboard-)switch (301) activates solenoid/startrelays (302) which in turn activates startermotor (303). In rest, contact (305) of relays (304) connects said starter in series with glowplugs (306) with may have a parallel or a series-parallel arrangement and act as current limitter for said starter in order to prevent a to rapid spin-up.

**[0014]** For actual starting said glowplugs are shortcut by contact (305), coming in when switch (307) activates relays (304). A second contact on said relays activates brake-servo (308) blocking the ringwheel-brake. Full electric power is now fed to the starter and, combined with the flywheel energy, applied to the engine. It may be clear this results, even in extreme cold conditions, in a net start-torque which would normally not even be available at optimum conditions.

**[0015]** As the engine temperature on itself is a reliable indicator for the need of a flywheelstart, the machines control-electronics can be easily incorporated in existing temperature-based automatic diesel startcircuits, whether or not with a fixed preglow-timing.

**[0016]** Fig. 3B shows a electronic circuit with a more refined automatic startmode-selector. Beside engine temperature, battery-condition is tested here as well, both indirectly however. This makes the circuit very well suited for critical applications like emergency-power-generators etc. where battery-condition may be affected by long off-duty-cycles. The circuit is shown here in spin-

up mode.

**[0017]** Primarily, the engine is started in a direct mode. When relays/solenoid (328) comes in, (closing the integrated switch (328) ) the starter and amplifier (321) are powered up. Said amplifier feeds relays (320), closing contacts (320) one of which shortcuts series-connected glowplugs (331). Brake servo (329) comes in and a direct start follows. This start-attempt may be aborted directly or after some revolutions, when the voltage-drop of the battery (330) is to big. As the internal resistance of the battery increases if its (charge-)condition decreases and temperature drops, this comes to expression as a resulting voltage-drop once the battery is heavily loaded, i.e. during the direct-start-mode of a cold engine. As a result of this voltage-drop condenser (323), initially charged under no-load-conditions using (324) and (325), is discharged by circuit (326) and (327), until the voltage drops under the threshold-level of zener (322). Amplifier (321) is now blocked, brake-servo (329) is disengaged and glowplugs (331) series-connected with the starter. This results in a low-current spin-up/preglow period during which the battery-voltage recovers and condenser (323) is gradually charged again, the timing of which depending on battery condition and the values of (325), (323) and (322). Once the voltage over (323) rises again above said threshold, a direct start is once again initiated, now combining the energy accumulated in the flywheel.

**[0018]** Fig. 3C shows a circuit where engine temperature is measured directly, using thermistor (350) and temperature meter (352), already in place in most vehicle-dashboards. Again the circuit is shown in spinup mode. As condenser (353) is only charged via (355) when dashboardswitch (351) is closed, the starter always spins up before starting. The timing before a direct start takes

place, now depends on the value of condenser (353) and the actual, temperature based, value of thermistor (350). **[0019]** It may be clear that the principles used in fig. 3b and 3c allows for variations depending on the application. One example is for use with gasoline-engines where sparkplug-energy may drop to low levels under adverse conditions. As no (current limiting) preglowing takes place, energy accumulates very rapidly in the flywheel. Starting eventually may be pure mechanical, preserving all battery-power for the sparkplugs.

**[0020]** In all circuits described here a centrifugal switch (not shown here except for 407 in fig. 4) may switch off the machine when maximum flywheel-speed is reached. As at this point the battery-voltage very rapidly recovers, a direct start follows almost immediately. With conventional DC-series-motors its increasing impedance with rising r.p.m. (allowing battery-voltage to recover) may offer another reference. The machine may be switched to direct-mode once the (decreasing) voltage over the sparkplugs reach a given value.

**[0021]** For manually operated ringwheel brakes a modification of figure 3b or 3c may be used. Fig. 4a shows shows the relevant part in common. The circuit is shown in the situation where relays (401) is deactivated because

of low battery-voltage and its restcontact activates lamp (403). This is a signal to deactivate the ringwheelbrake thereby closing switch (405). When relays( 40)1 comes in again, buzzer (405) sounds as a signal to engage the ringwheelbrake.

**[0022]** Fig. 4b shows a tacho-circuit to control the ring-wheelbrake-tension. Tacho (420) may be placed to the teeth of the engine-flywheel and its output, rectified by (421), used to control amp. (422) feeding brake-solenoid (423), or a servo- or spindlemotor. As shown, the amplifier delivers full power to said solenoid until, with increasing engine-speed, the tacho-output exceeds the zener-threshold and reduces the power to the solenoid. Alternatively the amplifier may feed a spindlemotor and/or the tacho may be placed on the starter. The spindle-motor overcomes a spring-load and pulse the tape with a tacho-regulated force.

