

# PATENT SPECIFICATION

926,693

DRAWINGS ATTACHED.

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926,693



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## COMPLETE SPECIFICATION.

### Improvements in or relating to Vehicle Brake Systems.

We, HARRY FERGUSON RESEARCH LIMITED, of "Abbotswood", Stow-on-the-Wold, Gloucestershire, England, a British Company, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to motor vehicles and to means for controlling the brakes of such vehicles.

The invention is applicable to motor vehicles having a previously proposed transmission system (of a previously proposed type) of the type in which the engine power is transmitted not only to the rear road wheels but also to the front road wheels and in which a controlled intermediate differential gear is interposed between front and rear propeller shafts constituting components of the drive to the front road wheels on the one hand and the drive to the rear road wheels on the other hand, there being in said drives the customary differential gear between the rear road wheels and a corresponding differential gear between the front road wheels. A transmission system of this type will be referred to hereinafter and in the claims as a transmission system "of the type stated".

The term "controlled" as applied to the intermediate differential gear is used herein to indicate that means are provided for limiting the differential action of this gear; that is to say, each propeller shaft is permitted by the gear to differ in speed from the other propeller shaft only within predetermined higher and lower limits, the arrangement being such that full freedom for steering is allowed.

In a vehicle having a transmission system

of the type stated one may use inboard brakes applied to the half-shafts of the respective road wheels, although one could apply brakes to the wheels themselves. Moreover, by virtue of the controlled intermediate differential gear it is practicable to use a single rear brake applied to a component driven by the rear propeller shaft at the input side of the rear differential gear and to use separate front brakes applied to the front half-shafts of other driven components at the output sides of the front differential gear. In such a system the controlled intermediate differential gear positively prevents locking (with consequential skidding) of any one of the road wheels and of either pair of front road wheels or rear road wheels. On the other hand, a front wheel and either rear wheel might lock simultaneously and all wheels might tend to lock simultaneously, and such locking would be outside the control of the intermediate differential gear.

Now, in connection with the ground wheels of aircraft, there has been adopted in recent years the practice of incorporating in the brake mechanism a safety device developed by Dunlop Rubber Company Limited and known as the "Maxaret Anti-Skid Unit", (Maxaret being a Registered Trade Mark), and it has been proposed to apply a corresponding device to motor-driven road vehicles. As proposed for road vehicles, one such anti-skid unit is to be applied to each road wheel to be braked. Each unit includes a small flywheel which is driven by the road wheel. The unit also includes a spring which is in effect the spring component of a resilient coupling between the flywheel and the road wheel and which acts to decelerate the flywheel

in the event that the road wheel is decelerated, for instance by braking. The unit also includes what may be called an actuator; this actuator has hitherto consisted of a relief valve in a valve mechanism which is subjected to the action of the spring and which controls an hydraulic system. The arrangement is such that if the valve mechanism is operated, the valve opens against the spring action to relieve the brake pressure. If the deceleration of the wheel is normal during braking, the valve mechanism rests ineffective. However, should the deceleration be abnormal, indicating that the wheel is tending to lock under the brake action, the flywheel overcomes the spring and operates the valve mechanism, in which event the brake pressure is relieved and the relief is maintained until the wheel resumes a normal speed of rotation and the flywheel regains its normal positional relationship with wheel.

Although hitherto, as aforesaid, the actuator of the anti-skid unit has been a valve, it will be apparent that one might use instead an actuator devised to relieve the brake pressure by operation through means other than an hydraulic system.

An object of the present invention is to apply an anti-skid unit to a motor vehicle transmission system of the type stated in such a manner as to combine the advantages derived from the controlled differential gear with the advantages derived from the anti-skid unit.

The invention is a motor vehicle having a transmission system of the type stated in which an anti-skid unit including a flywheel and an actuator is driven by a rotary engine-driven component of the transmission system connected with the input component of the controlled intermediate differential gear, the actuator being operatively connected with the system by which the several brakes of the vehicle are applied and being devised to be moved by the flywheel to reduce the brake action in the event of abnormal deceleration of said rotary engine-driven component.

