

Nov. 17, 1942.

O. GEORG

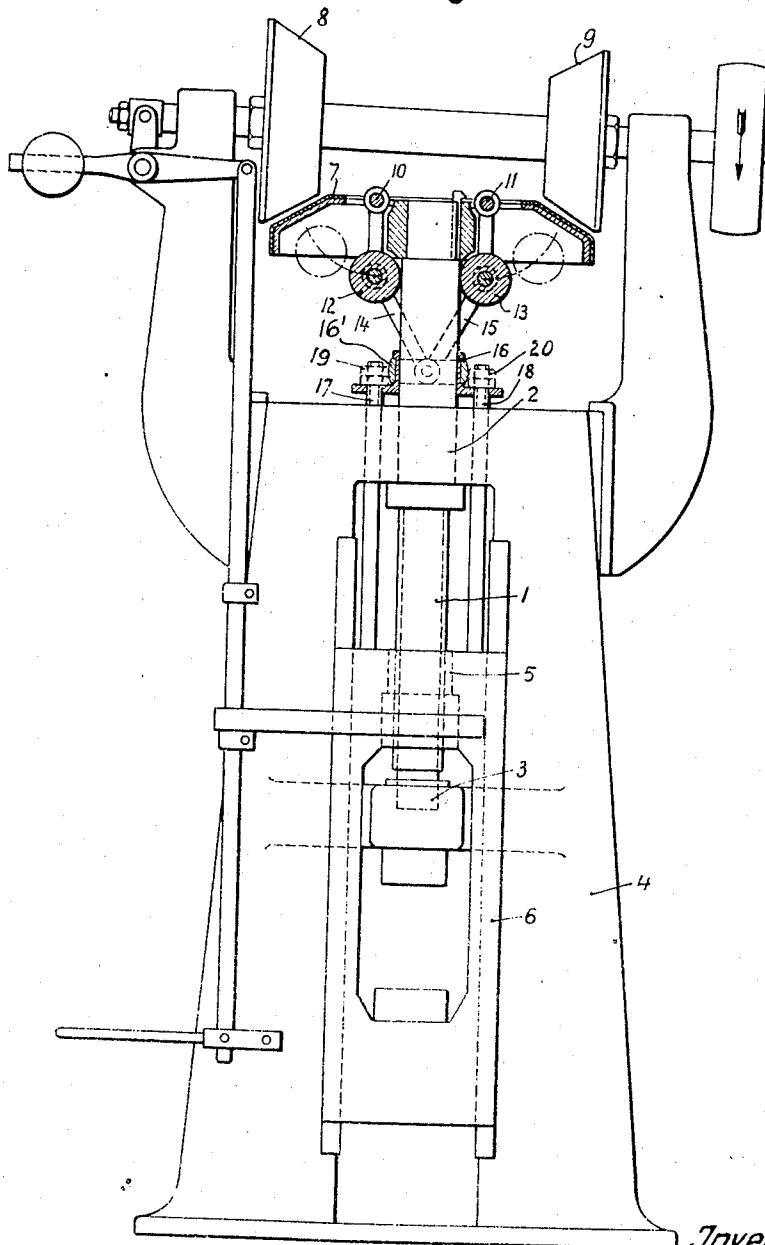
2,301,943

WORKING MACHINE WITH FLY WHEEL OF VARIABLE INERTIA MOMENT

Filed July 8, 1938

4 Sheets-Sheet 1

Fig. 1



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Fig. 2

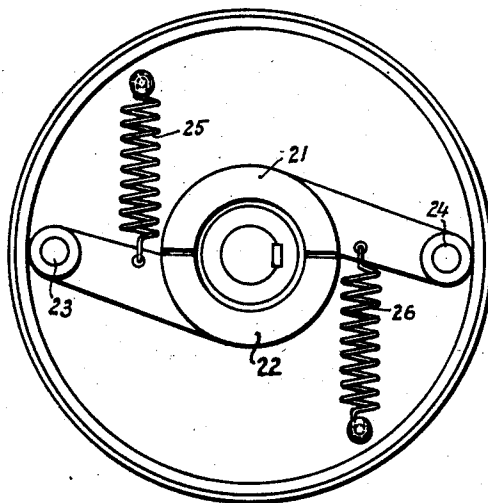
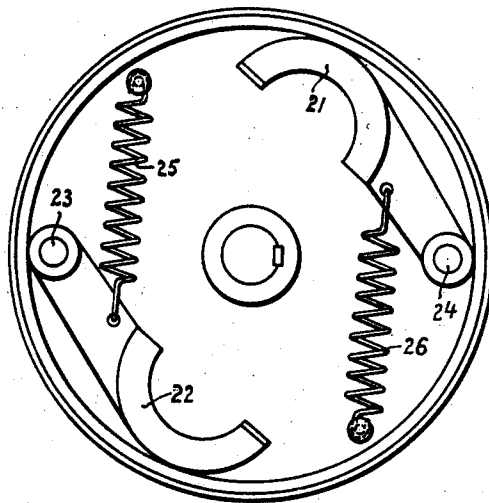