**[0023]** In fig. 5 said spindlemotor (501) is shown in a double-function. From its freewheel-middle-position it may act either for the ringwheel-brake or for a tacho-controlled locking device, locking the ringwheel and the planet-carrier of the planetary gear. Using a bowden-cable (502) the spindlemotor can pull a flanged pin (503) through hollow outputshaft (504) against spring (505). Secured to the other end of said pin, through slots in said outputshaft, is the actual locking device (506), fitting in a blank space in the flange of brakedrum (508) when pulled to the left. When the bowden-cable releases, spring (505) pushes (506) back to the right decoupling said gears. The locking construction is very similar to those used for planetary bicycle gearings, and it may be clear that well-known alternative constructions may be used as well, for example using plate-couplings, to achieve the same result. The resulting two-speed-plus-freewheel machine may be used as a starter/generator and directly coupled to the engine. The two-step gearing allows for high generator-output at all engine speeds and the machine may act as a temporary power booster for extra acceleration by going into motor-mode.

**[0024]** It may be clear that for starter/generator use, preferably brushless machines should be used, ideally with permanent magnets. To overcome the drawback of to high centrifugal forces acting on said magnets the machine may be inverse built. In that case, extra flywheel-mass may be added to the (outward) rotor.

**[0025]** Using a two-quadrant inverter, the machine, due to its fast shaft and flexible coupling to the engine, is perfectly suited for turbo-compounding, feeding surplus exhaust-energy from the engine back to its crank-shaft. Fig 6 shows a diagram for this, where machine (601) whether or not using extra step-up gears or a coupling (602) is connected to turbine (603) and a (preferably) non-turbo compressor (604). The use of non-turbo compressor (like Wankel, Roots- and Velox-blowers) have the advantage of a more linear yield and lower speed. By feeding exhaust-energy back to the crank-shaft, motor-efficiency may be increased by up to 15 % while the sustained compressor may increase specific

power up to 35 % and more over the total bandwidth.

**[0026]** For cars, a problem with direct coupled turbo's lies in the sudden big speed variations while shifting gears. Using multiple tacho's combined with car-management-information like from clutch and accelerator-pedals, a micro-controller, not shown here, is fully able to coordinate the machines gearshifting and inverter-mode with turbo-, compressor- and engine-management whether or not in combination with servo-controlled compressor-input-restrictions and/or wastegates. Therefore, with sudden engine-speed variations the machine immediately goes into freewheel-mode during which the machines flywheel preserves power for the compressor, curing the dreaded turbo-gap by maintaining high compressor yield. In this freewheel-mode the machine may sustain or even increase compressor-speed by going into electric motor-mode. A very fast compressor-acceleration may further be achieved mechanically, by using the machine's first gear with the brake in slip-mode.

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## Claims

1. Electric machine for starting an internal combustion engine, the device comprising an electric motor [101] and the rotor of said electric motor being directly connected to a flywheel [102] and to the sunwheel [104] of a planetary gear [105], the device further comprising an outgoing shaft connected to said planetary gear, whereby said shaft is configured to be connected to the internal combustion engine.
2. Electric machine according to the previous claim where the outgoing shaft of said planetary gear is connected to its planetcarrier (106) and the other side of said shaft is connected to the engine, be it directly or using the usual starter-construction of a splined sheath and solenoid arrangement moving a gear into contact with the engine-flywheel (108).
3. Electric machine according to the previous claims where the ringwheel (109) of said planetary gear is connected to a brake, preferably of the tape and drum type which, in free running mode, may permit the accumulation of kinetic energy in said flywheel (102), while in brake mode said energy may be released to start said engine c.q. permits a conventional direct-start.
4. Electric machine according to one or more of the preceding claims, further comprising an electric circuit, where, for diesel-engines, in order to limit the power-built-up in said flywheel (102) during spin-up, said machine may be connected in series with a series-, parallel-, or series-parallel-arrangement of the glowplugs of said engine.
5. Electric machine according to one or more of the

- preceding claims, further comprising an electronic circuit, where, in order to establish the necessity for a flywheelstart and its eventual spin-up time and, for diesels, the preglow-time, engine-temperature and/or the voltage-drop of the battery is measured the latter during the first revolutions of a direct start of said engine, preferably using a series-switched zener-diode forming a threshold beneath which said brake is deactivated for spin-up of said flywheel.
6. Electric machine, according to the preceding claim where, for timing, a condenser is charged and/or discharged by a circuit of two anti-parallel diodes, both connected to the battery via series-resistors, whereby the value of the discharge resistor is chosen to allow for at least several revolutions of said engine during the initial direct start, and the value of the charge resistor is chosen to allow for sufficient spin-up time for said flywheel.
7. Electric machine according to one or more of the preceding claims where, for a double-function as generator said machines is, more or less directly, coupled to (the crankshaft of) said engine and the servo-system allows for a fixation of at least two elements of said planetary gear, together with previous measures allowing for a two-speed plus freewheel-mode.
8. Electric machine according to one or more of the preceding claims where the electric motor of said machine may be inversely built and flywheel-mass added to said rotor.
9. Electric machine according to any of the preceding claims, **characterized in that** means are provided for connecting, directly or indirectly, by means of a gear or a clearance means and/or a coupling [602], the rotor of said electric motor to one or more turbine(s) [603] and/or one or more compressor(s) [604] said compressors preferably being of the non-turbo type.
10. Electric machine according to one or more of the preceding claims, **characterized in that** a control system is provided by means of which the operation of a brake of the ring wheel [109] can take place on the basis of tacho information or information regarding the coupling, the brake or the accelerator pedal, in such a way, that sudden (expected) changes of the engine-speed results in a freewheel-mode of said machine during which a two-quadrant inverter may go into generator or motor-mode to control or boost said flywheel-speed and/or said machine may be forced into a slipping first-gear mode to mechanically boost said flywheel-speed in all cases with or without eventual compressor(s) or turbine(s) attached and/or engaged.