In a motor vehicle having a transmission system incorporating at least one anti-skid unit, conditions could be met under which the anti-skid unit may become effective prematurely. That is to say, in a motor vehicle having a transmission system of the type stated, the anti-skid unit might unnecessarily and undesirably forestall or over-rule the controlled differential gear.

Accordingly, another object of this invention is to make provision for automatically varying the magnitude of roadwheel deceleration at which the anti-skid unit will become effective under varying road surface conditions.

Examples of the invention are illustrated

with reference to the drawings accompanying our Provisional Specification No. 12206/59, in which:—

Fig. 1 shows alternative ways of applying an anti-skid unit to a transmission system of the type stated; and

Fig. 2 shows an automatic regulator applied to an anti-skid unit; and with reference to the accompanying drawings in which:—

Fig. 3 is a section of an anti-skid unit modified for incorporation in a transmission system of the type stated; and

Fig. 4 is a corresponding part-sectional view of a detail.

Referring to Fig. 1, there are represented conventionally therein the following parts:—

A unidirectional engine-driven shaft 11; driving gearwheels 12, 13 and 14; the controlled central differential of which the planet-carrier 15 is driven by the gear wheel 13 and the output gearwheels 16, 17 drive the front and rear propeller shafts 18, 19; the front and rear inter-wheel differential 20, 21; one-way free-wheel devices of which the over-running members 22, 23 are driven by the gearwheels 12, 14 whereas the running members 24, 25 are connected to and rotate with the shafts 18, 19. In the example, the brakes are shown as disc brakes 26 applied to the output members 27, 27 and 28, 28 of the front differential 20 and rear differential 21, respectively.

A foot pedal lever 30, of low mechanical advantage, is connected to an hydraulic system 31 for applying the brakes. The lever is connected to a servo-motor piston 32, the cylinder 33 of which is connected by a pipe 34, 35 to the suction system of the intake manifold of the engine.

In Fig. 1, the casing of the anti-skid unit is indicated by 40. Its internal flywheel (described later herein with reference to Fig. 3) has a resilient coupling with the engine-driven shaft 11, which is connected through the gearwheel 13 to the input member, namely the planet-carrier 15, for the controlled differential. The actuator of the unit is the usual relief valve, the housing of which is indicated by 41 and an example of which is described with reference to Fig. 2. This relief is interposed in the suction pipe 34, 35.

The arrangement is such that when the application of the brakes causes excessive deceleration of the shaft 11, the relief valve will be opened and the suction effect on the pedal lever 30 will be destroyed; and so this lever will come under merely the pressure of the driver's foot. Accordingly, the brake action will be greatly reduced and the tendency of one or more of the wheels to lock will be removed.

In Fig. 1 there is shown partly in dotted

lines an alternative arrangement using a foot pedal lever 50 of high mechanical advantage operable wholly by the driver's foot pressure and transmitting the brake action through a hydraulic system 51. The lever 50 is connected to the piston 52 of a normally inactive hydraulic servo motor, the cylinder 53 of which is connected by a pipe 54 to an oil pump 55. This pump is normally empty of oil and therefore disabled. The suction side of the pump is connected through pipes 56 and 57 with an oil sump. In this arrangement, the actuator of the anti-skid unit 40 is again a valve in the housing 41, and this valve is interposed between the pipes 56, 57 so that when the valve is opened oil is supplied to the pump 55. Thus, if the application of the brakes causes the shaft 11 to decelerate excessively, so that the valve of the unit is opened, the oil flow from the pump will set up in the cylinder 53 a pressure sufficient to weaken considerably the influence of the driver's foot pressure, so much so that the tendency of one or more of the wheels to lock will be removed.