Fig. 3



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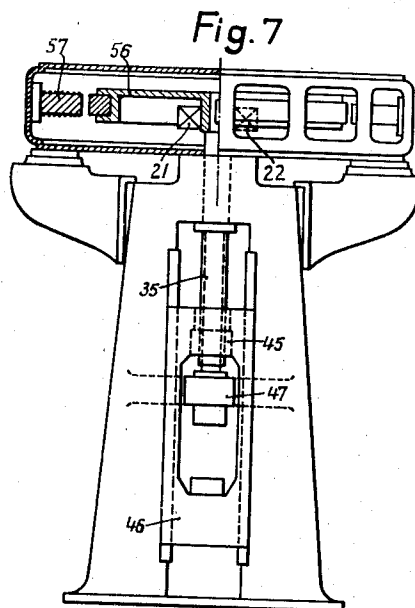
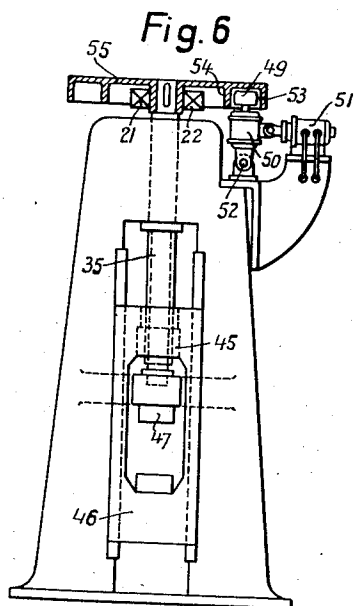
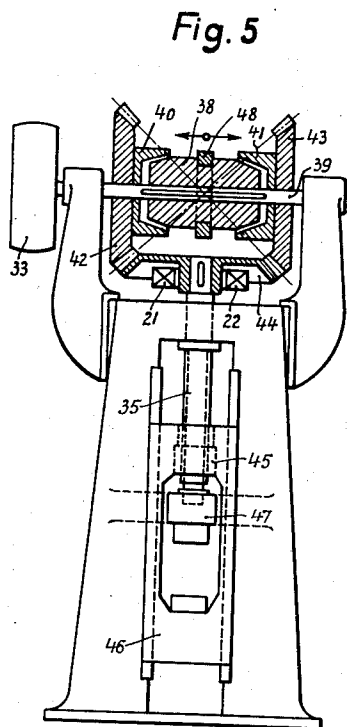
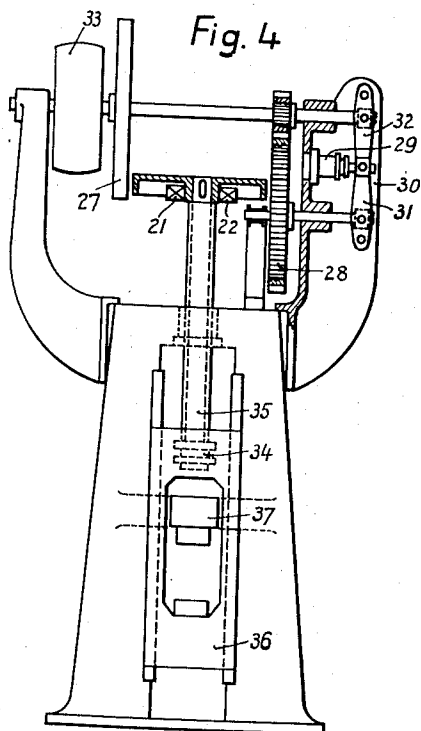