## Patentansprüche

1. Vorrichtung zum Starten von Verbrennungsmotoren, **dadurch gekennzeichnet, dass** die Vorrichtung einen Elektromotor enthält und die Rotorwelle der erwähnten Elektromotor, mit einem Schwungrad und mit dem Sonnenrad eines Planetengetriebes direkt verbunden ist, und die Ausgang Welle des besagten planetarischen Zahnrades konfiguriert ist um an die Verbrennungsmotor angeschlossen zu werden..
2. Vorrichtung entsprechend vorhergehendem Anspruch, in dem die abgehende Welle des genannten Planetengetriebes an einer Seite mit dem Planetenradträger verbunden ist, während die andere Seite der erwähnten Welle mehr oder weniger direkt, in permanenter Verbindung mit der Kurbenwelle des Verbrennungsmotors ist, oder mit der für Startmotoren gebrauchlichen Bendixkonstruktion versehen ist, die, mittels eines Solenoids, ein Zahnrad mit dass Schwungrad des gemeinten Motors im Verbindung bringt.
3. Vorrichtung entsprechend vorhergehenden Ansprüchen, in denen das Hohlrad des genannten Zahnradsystems in einer Bremstrommel eingefasst ist, wobei im Leerlaufmodus, die Speicherung der kinetischen Energie in besagtem Schwungrad ermöglicht ist, während im gesagten Bremsmodus ein normaler Direct-start ermöglicht bzw Energie wird freigegeben für ein Schwungradstartmodus.
4. Vorrichtung entsprechend vorhergehenden Ansprüchen, in denen ein elektrische Schaltung zugunsten eines Schwungradstartmotors für Dieselmotoren, **dadurch gekennzeichnet ist, dass** die erwähnte Maschine dass Schwungrad während einer eventuellen Vorglühperiode hochdreht, in der die elektrischen Leistung der gemeinten Maschine begrenzt wird durch, auf einerlei Weise geschalteten, mit der Maschine aber seriell geschalteten Glühkerzen, die vor dem tatsächlichen Start kurzgeschlossen werden.
5. Vorrichtung entsprechend vorhergehenden Ansprüchen, in denen ein elektrische Schaltung zugunsten eines Schwungradstartmotors **dadurch gekennzeichnet ist, dass** die Feststellung der Notwendigkeit zum Schwungradstart und die Länge einer eventuellen Vorglüh- oder Hochdrehperiode, **dadurch** stattfindet, dass während eines direkten Starts der Komplex der Startfaktoren, in Kombination mit der Temperatur des Motors oder nicht, und Batteriekondition festgestellt wird mittels einer Registrierung des Spannungsverfalls über dem innerlichen Widerstand der Startbatterie, und vorzugsweise einer in Reihe geschalteten Zener-diode, die eine Schwelle