The application of an anti-skid unit to a transmission system of the type stated has various advantages, notably the following:—

- (1) A single anti-skid unit serves all road wheels, as compared with four such units which would be required in the usual motor-driven road vehicle;
- (2) the unit, being embodied in the vehicle transmission, forms part of the sprung mass, so that the unsprung mass is not increased;
- (3) additional gearing is not essential to drive the unit, and such gearing would be expensive, noisy and endangered by dirt;
- (4) the unit is very easily protected against dirt and vibration.

Referring to Fig. 2, there is shown therein a stationary casing 60 of an anti-skid unit containing a rotary central drive shaft, to which the engine-driven transmission shaft 11 is connected. The casing 60 also contains the following parts:—a flywheel which has a resilient coupling with the drive shaft (the coupling being such that the flywheel can over-run the drive shaft); a cam device which whenever the flywheel is decelerated abnormally by excessive deceleration of the shaft 11 is operated to move the actuator, namely a valve, axially of the unit; and a compression spring under the action of which the flywheel decelerates and against the resistance of which the valve is opened. The central drive shaft, the flywheel, the cam device and the spring are not shown, being described hereinafter with reference to Figs. 3 and 4. The valve however is shown, being indicated by 61; and the valve rod on which the cam device works is indi-

cated by 62. The valve housing 63 is shown as having three available connections 64, 65 and 66, which would be used according to whether the unit is applied to a vacuum type servo system or a hydraulic type anti-servo system, these alternative systems being as described with reference to Fig. 1.

Thus, the connections 64 and 65 may have the air suction pipes 34 and 35 respectively connected to them, in which event the connection 66 is an opening to atmosphere. The arrangement is such that whenever, during braking, the unit becomes effective to open the valve 61, the connection 64 to this vacuum type servo-motor apparatus 32, 33 is opened to the atmosphere connection 64, so that the apparatus is temporarily disabled.

Alternatively, the connections 66 and 65 may have the pipes 56 and 57 respectively connected to them, in which event the connection 64 is plugged. This arrangement is such that whenever the unit becomes effective to open the valve 61, oil is supplied through the connections 65, 66 to the pump 55, so that the hydraulic unit 52, 53 will oppose the driver's foot action through the brake pedal 50.

The automatic regulator, which under appropriate conditions over-rides the anti-skid unit, is supported by a bracket 68 on the casing 60 of the unit. This regulator includes a rod 69 by which is an extension of the valve stem 62 and is movable in unison with the valve 61. The regulator includes another component, namely a pendulum 70 of appreciable mass, which is suspended by a lever 71 pivoted at 72 on the bracket 68. The top of this lever 71 is inter-engageable with a pin 73 at the end of the extension rod 69. Normally, when the unit is ineffective, the pendulum lever bears against a stop 74, which is an adjustable screw in the bracket 68; and there is left between the pin 73 and the lever top a working clearance gap 75 sufficient for effective opening of the valve 61. There is an opposite stop 76, which is also an adjustable screw and which serves to prevent swinging of the pendulum beyond a predetermined limit. The second stop 76 is screwed through a lug 77 in the bracket 68, and an initial setting spring 78, which is a compression spring, is interposed between the face of the lug 77 and the pendulum lever and which holds the lever normally against the first stop 74.

In operation of the unit, opening of the valve 61 by excessive deceleration of the engine-driven shaft 11 is effected against the opposition not only of the internal spring of the unit but also against whatever opposition may be set up by the inertia of the pendulum 70. The strength of this latter opposition is variable between zero and a

maximum, being dependent upon the rate of deceleration of the vehicle.

Where the road surface is good, giving good tyre adhesion, it is permissible to apply the brakes much more heavily than when the surface is poor, an extreme instance being when the surface is ice, when tyre adhesion will be very poor. Accordingly, it is desirable that under conditions of good tyre adhesion, the anti-skid unit shall be kept out of action, at least until the deceleration of the shaft 11 becomes greatly excessive, so that in effect the control against skidding will be confined mainly to the controlled central differential.