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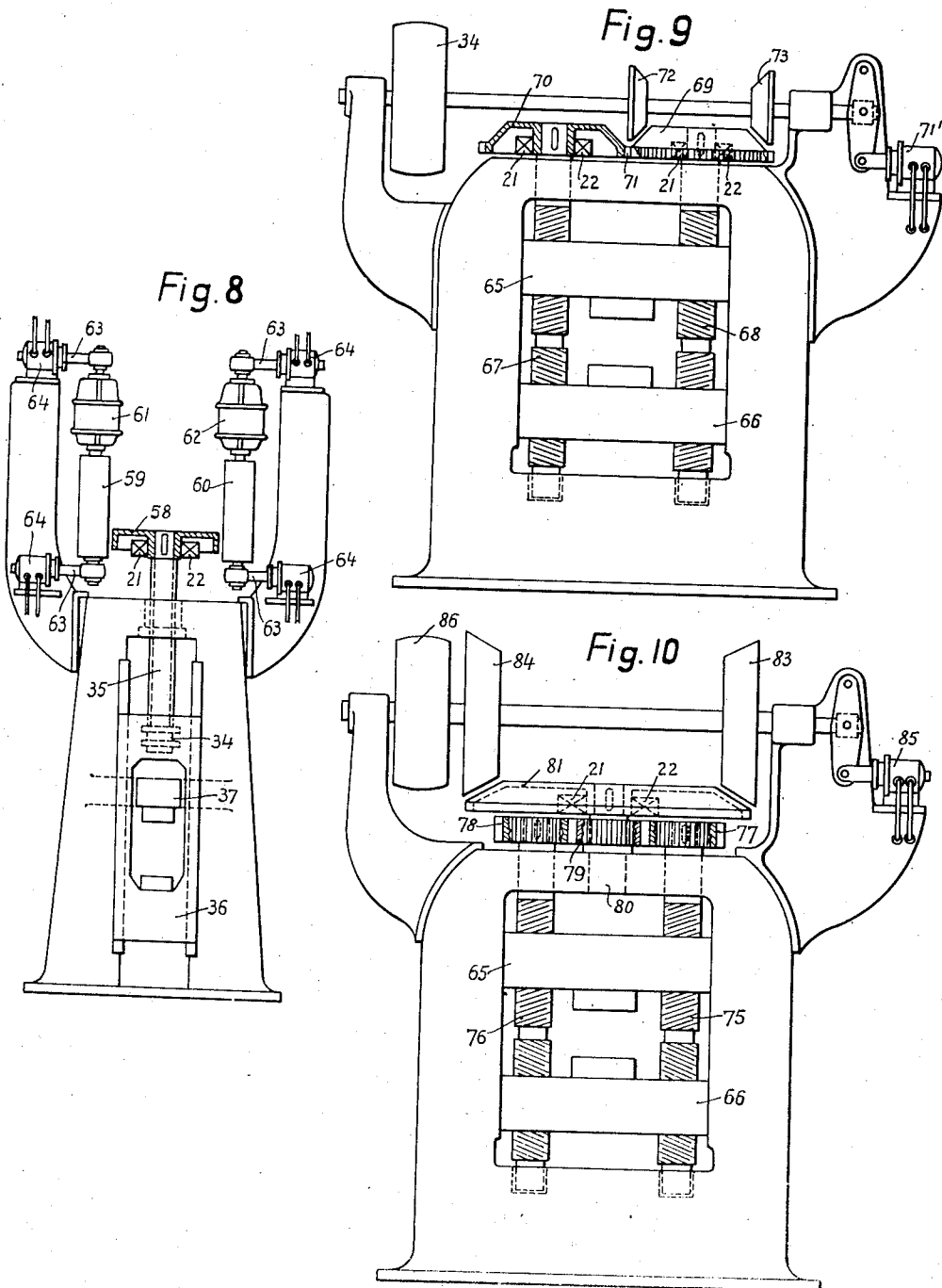
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WORKING MACHINE WITH FLY WHEEL OF VARIABLE INERTIA MOMENT

