Feb. 14, 1933.

H. ERNST

1,897,032

CONVERTIBLE TYPE FEED SYSTEM

Filed Aug. 31, 1928

2 Sheets-Sheet 1

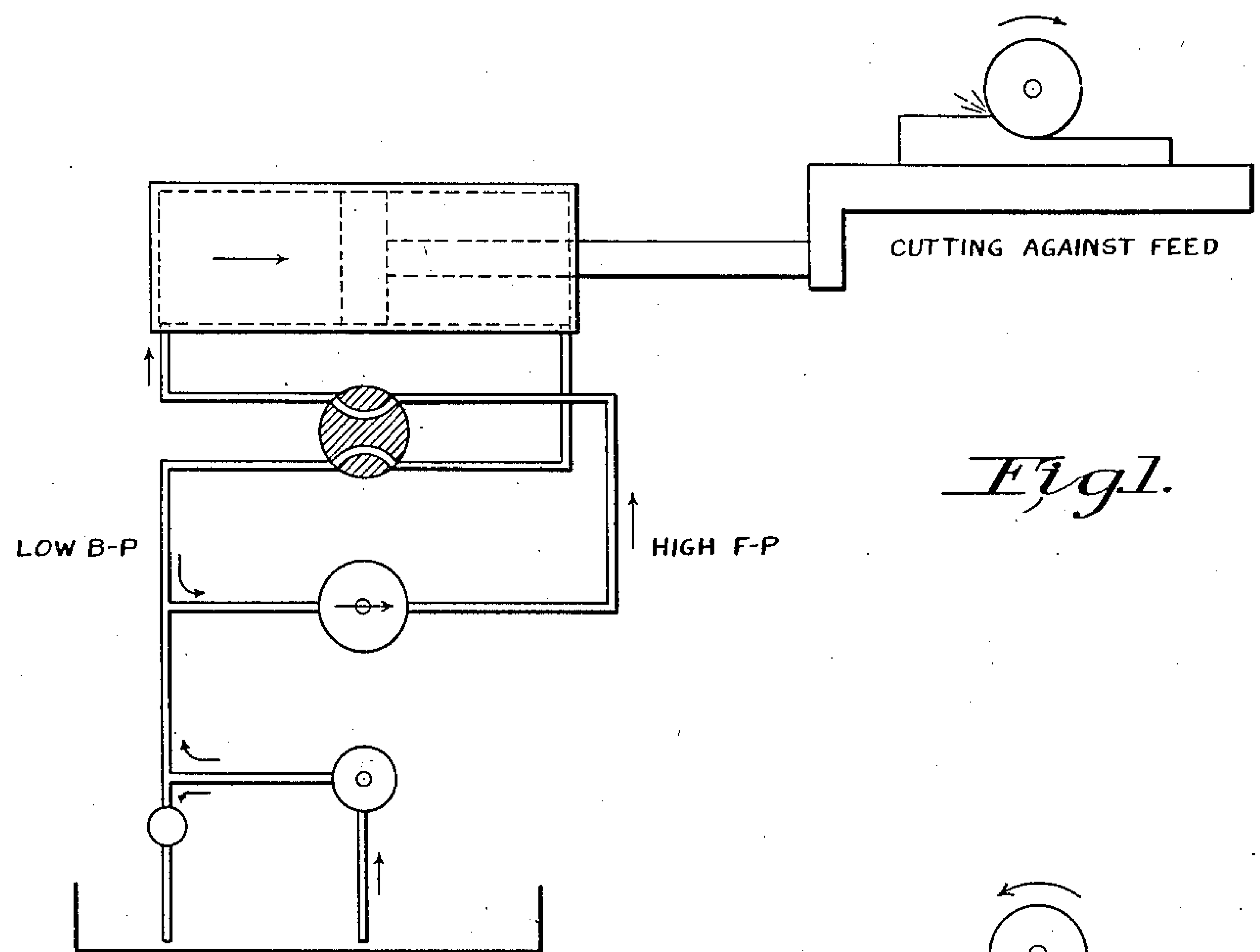

Fig.1.