Assume therefore that the tyre adhesion conditions are good and that the brakes are applied so heavily that the deceleration of the shaft 11 is considerable. Under such conditions the anti-skid unit would come into action and relieve the brakes if no provision were made for over-ruling the unit. However, by virtue of the automatic regulator according to Fig 2, premature action of the anti-skid unit is prevented, as now to be explained. Because of the heavy but effective brake action, the vehicle itself decelerates at a high rate and the pendulum 70 swings forwards under its inertia, against the resistance of the spring 78 acting on the pendulum lever 71. The effect of this forward swing is to stiffen the customary spring of the anti-skid unit, so that the spring resistance to opening of the valve 61 of the unit is increased. It will be apparent that the various parts may be so devised that the anti-skid unit cannot come into action until after the central controlled differential has become effective to prevent locking of any one wheel, or of the front pair of wheels or the rear pair. In other words, the anti-skid unit is temporarily over-ruled, but is nevertheless set to come into action to prevent locking of both a front and a rear wheel or all four wheels.

Conversely, assume that the tyre adhesion conditions are extremely poor, so much so that comparatively light braking may tend to lock one or more of the road wheels. Assume also that the brakes are applied with sufficient pressure to lock one or more wheels. In this instance, the deceleration of the vehicle is so low that the pendulum 70 presses forwards very slightly, so much so that the pendulum adds practically nothing to the spring action against the valve 61. Accordingly, although the controlled central differential will prevent locking of any one road wheel or of the front pair of wheels or the rear pair, the anti-skid unit will be quickly effective to prevent locking of any two front and rear wheels or all four wheels.

It will be apparent that the regulator self-adjusts itself to conditions between the two

extremes described, namely conditions of good tyre-adhesion and conditions of extremely poor adhesion. In motor-vehicle transmission systems to which anti-skid units of the type stated have been applied, each unit has been devised to come into action and release the associated brake in the event that the deceleration exceeds approximately 1.5 g. ("g" being the magnitude of gravitational acceleration), a value suited only to good tyre-adhesion conditions. By virtue of the automatic regulator, an anti-skid unit can be set to come into action at so low a value as approximately 0.5 g. under poor adhesion condition, and the upper limit may still be as high as 1.5 g.

In the example according to Fig. 2, the automatic regulator is applied to an anti-skid unit incorporated in a transmission system of the type stated (as exemplified by Fig. 1) However, an automatic regulator can be applied to any anti-skid unit of the type stated as incorporated in any motor-vehicle transmission system, for instance a system of the type stated (as exemplified by to each roadwheel brake, in which event the shaft 11 of the unit is driven in unison with the roadwheel.

Referring to Figs. 3 and 4, the anti-skid unit therein shown includes a casing 80 (which corresponds with the casings 40 and 60, Figs. 1 and 2), a relief valve 81 with its stem 82 and a valve housing 83 provided on the casing 80. This housing 83 has connections 84, 85 and 86 (corresponding respectively to the connections 64, 65 and 66, Fig. 2).

The flywheel is indicated by 87; it is driven by an extension 11A of the engine-driven shaft 11. The spring of the resilient coupling of the anti-skid unit is indicated by 88. The valve 81 is the actuator of the anti-skid unit. The resilient coupling also includes an annular cam 90, which is formed with a cam-profiled face 91, and a pair of rollers 92 which are provided at the end of the extension 11A and which engage the face 91. The drive is transmitted from the shaft 11 through the rollers 92 to the face 95, of the cam 90, the coupling between the rollers and face being maintained by the spring 88, which re-acts against a rotary shell 93 and presses against the annular cam 90.

The rotary shell 93 is supported in bearings 94, 94 within the casing 80. A yoke 95 which is secured to the cam 90 has a central bearing 96, which receives the end of the valve stem 82. A light spring 97 reacting against the bearing 96 presses against a collar 98 on the stem 82 and by so doing tends to maintain the valve 81 closed.

The rotary shell 93 has splines 100 engaging complementary splines 101 on the yoke 95 so that the rotary shell rotates in

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unison with the annular cam 90. The flywheel 87 is supported on the shell 93 and has a driving connection with it consisting of a friction clutch 102.