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4 Sheets-Sheet 4



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UNITED STATES PATENT OFFICE

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WORKING MACHINE WITH FLYWHEEL OF
VARIABLE INERTIA MOMENTOtto Georg, Brunswick, Germany; vested in
the Alien Property CustodianApplication July 8, 1938, Serial No. 218,149
In Germany July 28, 1937

14 Claims. (Cl. 74-202)

The present invention is based on a recognition of the fact that the drives hitherto in vogue for operating machines in which a fly-wheel is repeatedly accelerated through the intermediary of coupling devices which can be engaged and disengaged, suffer from a number of very serious drawbacks. Every coupling engagement must, axiomatically, be regarded as an impact engagement. A mass possessing a definite velocity endeavours within a long or short time suddenly to drag with it a second mass with which it is coupled, and this mass possesses a different, preferably a smaller velocity, frequently equal to zero owing to the mass starting from rest. As the driven mass is accelerated in this way there occurs an impact-loss. When the driving is effected by friction, this impact-loss, on the supposition that the driving-speed is V and is assumed to be constant, is equal to $\frac{1}{2}M.V^2$ where M denotes the mass to be driven. As the driven body further acquires, after the impact or after the engagement, a kinetic energy of equal amount, the energy expended in the engagement is $M.V^2$. The efficiency of the completely similar friction coupling is thus, theoretically, 50% or, in other words, half the energy is lost in the coupling.

The significance of this fact in the operation of machines that are repeatedly accelerated over such engageable and disengageable couplings and which, therefore, work preferably intermittently, is sufficiently obvious when it is remembered that two such coupling operations must take place for a single working stroke, that is to say that the efficiency of such machines is, purely theoretically, only as high as 25% though in reality its value is very considerably less. Thus, for instance, it has been ascertained from scientific investigations that in friction-pulley-screw presses of the type hitherto known, efficiencies of only 6% or less are attainable. Thus 94% of the energy fed in is expended without useful effect. The chief object of the present invention is radically to improve such drives.

The said problem has been solved according to the present invention in that in drives for operating machines, whose flywheel mass is repeatedly accelerated during the operating process from low to higher velocities, the drive of the operating machine is adapted to be connected through engageable and disengageable friction couplings with a flywheel mass, whose moment of inertia is variable automatically or in dependence on operating movements of the machines.

It is already known to use flywheel masses of

variable moment of inertia in order to impart with restricted forces within a certain space of time a certain energy to a flywheel mass. The drives according to the invention in which friction couplings must be arranged for coupling or connecting the machines or gearing rotating with constant or approximately constant velocity with the operating machine in order to repeatedly accelerate the operating machine from low to higher velocities and to drive same in different directions have advantages which cannot be obtained in the known arrangements because the latter are used only in connection with elastic driving machines.

If, for instance, the fly-wheel to be driven has a variable moment of inertia, the radially-displaceable mass of the fly-wheel being in its innermost position distant by one unit of length from the axis of rotation, while in its outermost position, it is distant by three units of length from the said axis, then the greatest moment of inertia, seeing that it increases as the square of the distance, will be equal to nine times the minimum moment of inertia. If a fly-wheel of this type is coupled with a drive of an angular velocity w then in the coupling there will be a loss of the order of magnitude of $\frac{1}{2}w^2$. After this first coupling, however, the fly-wheel possesses the angular velocity w of the drive. If now with the angular velocity kept constant, the mass that is free to shift in space is radially displaced outwards, then this mass, supporting the angular speed to be maintained absolutely constant, becomes accelerated, without it being possible for the slightest slip to occur at the friction-surfaces of the coupling. Thus, and this is of primary importance and is the fact underlying the present invention the fly-wheel, without the slightest loss in the energy $w^2/2$ undergoes an acceleration of the order of magnitude of $9w^2/2$. Thus as against an expenditure of 100 units of energy there are 90 units of energy stored in the fly-wheel after the acceleration. Hence the efficiency of the coupling jumps at one bound from 50% to 90%. This will serve for the correct appraising of the main advantage of an acceleration with constant angular speed.