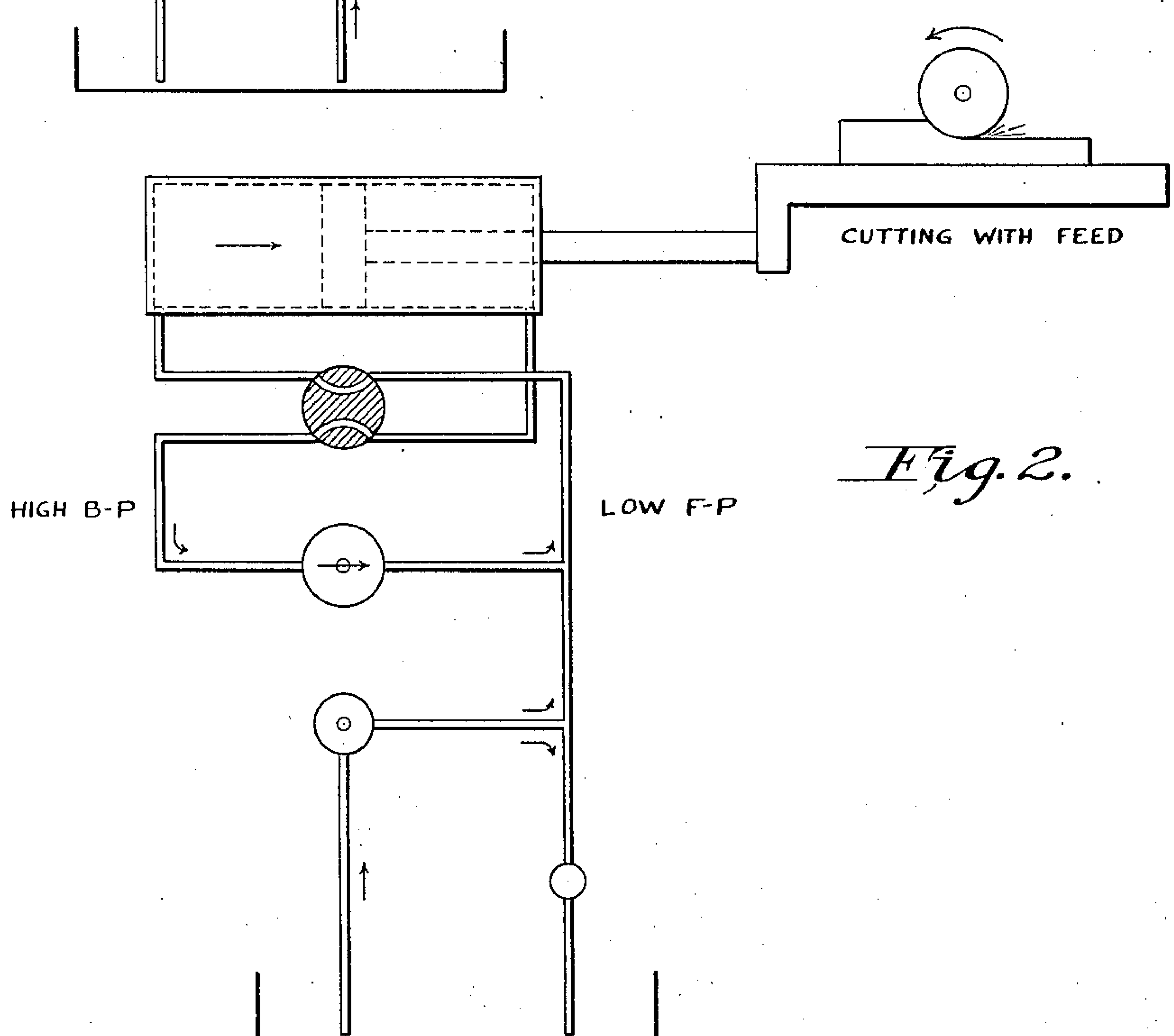

Fig. 2.