- bildet, worunter die besagte Bremse entaktiviert wird für dass Hochdrehen des besagten Schwungrades.
6. Vorrichtung entsprechend vorhergehenden Ansprüchen, in denen ein elektrische Schaltung **dadurch gekennzeichnet ist, dass** zur Registrierung des gemeinten Spannungsverfalls, während des erwähnten direkten Starts, mittels eines Widerstandes und einer Diode, einen anfänglich geladenen Kondensator bis zur aktuellen Spannungsebene der Batterie entladen wird, wobei der direkte Start zugunsten einer eventuellen Vorglüh- oder Hochdrehperiode abgebrochen wird, wenn die erwähnte Spannungsebene bis unter einem gegebenen Schwellenwert sinkt, wonach eine eventuelle Wiederherstellungszeit bis über dem erwähnten Wert maßgebend für die Länge der gemeinten Hochdrehperiode ist.
7. Vorrichtung entsprechend vorhergehenden Ansprüchen, in denen, für eine Doppelfunction als Generator, besagte Maschine, mehr oder weniger direkt, verbunden ist mit der Kurbelwelle von genannten Verbrennungsmotor und wobei das Servosystem mittels eine Fixierung von mindestens zwei Elementen des genannten planetarischen Zahnrades, zusammen mit vorhergehenden Massnahmen zwei Getriebeverhältnisse und ein Freilaufmodus entsteht.
8. Vorrichtung entsprechend vorhergehenden Ansprüchen **dadurch gekennzeichnet, dass** der Elektromotor von gemeinte elektrische Maschine invers ausgeführt werden kann und extra Schwungradmasse am Aussenrotor zugeführt werden kann.
9. Vorrichtung entsprechend vorhergehenden Ansprüchen, in denen der Rotor der genannten Elektromotors, ob oder nicht mit extra Zahnrädern oder Kupplungen, an eine oder mehrere Abgasturbinen und/oder einen oder mehrere Kompressoren ange schlossen wird.
10. Vorrichtung entsprechend vorhergehenden Ansprüchen, in denen ein Steuersystem für die elektrische Maschine wobei, auf Grund von Tachoinformation oder die Informationen die Kupplung, die Bremse oder das Gaspedal betreffend, plötzliche (erwartete) Änderungen der Verbrennungsmotor-drehzahl einen Freilaufmodus der genannten Maschine ergibt, während dessen ein Zweiquadrant Inverter in den Generator oder in Motormodus einsteigen kann, zum Steuerung der genannten Schwungrad-drehzahl und/oder der genannten Maschine in einem gleitenen Erstgangmodus gezwungen werden kann, um besagtes Schwungrad mechanisch aufzuladen, in allen Fällen mit oder ohne etwaige Kompressoren oder Turbinen verbunden und/oder engagiert.
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- Revendications**
- Dispositif de mise en marche d'un moteur à combustion interne comportant un moteur électrique dont le rotor est directement relié à un volant d'inertie et au soleil d'un train épicycloidal, le dispositif comportant une axe de sortie relié à ladite train épicycloidal, ledit axe soit configuré pour être relié au moteur à combustion interne.
  - Dispositif selon la revendication 1 ci-dessus où l'axe de sortie solidaire du porte-satellites est relié au moteur à combustion interne, que ce soit directement ou en utilisant une construction habituelle selon laquelle un solénoïde met en prise avec la couronne dentée du volant du moteur à combustion interne un lanceur coulissant sur un arbre cannelé.
  - Dispositif selon les revendications 1 et 2 ci-dessus où la couronne extérieure du train épicycloidal est reliée à un frein, de préférence à bande sur tambour qui, en position desserrée permet l'accumulation d'énergie cinétique par le volant d'inertie, alors qu'en position serrée l'énergie cinétique du volant est communiquée au lanceur permettant le démarrage du moteur à combustion interne.
  - Dispositif selon un ou plusieurs des revendications précédentes, comportant en outre une circuit électrique d'alimentation, mettant à profit, en vue de limiter la consommation électrique de ladite machine dans le cas du moteur diesel, le branchement en série, ou en parallèle, ou en série-parallèle des bougies de préchauffage dudit moteur diesel.
  - Dispositif selon un ou plusieurs des revendications précédentes, comportant en outre un circuit électronique de contrôle où, en vue de déterminer la nécessité du lancement par inertie, le temps de mise en régime éventuel et dans le cas du moteur diesel le temps de préchauffage, on mesure la température du moteur à combustion interne et/ou la chute de tension de la batterie de démarrage, cette tension étant mesurée pendant les premiers instants du mouvement de rotation, de préférence au moyen d'une cascade de diodes "Zener" formant un seuil de tension en dessous duquel ledit frein est desserré pour accélérer le volant d'inertie.
  - Dispositif selon un ou plusieurs des revendications précédentes, comportant en outre un circuit électronique de contrôle où, pour définir l'unité de temps, un condensateur est chargé/déchargé au moyen de deux diodes anti-parallèles connectées toutes deux à la batterie de démarrage par des résistances en série, la résistance de décharge est choisie pour permettre au moins plusieurs tours dudit moteur thermique lors du démarrage, la résistance de charge

est choisie de façon à laisser au volant d'inertie un temps d'accélération suffisant.

7. Dispositif conforme aux revendications précédentes, mettant en oeuvre la double fonction de démarreur et générateur, ladite machine est entraîné plus ou moins directement par le vilebrequin du moteur à combustion interne et le servosystème tient compte d'une fixation au moins de deux éléments de ladite train épicycloidal, combiné avec des mesures précédentes, permettant le fonctionnement en deux vitesses et en roue libre. 5
8. Dispositif selon une ou plusieurs des revendications ci-dessus où, la moteur électrique de ladite machine peut être inversement construite et de la masse être ajoutée à ledit rotor. 15
9. Dispositif selon une ou plusieurs des revendications ci-dessus où le rotor de ladite machine électrique, utilisant ou pas des renvois ou embrayages, est connecté à un ou plusieurs turbine(s) et/ou avec un ou plusieurs compresseurs. 20
10. Dispositif selon une ou plusieurs des revendications ci-dessus, comportant en outre une système de régulation où tout (prévus) changement brusque de régime du moteur thermique sur la base de l'information de tacho ou l'information concernant l'accouplement, le frein ou la pédale d'accélérateur, provoque la mise en roue libre de ladite machine compensé par l'introduction d'une alimentation dite "two quadrant" permettant de contrôler ou de majorer la vitesse dudit volant d'inertie et/ou de forcer la transmission dans un régime glissant pour majorer la vitesse dudit volant d'inertie, dans tous les cas avec ou sans compresseur(s) ou turbine(s) relié et/ou engagés.. 25 30 35