There are other advantages arising from the fact that during the return stroke, when the machine can perform no useful work, the motion may be limited to that of the least moment of inertia so that during the return, there occurs a loss of the order of $w^2/2$ only.

The total efficiency of the working machine, including its return stroke, is therefore theoretic-

cally 80% as against 25% which was the efficiency attained with the machines in vogue hitherto.

It is almost superfluous to add that the operating speed of the machine is raised and the wear of the coupling elements lowered as these facts may be inferred automatically from the technical advance made by the invention.

Of special importance, as indicating a very great step forward, is the application of the basic idea of the invention to screw presses, which are, in general, operated by friction-wheel reversing gear. The fly-wheel and central wheel are here, during a single working stroke, accelerated once in the one direction and once in the other direction during the return. The losses specified above occur, therefore, and a like result is obtained when use is made of bevel-wheel reversing gear with friction couplings. In such machines, therefore, as already stated at the outset, the coupling losses for the fly-wheel acceleration may be reduced to a hitherto unprecedented low value, if, in accordance with the invention, the moment of inertia of the fly-wheel is maintained during the coupling at a fraction of the efficiency value and not increased to its maximum value, until slipping ceases. As there is no intention of storing energy during the return stroke, the minimum moment of inertia will be used.

The fundamental idea of the invention is illustrated by way of example in the practical constructional forms shown in the drawings, wherein:

Figure 1 is a view of a friction-pulley screw press of normal construction, and modified according to the invention;

Figure 2 is a plan view of a different arrangement of the masses that serve to vary the moment of inertia in the position for giving the minimum moment of inertia;

Figure 3 shows, in a similar view to Figure 2, the position of the masses for giving the maximum moment of inertia;

Figure 4 exemplifies the idea of the invention as applied to a friction wheel screw press with spaced pulleys;

Figure 5 shows a press equipped with a bevel-wheel reversing gear;

Figure 6 exemplifies the idea of the invention as applied to a friction-roller drive for a friction wheel screw press, directly driven from an electric motor;

Figure 7 shows a construction in which the fly-wheel of the screw press takes the form of the rotor of an electric motor;

Figure 8 exemplifies the idea of the invention as applied to a friction wheel screw press equipped with friction rollers;

Figure 9 illustrates the idea of the invention as applied to counter-stroke presses with friction-cone drive, while,

Figure 10 exemplifies a counter-stroke press with a different drive.

The press shown in Figure 1 has a vertical spindle 1 supported at its upper end in a journal 2 and at its lower end in a step bearing 3 of the press pedestal 4. The spindle engages in a nut 5 which is mounted in the upper bridge of a frame-like slide 6. The spindle 1 extends above the conical fly-wheel 7 to which a rotation both to the right and to the left can be imparted through side wheels 8 and 9 also of conical shape. The slide 6 moves up and down accordingly. It is the left hand wheel that effects the upward movement of the slide, that is, its operative stroke.

Whereas up to now, the centre pulley 7 has

possessed a constant moment of inertia, this is now, as appears from the drawing, variable. To the two journals 10, 11 on the wheel are connected heavy weights 12, 13 which are free to swing outwards but can be prevented from doing so by the straps 14, 15 which are, in turn, hinged to a sleeve 16 rotatably mounted on a flanged collar 16, rigidly connected with the slide by means of two adjustable rods 17, 18. If now pressure is applied to the left hand wheel 8, the centre wheel 7 will move slightly in unison as its moment of inertia is at first small. The slide 6 moves upwards and the weights 12, 13, as the slide releases the sleeve 16 by means of the rods 17, 18, swing outwards under the influence of centrifugal force, the momentum of the fly-wheel increasing more and more in the meantime until it reaches its maximum shortly before the impact.