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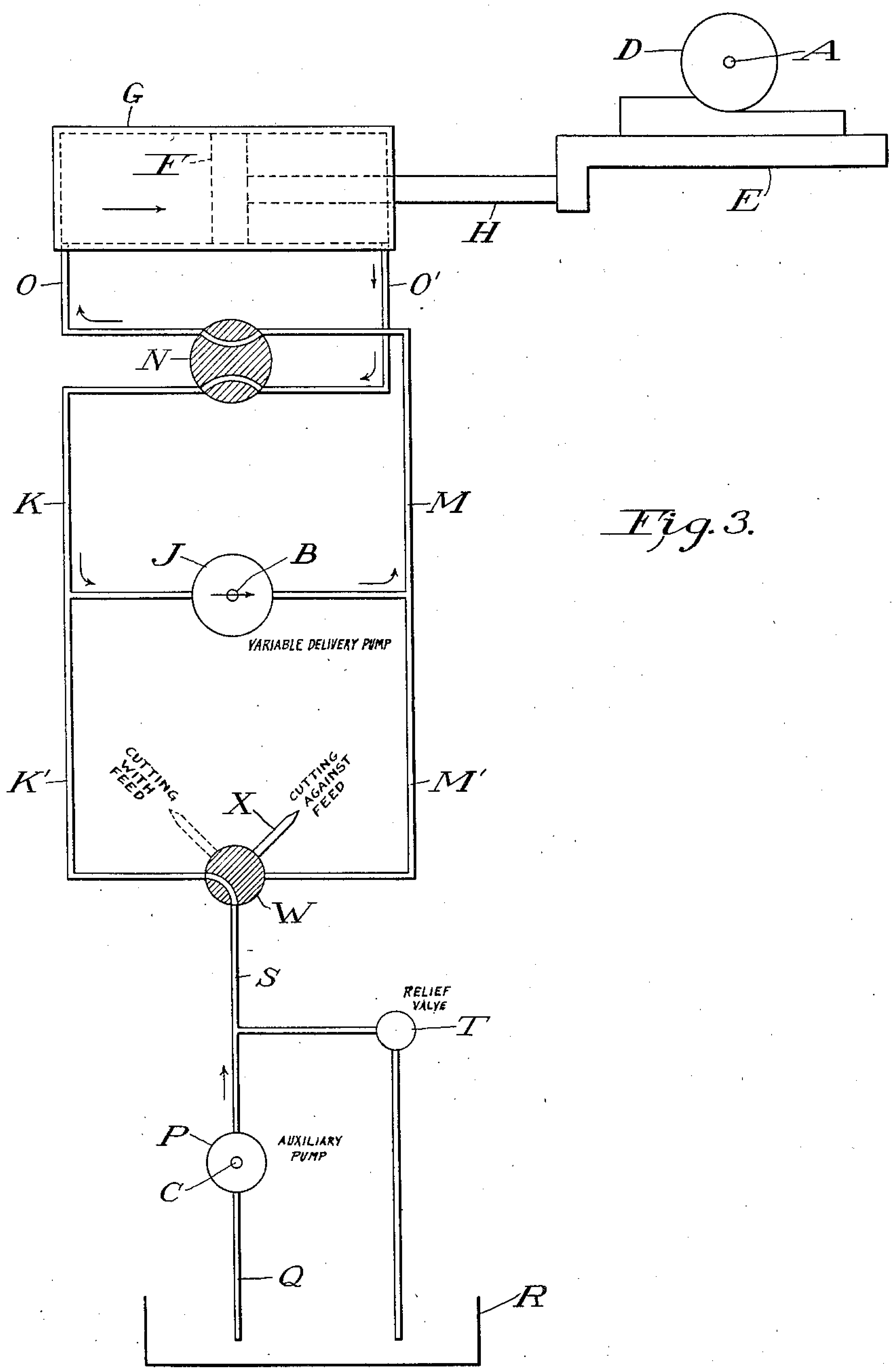

Fig. 3.

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UNITED STATES PATENT OFFICE

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CONVERTIBLE TYPE FEED SYSTEM

Application filed August 31, 1928. Serial No. 303,176.

This invention undertakes so to contrive an hydraulic propulsion system as to be readily convertible from one type to another e. g. from that type which seeks to produce a uniform travel of an actuated member by delivering oil to an hydraulic motor at a volumetrically uniform rate, to that type which governs the rate of travel by maintaining the discharge of oil from the hydraulic motor at a volumetrically uniform rate.

In the drawings, Figure 1 represents diagrammatically a conventional hydraulic system; Fig. 2 represents what is known as a locked or metering system; while Fig. 3 represents a convertible system conforming to the present invention.