5 Assume that the connections 84 and 85 are respectively connected through pipes 34 and 35 as in the construction according to Fig. 1 and that the connection 86 is open to atmosphere. Under normal running conditions the valve 81 is a relief valve that is maintained closed so that the servo-motor unit (such as 32, 33, Fig. 1) is operative to assist the driver in the application of the brakes. When the brakes are applied, if 10 the deceleration of the engine-driven shaft 11 is normal the flywheel 87 will decelerate in unison with the shaft. If however the deceleration should be abnormally great, indicating that one or more of the road-wheels tend to lock under the brake action, the flywheel will over-run the decelerating shaft 11; that is to say, the flywheel will overcome the action of the spring 88, with the result that there will be relative rotational motion between the cam 90 and the rollers 92, the effect of which will be to pull the valve 81 open. Thus, the system will be opened to atmosphere and the suction effect on the servo-motor unit will be destroyed, so that the brakes will be operable by the pressure only of the driver's foot and the braking effect will be considerably relieved. This condition of relief will be maintained until the engine-driven shaft 11 resumes a normal speed of rotation and the flywheel 87 regains its normal positional relationship with the shaft.

It will be obvious that instead of using the connections 84, 85, 86 in the manner described, the connection 84 could be plugged, the connection 86 connected to an oil pump (as by the pipe 56, Fig. 1) and the connection 85 connected to the oil sump of the engine. With such connections, the anti-skid unit can be used in a braking system in which the brake action is by the pressure of the driver's foot through a pedal lever of high mechanical advantage. If the anti-skid unit becomes effective to open the valve 81 oil is supplied through the connections 85, 86 to the pump, so that the hydraulic unit such as the unit 52, 53, Fig. 1 will oppose the driver's foot pressure on the brake system.

55 The anti-skid unit has been described above with reference to the transmission system according to Fig. 1. It will be obvious that the anti-skid unit is equally applicable to a transmission system having an automatic regulator according to Fig. 2.

60 Examples of the transmission system of the type stated are described in our Patent Specifications numbered 731,938; 770,323; 860,546.

#### WHAT WE CLAIM IS:—

65 1. A motor vehicle having a transmission system of the type stated in which an anti-skid unit including a flywheel and an actuator is driven by a rotary engine-driven component of the transmission system connected with the input component of the controlled intermediate differential gear, the actuator being operatively connected with the system by which the several brakes of the vehicle are applied and being devised to be moved by the flywheel to reduce the brake action in the event of abnormal deceleration of said rotary engine-driven component.

2. A motor vehicle in combination with an anti-skid unit, the motor vehicle having a transmission system of the type stated including an engine-driven rotary shaft connected with the input component of the controlled intermediate differential gear, and a brake system under the control of a foot pedal, and the anti-skid unit including a flywheel which is driven through a resilient coupling by said engine-driven shaft, said coupling incorporating a cam device, and an actuator which is connected with the cam device and the brake system, the arrangement being such that if the engine-driven shaft is abnormally decelerated by the brake action the resilient coupling permits the flywheel under its inertia to operate the cam device so that the actuator is moved to reduce the brake effect.

3. A motor vehicle according to Claim 1 or 2 in which the anti-skid unit is associated with an automatic regulator comprising two interengageable components, one of them being movable under the influence of the actuator of said unit and the other being a mass movable normally in unison with the vehicle in its forward motion and also movable relatively to the vehicle under the inertia of this mass when the vehicle is braked, such relative movement of this other component acting through the first-mentioned component to oppose movement of the actuator by the flywheel of the anti-skid unit.

4. A motor vehicle according to any preceding claim in which the actuator is a relief valve in a pressure fluid system from which the brake action is derived, the arrangement being such that the valve is opened by the flywheel to disable the pressure fluid system in the event of abnormal deceleration.