By the impact the centre pulley is brought to a standstill and the weights sink downwards. If this sinking occurs prior to the impact then the energy of the impact will be further increased by the gravitational force of the weights. The impact is delivered with a speed that is fairly constant. Should the sinking of the weights, which occupies a certain time, occur after the recoil, then the force of gravity tends also to accelerate the fly-wheel, so that the return travel starts under ideal conditions. In general, it will then prove unnecessary to apply any further pressure to the right hand wheel 9 which produces the downward motion and, should it be necessary, a slight blow will be sufficient. At all events, precautions are taken that only the least moment of inertia is set up during the return travel. To this end the right hand wheel is made 10-20% smaller than the left one so that the return speed of the centre wheel is kept within limits. The advantageous result is thus attained that the centrifugal force of the inwardly located weights can never be great enough to raise their weight and that of the sleeve. Thus the return movement is also effected considerably more economically and it becomes possible to increase the efficiency of the screw press to several times its original value. A further advantage is that it becomes possible to limit the outermost position of the centrifugal masses 12, 13 by shifting the nuts 19, 20 on the suspension rods. The momentum of the centre wheel may thus, without altering the working speed, be arbitrarily adjustable this being a feature of great value in practice, since screw presses are in universal use.

In Figures 2 and 3 a constructional form of the invention is shown in which the masses pivot in the plane of the fly-wheel. The weights 21, 22 are rotatably supported in journals 23, 24. In their inner position (Figure 2) they surround the hub of the fly-wheel in the form of a hollow cylinder, and fit it as closely as possible, for the efficiency of the fly-wheel depends on the magnitude of the ratio of the distance of the weights from the axis in their innermost position to that in their outermost position. The moment of inertia increases as the square of the distance and so does the efficiency of the fly-wheel. The weights are retained in their inner position by springs 25, 26 and the springs are so adjusted that they can balance the centrifugal force up to a definite speed which may be some 10% below the maximum speed so that if the return movement is carried out at this speed or below it, only the smallest moment of inertia requires to be accelerated. Any further regulation of the weights from without is then superfluous. In

Figure 3 the outermost position of the weights 21, 22 is shown when the moment of inertia is highest.

The idea at once suggests itself of improving the efficiency of the fly-wheel by having all the dead masses, such as the rim, the hub and the arm, made as light as possible, for which light metal (magnalium) might be employed. The moving masses, on the other hand, are made as heavy as possible, as, for instance, by means of inserts of lead.

It follows from the above that the idea of the invention is independent of the construction of the press itself. Figure 4 shows the application of the idea of the invention to a friction wheel screw press equipped with disks 27, 28 which are in staggered formation relatively to each other and are displaced through the intermediary of a pressure-oil-operated servo-motor 29 and piston rods 30 and guide rods 31, 32 the actual operation being effected at 33. The centrifugal weights constructed as in the case of Figures 2 and 3 are, in this case also, arranged at 21, 22. The slide 36 is moved over the spindle 35 via the thrust-bearing 34, resistance thrust-blocks being fitted at 37.

In the form of construction exemplified in Figure 5, the drive is in the form of a bevel-wheel reversing gear. A displaceable double cone 38 which is mounted to rotate with the driving shaft 39, can be coupled with either of two coupling elements 40 or 41. The bevel wheels 42, 43 are rigidly connected with the coupling elements 40, 41 and these wheels both mesh with the centre wheel 44 which is also of bevel form. The centrifugal weights 21, 22 are built integrally into the centre wheel 44, and the spindle 35 is guided in the nut 45 of the slide 46. The spindle 35 is, further, supported in a thrust block 47. The actuation of the double cone 38 is effected by the fork 48, which is operated either by hand or by a servo-motor.

In the case of Figure 6 the press is operated through a friction-roller 49 driven by an electric motor 50. A servo-motor 51 brings the motor 50, which is hingedly mounted at 52, either into the inoperative central position or into engagement with the outer or inner rim 53 or 54 of the fly-wheel 55. The latter is provided with centrifugal weights 21, 22 as shown in Figures 2 and 3 gives the efficiencies calculated for these figures.