In the course of development of so-called hydraulic propulsions for machine-tools in general, an hydraulic motor was mechanically connected to cause a relative advance between the tool and the work; either the carrier for the tool or the work, as the case happened to be, being advanced by the piston under the pressure supplied by the pump. Habitually, this advance was opposed by what may be called the cutting force, i. e., the power required to force the tool to take its cut and remove the metal.

In the case of a milling operation, it is more convenient, and hence was customary, to mount the cutter on a rotary non-shiftable spindle, and to propel the carrier on which the work-piece is mounted, to wit, the table. For various reasons, it had likewise become habitual to rotate the cutter against the work, i. e., in a direction such that its cutting edge swept through an arc in a direction contrary to the direction of advance of the work.

The pump selected was, of course, one of the variable delivery type; this being to enable the user so to regulate the rate of feed as best to conform to each particular requirement. In other words, this easily adjustable pump was used to perform the office, but with a closer degree of graduation, heretofore performed by mechanical change-gears.

In a milling-machine, depending upon whether the cutter is being employed to remove only an extremely light finishing cut, or ranging up to a very heavy roughing cut, the cutting force will vary from but little up to the full strength of the machine; in which latter case it may be perhaps as much as twelve thousand pounds. If the area of the piston be considered, then this would mean (neglecting friction, piston-rod, etc.) an hydraulic pressure in pounds per square inch equal to the opposing component of the cutting force divided by the area of the piston in square inches.

And, ergo, the variable delivery pump, when arranged to meet the above-stated conditions, obviously had to be able to deliver its oil under at least that much pressure.

As before stated, it became appartent at the outset that, like all pumps, the table-propelling pump should be kept supplied with oil. That pump was naturally arranged in circuit to receive the oil directly from the discharge side of the piston and, to compensate for leakage, an auxiliary pump was resorted to to make up the loss by pumping oil from a reservoir.

Now, inasmuch as the pressure in the line from the variable main pump to the piston might, under heavy duty, be quite high; and as the auxiliary pump was initially designed to deliver a large volume at low pressure (as when it also was used for table return at a rapid rate) it became manifest that it could not be arranged to inject oil into the system in the high-pressure line ahead of the main pump. It obviously, therefore, had to be arranged to inject the "make-up" oil into the low-pressure line from which the main or variable delivery pump derived its source. Furthermore, as the auxiliary pump was of the constant delivery type, and naturally had to deliver more than was actually needed for replacements, it was associated with a relief-valve for by-passing the excess overflow.

The outcome of these considerations was a system which is represented in diagram by Fig. 1. In that system, there always existed a constant back-pressure of low magnitude due to the provision for escapage through the low-pressure relief-valve which, in turn, had to function at a relatively low pressure to correspond with the low-pressure auxiliary pump. This system, as has been mentioned, was contrived for the then conventional "set-up" of a milling machine wherein the cutter was so rotated as to oppose the travel of the table and, for that purpose, that system was economical to the extent that the forward pressure needed to overcome only a moderate back-pressure plus, of course, the horizontal component of the opposing cutting force and friction. But its utility was restricted to usage where the cutting force acted in opposition.

To be able to run the cutter with the work would, however, be desirable in certain circumstances. Of late, what is known as a metering or locked system has been contrived with that end in view. In this system, which is diagrammed by Fig. 2, there is no low-pressure relief-valve or the like in the discharge-line. Consequently, the back-pressure is not constant but becomes greater as the cutting force increases; being equal to the forward pressure plus the cutting force, disregarding friction etc. If, for example, the component of the cutting force in the direction of travel should be sufficient, either alone or supplemented by the forward hydraulic pressure, to advance the table despite friction, then the effect will be to try to urge the oil through the variable delivery pump. But, as the latter is power-driven at a constant speed, it will neither draw nor permit oil to pass at any rate faster than that for which it has been regulated. The back-pressure will accordingly rise automatically to whatever extent is necessary to prevent the table from over-running under the push of the cutter; restraining its rate of advance definitely to the rate at which the variable delivery pump, which now functions as a meter, has been regulated. In this "locked" system, where the back-pressure may attain a magnitude in excess of the head of an auxiliary make-up pump of the low-pressure type (with its low-pressure relief-valve), it has been found possible to admit the oil-replacements to the conduit line into which the variable delivery pump discharges. In so doing, advantage is taken of the fact that, the greater the cutting force, the less will be the forward hydraulic pressure required. In this system, the forward pressure will in no instance exceed the value of the relief valve, but the table cannot overrun because of the high back-pressure, and it is consequently well suited for use when the cutter tends to advance the table. In the earlier system, on the other hand, which can be used when the cutter opposes the advance of the table, the forward hydraulic pressure may be great but the back-pressure will never exceed the value of the relief valve.