5. A motor vehicle according to Claim 1, 2 or 3 in which the actuator of the anti-skid unit is a relief valve applied to the pressure fluid system of a servo-motor connected with a brake pedal lever of low mechanical advantage so as to relieve the servo-motor action when the anti-skid unit becomes effective.

6. A motor vehicle according to Claim

- 1, 2 or 3 in which the actuator of the anti-skid unit is a valve applied to the pressure fluid system of a hydraulic servo-motor connected with a brake pedal lever of high mechanical advantage and devised to oppose the movement of said pedal when the anti-skid unit becomes effective.
- 5 7. A motor vehicle according to Claim 3 in which the actuator is a normally closed valve and in which one of the interengageable components of the automatic regulator is a rod extending from the valve whereas the other component is a pendulum lever which swings to engage said rod and oppose opening of the valve in the event of deceleration of the vehicle.
- 10 15 8. A motor vehicle having a transmission system of the type stated and an anti-skid unit substantially as described with reference to Figs. 1 and 3 of the drawings. 20
9. A motor vehicle having a transmission system, of the type stated and an anti-skid unit with an automatic regulator substantially as described with reference to Fig. 2 of the drawings. 25

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FIG.3.

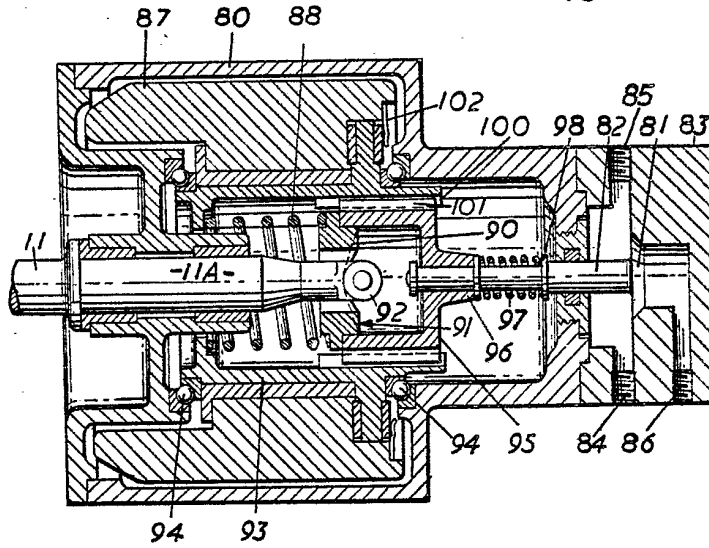


FIG.4.

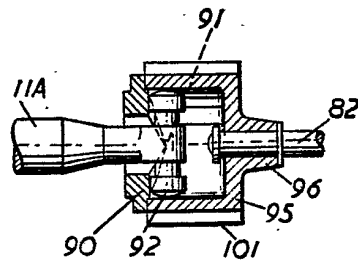


FIG. 1.