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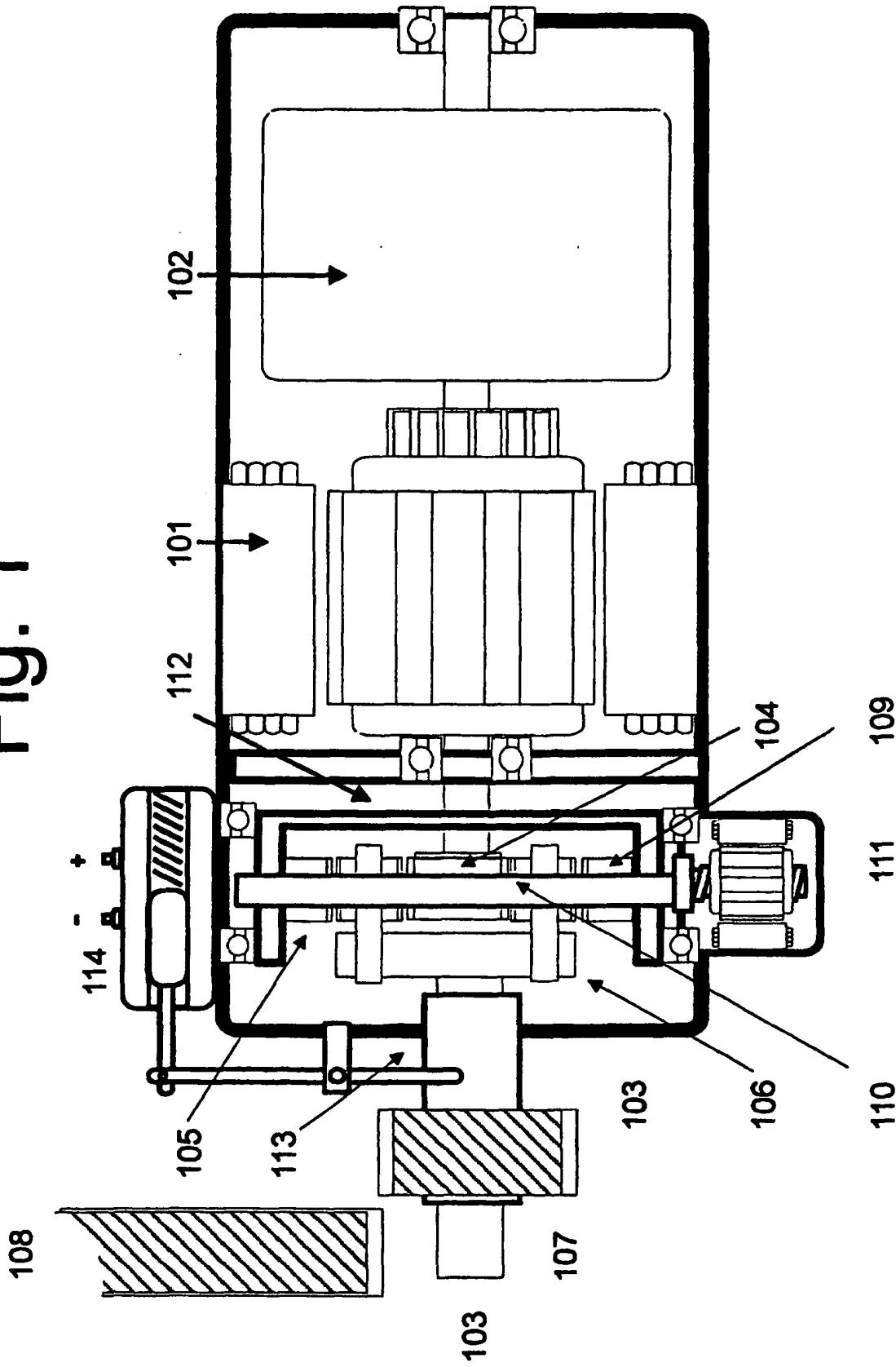
**Fig. 1**