It will thus be seen that hydraulic feed systems are of two distinct types; the one having characteristics that befit it more advantageously for certain operations, and the contrasting type for other operations. The more common type seeks to produce an uniform travel by deliverying oil at a volumetrically constant rate to the motor. By some, this is regarded as the best available for certain sorts of work. The other type governs the rate of travel by maintaining the discharge of the oil at a volumetrically uniform rate. This type in its improved form is of more universal utility and exhibits pronounced advantages; especially in performing certain operations incompatible with the other type.

In a milling machine, it may as before stated become desirable, for example, at one time to run the cutter with the feed and at another time counter to the feed; depending upon the cycle, or upon the nature of the operation. It is accordingly highly desirable, from the standpoint of those who may expect to meet such diverse conditions, that the system shall admit of immediate conversion from one type to the other, and to this problem this invention is addressed. My attainment of that desideratum takes advantage of the fact, previously explained, that even when the "make-up" oil is derived from a low-pressure source (as where the relief-valve has a low value) it may be admitted readily to the discharge-line in the first system or to the delivery-line in the later system. In other words, that the conditions of the respective systems are fortunately converse with respect to the needful arrangement of the relief-valve. From this standpoint, I have developed the convertible system represented diagrammatically by Fig. 3.

In that diagram, three of the elements are understood to be driven mechanically; i. e., by conventional transmissions from any suitable prime-mover such as the main pulley or the electric-motor commonly built into the machine. These three elements are the spindle A, the shaft B of the table-feeding variable-delivery pump, and the shaft C of the auxiliary pump. The transmission to the spindle, following conventional practise, is understood to include change-gears for controlling its speed and a motion-reverser for selecting its direction of revolution. The spindle A (by means of an arbor) carries either one or two or more spaced cutters of which one is indicated by D. One, for example, may be set to cut when the table feeds to the right, and the other may be set to cut when the table feeds to the left; as for so-called reciprocating milling either always with or always against the cutters or alternately with and against the cutters according to the manner in which the work-pieces are handled.

The table is denoted by E and is mounted according to any conventional manner for travel on appropriate slides. It is, however, propelled, not by the usual mechanical transmission from the prime mover, but by an hydraulic motor which preferably is of the piston-cylinder type; F indicating the piston and G indicating the cylinder. One of these, it is immaterial which, is connected as by a rod H to the table; the other being of course affixed to the frame of the machine.

The main pump is denoted by J and is driven at a constant speed by its drive shaft B. This pump may be of any conventional so-called variable delivery type. That is to say, it admits of being adjusted manually to pass the liquid at any predetermined volumetrically constant rate. This it will do irrespective of the head against which it works or whatever back-pressure exists against the inlet side of the pump. So also, this pump preferably has an unidirectional rotation; always receiving the liquid from the return conduit K and always passing it into the forward conduit M.

So that the motor may be reversed in its direction of movement, an appropriate control valve denoted by N intervenes between these conduits and the two conduits O and O′ leading from the valve to the motor. According to the setting of the control valve, conduit O or conduit O′ may lead the liquid to the motor, and conduit O′ or conduit O may receive the liquid discharged by the motor. Of course, instead of depending upon a reversing valve, the pump itself may be reversed either in its direction of rotation or by adjusting its timing cycle.

It will be seen that the direction of feed of the table is reversible for cutting with or cutting against the travel of the work. In the former case, the chip will be removed by a downward cut, and in the other by an upward cut of any cutter having an unidirectional rotation.

But the system as thus far detailed would be operative for a limited period because of bleeding. To keep it full of oil, a supplemental pump is employed. This is denoted by P and it derives its oil through an intake line Q leading from a reservoir R which is so located and the frame of the machine so contrived that all oil leaking from the system will drain into the reservoir by gravity. The construction of the auxiliary pump is such that if the pressure in its discharge conduit S tends to become too great, or if the system be incapable of receiving the entire normal output of that pump, then will no harm be done. The simplest arrangement, and the one preferred for that reason, is to associate this pump with a relief valve T which, when the pressure exceeds an economical limit, will by-pass to the reservoir the excess or unrequired oil.