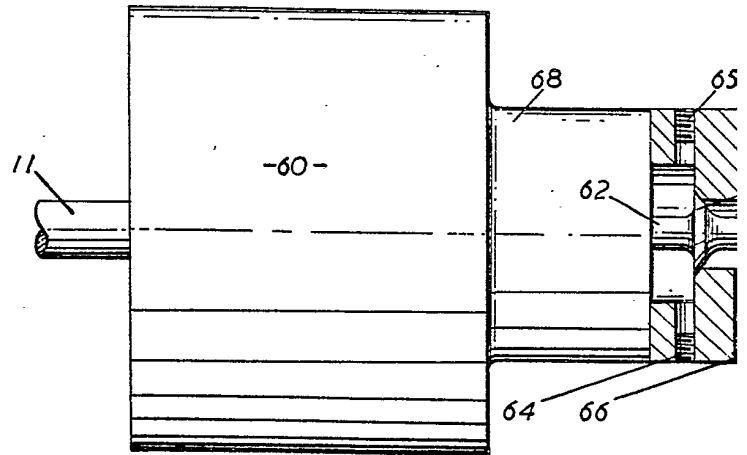
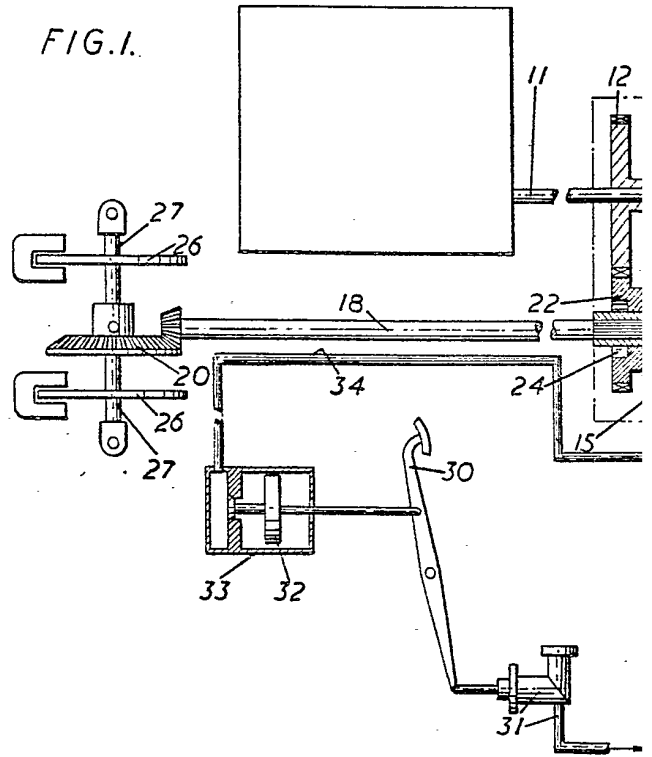
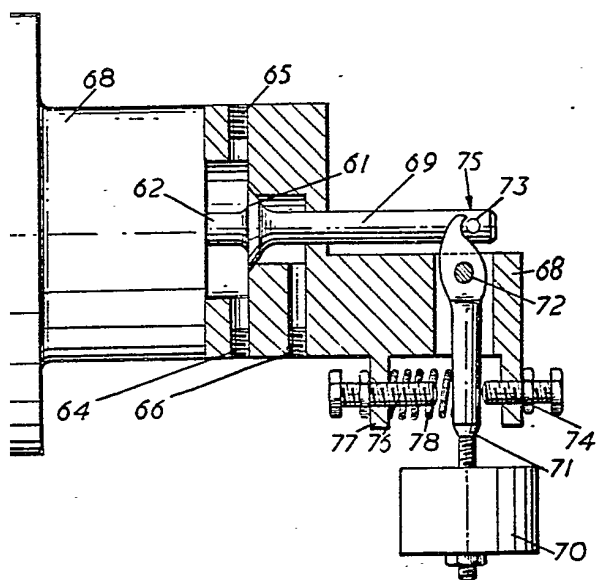
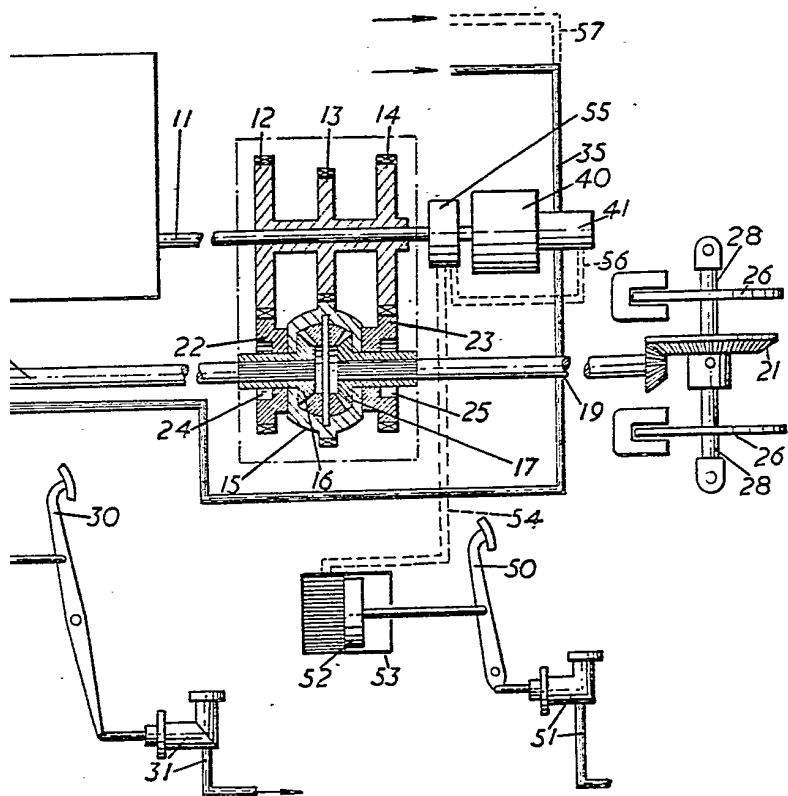