FIG. 2

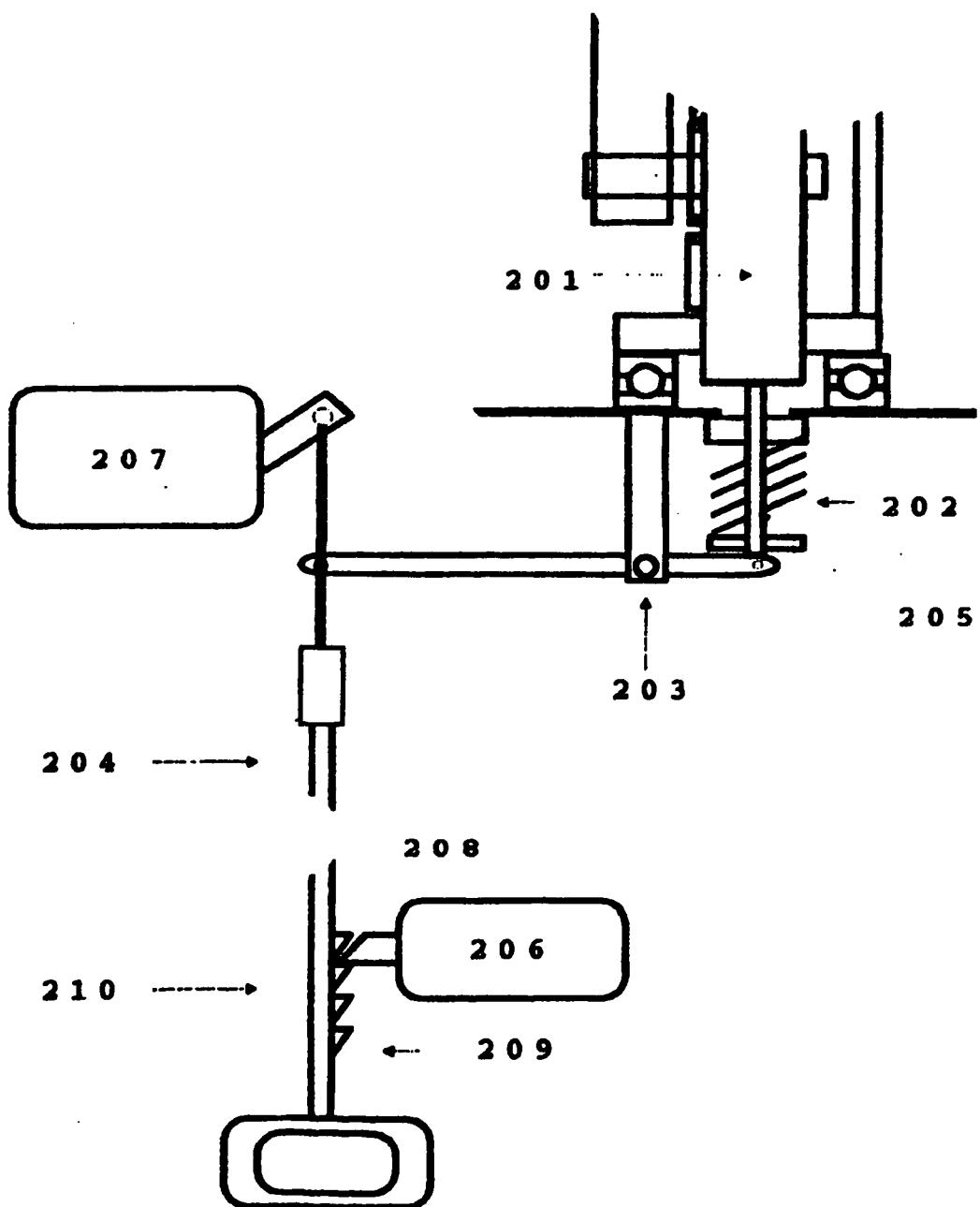


Fig. 3

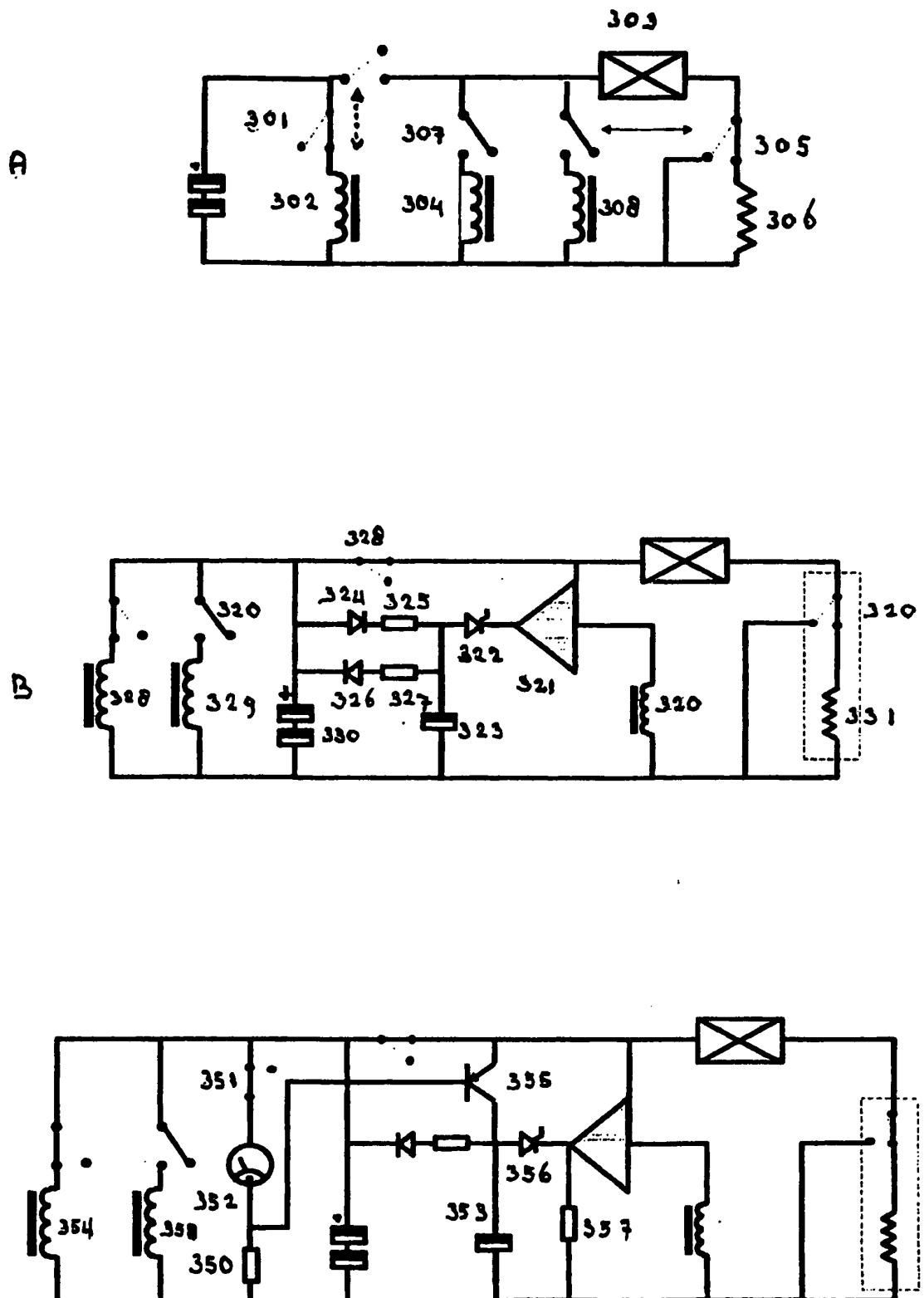
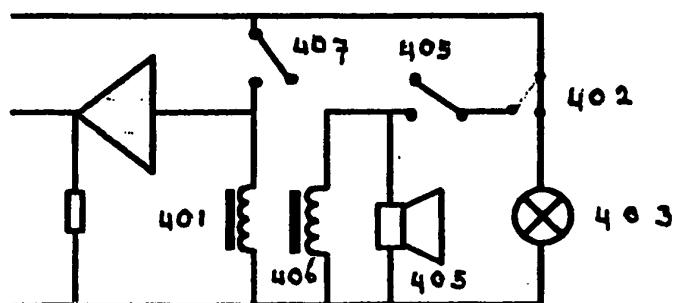