In accordance with the present invention, the source of the loss-replacing oil, instead of being connected only with the intake line to the main pump as in Fig. 1, and instead of being connected only with the outlet line from the main pump as in Fig. 2, is connected to both; to wit, through the conduit lines K′ and M′. With these lines are means for permitting the make-up oil to flow into line K′ to feed the main pump when it is working against the cutter, or to flow into line M′ to keep full of oil the line into which the main pump meters when operating under the "locked" system to oppose the cutter and prevent the table from being overrun by the high back pressure. Simultaneously any reverse flow is prevented from occurring through the line K′ or M′, as the case may be, which at the time is under high pressure either caused by the main pump when operating against the cutter, or by the cutter when operating in the same direction by the main pump.

A simple construction for that purpose is a three-way valve W which may be set manually by a hand-grasp X to divert the flow one way and block all flow the other way, or conversely. By this means, it will be seen that whenever the pressure falls lower than the value of the relief valve (on the one or other side of the piston according to the direction of the cutter) it will be boosted up to that value by the oil received from the auxiliary pump. Therefore, whether the table be fed for taking upward cuts or for downward cuts, the minimum pressure in the system will be constant determined by the relief valve, and the maximum pressure will automatically equal this constant minimum plus the horizontal component of the cutting force regardless of whether the table is being fed with or against the cutter. This result of converting from the one system to the other is clearly of material advantage to users of any mechanism in which, at one time, an hydraulic effort is required to propel an element against a resistance or, on another occasion, an hydraulic governor is required to regulate and keep constant the rate of travel of an element actuated by an independent force.

Without further analysis, the foregoing will so fully reveal the gist of this invention that others can, by applying current knowledge, readily adapt it for various utilizations by retaining one or more of the features that, from the standpoint of the prior art, fairly constitute essential characteristics of either the generic or specific aspects of this invention and, therefore, such adaptations should be, and are intended to be, comprehended within the meaning and range of equivalency of the following claims.

Having thus revealed this invention, I claim as new and desire to secure the following combinations and elements, or equivalents thereof, by Letters Patent of United States:—

1. An hydraulic propulsion system combining an hydraulic motor; a manually adjustable high-pressure pump; a delivery-conduit from said pump to the intake of said motor; a withdrawal-conduit from said motor to the intake of said pump; a low-pressure pump; and means selectively at will to cause said low pressure pump to discharge into the one or the other of said conduits in effecting a movement of said motor at a given rate.

2. A machine-tool combining tool and work carriers; a piston and cylinder arranged in propelling relation with one of said carriers; a constant-capacity pump; a variable-capacity high-pressure pump; and means adapted manually to be set for causing both of said pumps to deliver simultaneously to the intake side of said piston, or the latter to withdraw from, and the former simultaneously to deliver to, the discharge side of said piston, the rate of movement of the propelled carrier being a feeding rate and substantially the same in either setting.

3. A machine-tool combining tool and work carriers; a mechanically-driven reversible tool-spindle on one of said carriers; a piston and cylinder arranged in propelling relation with one of said carriers; a high-pressure pump; a low-pressure pump and means for causing both of said pumps to deliver simultaneously to the intake side of said piston, or the former to withdraw from, and the latter simultaneously to deliver to, the discharge side of said piston according to the direction of rotation of said spindle.

4. An hydraulic system combining a high-pressure pump driven unidirectionally at a constant rate; an hydraulic-motor; an element mechanically connected to said hydraulic motor; a supply conduit from said pump to said motor; a return conduit from said motor to said pump; an auxiliary conduit from each of said two conduits; and means for preventing fluid from passing from said supply conduit into its auxiliary conduit when said pump is employed to drive said motor to propel said element against a resistance, or for preventing fluid from passing from said return conduit into its auxiliary conduit to enable said constantly-driven pump to act as an hydraulic governor in regulating the rate of actuation of said motor when said element is being propelled by an independent force.

In witness whereof, I have hereunto subscribed my name.

HANS ERNST.