In the case of the screw press shown in Figure 7, the fly-wheel is constituted by the rotor of an electric motor the stator of which is indicated at 57. The centrifugal weights of the centre pulley are again denoted by 21, 22.

The centre pulley 58, in the example illustrated in Figure 8 is driven by two friction-rollers 59, 60 by electric motors 61, 62. The elements 59, 61 or 60, 62 are connected with piston rods 63 which are subject to the influence of the pistons of servo-motors 64. In this way pressure is brought to bear on either the friction roller 60 or the friction roller 59. The fly-wheel is provided with centrifugal weights 21, 22 as in the constructional form shown in Figures 2 and 3 or in that shown in Figure 1.

The press illustrated in Figure 9 is of the counter-stroke type. The slides 65, 66 move in opposite directions under the influence of the spindles 67, 68 which are provided with counter-cut threads. Each of the spindles is rigidly connected with its bevel wheel 69, 70 these two wheels meshing with each other by means of gear teeth

71. Each of the bevel wheels 69, 70 is provided with centrifugal weights as in the constructions of Figures 2 and 3. The drive is taken from a servo-motor 71 through friction wheels 72, 73 mounted so as to be longitudinally displaceable, and displaced by a device 74 during rotation.

In Figure 10 is shown a similar counter-stroke press having a few modified features. The spindles 75, 76 are here driven by two toothed wheels 77, 78 which are in the mesh with a central pinion 79. This pinion is keyed on a shaft 80 on which is mounted a fly-wheel 81, this fly-wheel again being provided with centrifugal weights 21, 22 as shown in Figures 1 and 2. The fly-wheel 81 is driven through conical pulleys 83, 84 which are again so constructed as to be longitudinally displaceable under the influence of a servo-motor 85. They are rotated by means of belt-pulleys or an electric motor 86.

It is obvious that the present invention is also characterized by the fact that all the types of construction shown may also have the kinematically reversed arrangement, that is to say the screw-threaded spindle is adapted to move up and down in a screw-threaded nut secured in the frame of the machine while the end of the spindle is rotatable in the slide but not axially movable against the slide. This constitutes the usual construction of a screw press as shown in U. S. Patent 1,810,996 while the drawings of the present application show the Vincent press in which the slide receives the screw-threaded nut and the frame of the press receives the collar bearing.

The method of operation of these presses can be inferred directly from the description.

The use of the device of the invention is, of course, not confined to screw presses.

I claim:

1. A drive for operating machines, containing a flywheel including displaceable masses, engageable and disengageable reversible power transmission means for engaging and disengaging said flywheel, the moment of inertia of said flywheel being variable by the variable distance of the displaceable masses from the center of rotation of the flywheel.

2. A drive for operating machines, containing a flywheel including displaceable masses, engageable and disengageable reversible power transmission means for engaging and disengaging said flywheel, the moment of inertia of said flywheel being variable by the variable distance of the displaceable masses from the center of rotation of the flywheel, and said power transmission means being designed as friction elements.

3. A drive for operating machines, containing a flywheel including displaceable masses, engageable and disengageable reversible power transmission means for engaging and disengaging said flywheel, the masses of said flywheel being regulatable in their distance to the center of rotation of the flywheel, and said masses being arranged in such manner that their displacement is automatically effected under the influence of the centrifugal force.

4. A drive for operating machines, containing a flywheel having displaceable masses, engageable and disengageable reversible power transmission means between a power source and the flywheel the masses of said flywheel being regulatable in their distance to the center of rotation of said flywheel, said masses being arranged in such manner that their displacement is effected automatically under the influence of the centrifugal force, and means adapted to balance the influ-

ence of the centrifugal forces wholly or in part.

5. A drive for operating machines, containing a flywheel having displaceable means, engageable and disengageable reversible power transmission means between a power source and the flywheel the masses of said flywheel being regulatable in their distance to the center of rotation of said flywheel, said masses being arranged in such manner that their displacement is effected automatically under the influence of the centrifugal force, and means adapted to balance the influence of the centrifugal forces wholly or in part and said balancing means being so dimensioned that the masses move only in the desired direction at certain speeds.