Fig. 4

A



B

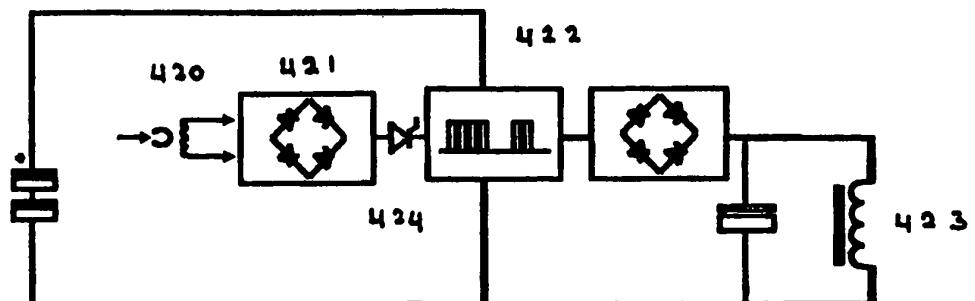
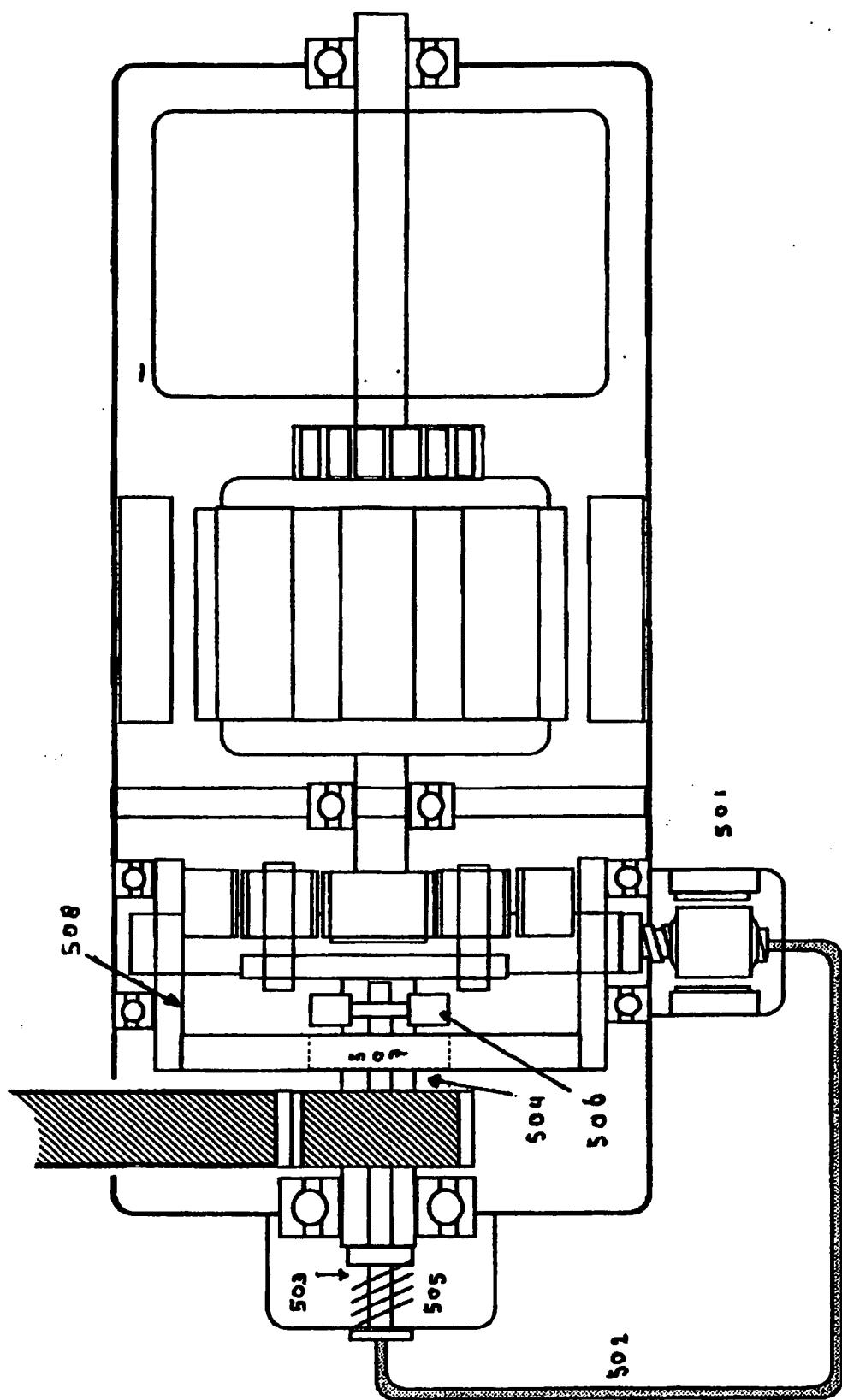