FIG. 2.



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1 SHEET

PROVISIONAL SPECIFICATION No. 12206<sup>59</sup>  
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the Original on a reduced scale



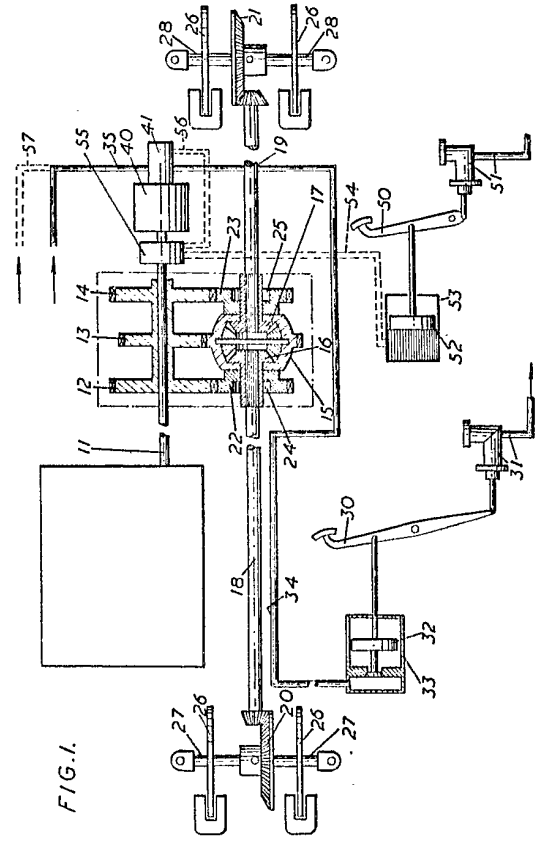


FIG. 1.

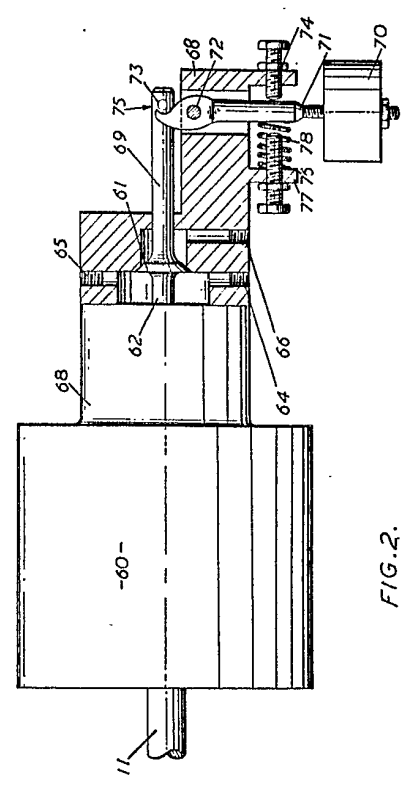


FIG. 2.