Fig. 5



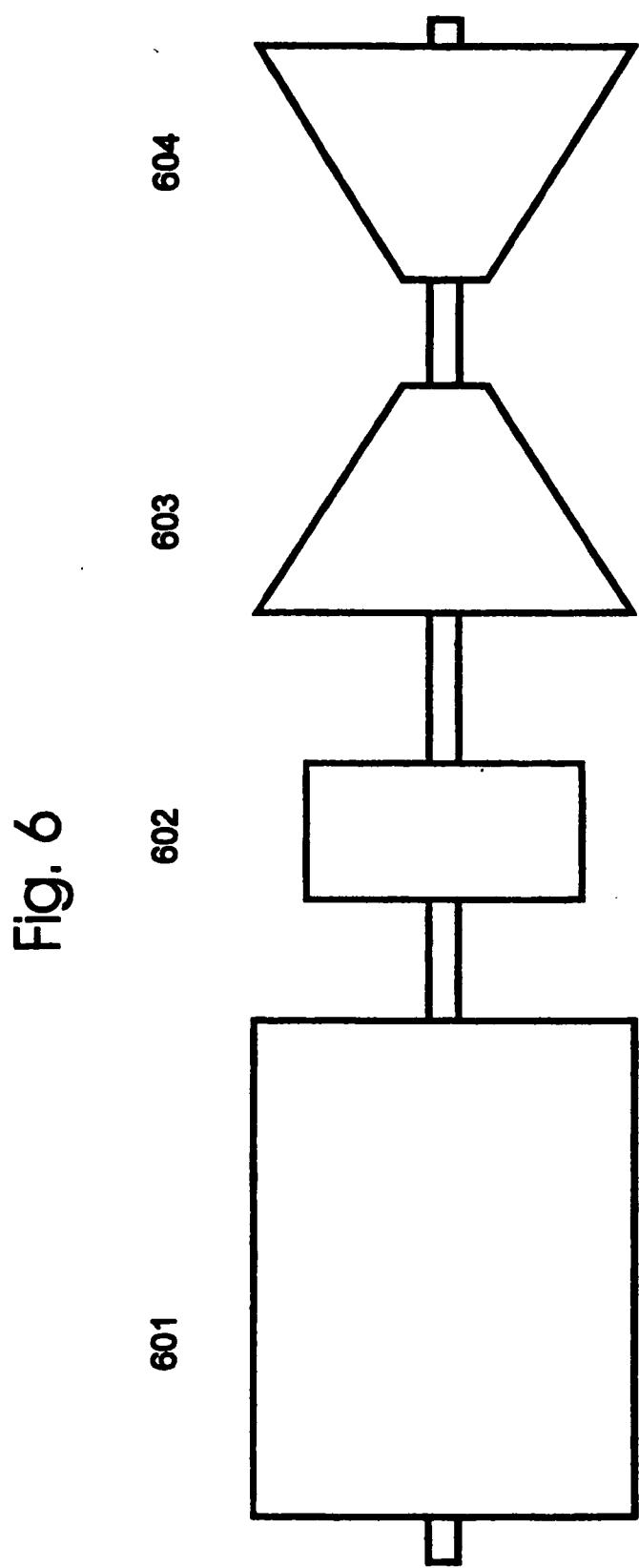


Fig. 6

**REFERENCES CITED IN THE DESCRIPTION**

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**Patent documents cited in the description**

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