6. A drive for operating machines, containing a flywheel including displaceable masses, engageable and disengageable reversible power transmission means between a power source and the flywheel, said power transmission means being designed as friction elements, the masses of said flywheel being regulatable in their distance to the center of rotation of the flywheel, said masses being arranged in such manner that their displacement is effected automatically under the influence of the centrifugal force, means to balance the influence of the centrifugal forces wholly or in part and said balancing means being so dimensioned that the masses move only in the desired direction at certain speeds.

7. A drive for screw presses, comprising a central flywheel including displaceable masses, driven friction elements arranged laterally of the central flywheel and adapted to be pressed alternately against the central flywheel while taking it along in an alternate direction of rotation, the moment of inertia of said central wheel being variable by the variable distance of the displaceable masses from the center of rotation of the flywheel.

8. A drive for screw presses, comprising a central friction flywheel including displaceable masses, driven friction elements arranged laterally of the central friction wheel and adapted to be pressed alternately against the central friction flywheel while taking it along in an alternate direction of rotation, the moment of inertia of said central wheel being variable by the variable distance of the displaceable masses from the center of rotation of the flywheel, the flywheel masses of said central wheel being regulatable in their distance to the center of rotation of the central wheel and means for controlling the varying distance of the flywheel masses of the central wheel from the center of rotation.

9. A drive for screw presses, comprising a slide, a central friction flywheel including displaceable masses driven friction elements arranged laterally of the central friction wheel and adapted to be pressed alternately against the central friction flywheel while taking it along in an alternate direction of rotation, the moment of inertia of said central wheel being variable by the variable distance of the displaceable masses from the center of rotation of the flywheel, the flywheel masses of said central wheel being regulatable in their distance to the center of rotation of the central wheel and means for adjusting distance of the flywheel masses of the central wheel from the center of rotation, said means consisting of a mechanical connection between the flywheel

masses of the central wheel and the slide of the screw press.

10. A drive for screw presses, comprising a reciprocating slide, a central friction flywheel including displaceable masses driven friction elements arranged laterally of the central friction wheel and adapted to be pressed alternately against the central friction flywheel while taking it along in an alternate direction of rotation, the moment of inertia of said central wheel being variable by the variable distance of the displaceable masses from the center of rotation of the flywheel, the flywheel masses of said central wheel being regulatable in their distance to the center of rotation of the central wheel, said driven friction elements being designed to advance the slide at one speed and to return the slide at a slower speed.

11. A drive for screw presses, comprising a reciprocating slide, a central friction flywheel including displaceable masses driven friction elements arranged laterally of the central friction wheel and adapted to be pressed alternately against the central friction flywheel while taking it along in an alternate direction of rotation, the moment of inertia of said central wheel being variable by the variable distance of the displaceable masses from the center of rotation of the flywheel, the flywheel masses of said central wheel being regulatable in their distance to the center of rotation of the central wheel, said driven friction elements being designed to vary the speed of the slide.

12. A drive for screw presses, comprising a slide, a central friction flywheel including displaceable means, driven friction elements arranged laterally of the central friction wheel and adapted to be pressed alternately against the central friction wheel while taking it along in an alternate direction of rotation, the moment of inertia of said central wheel being variable by the variable distance of the displaceable masses from the center of rotation of the flywheel, the flywheel masses of said central wheel being regulatable in their distance to the center of rotation of the central wheel, the flywheel masses of the central wheel closely surrounding the hub of the central wheel in the position yielding the least moment of inertia.

13. A drive for screw presses, comprising a slide, a central friction flywheel including displaceable masses, driven friction elements arranged laterally of the central friction wheel and adapted to be pressed alternately against the central friction flywheel while taking it along in an alternate direction of rotation, the moment of inertia of said central wheel being variable by the variable distance of the displaceable masses from the center of rotation of the flywheel, the flywheel masses of said central wheel being regulatable in their distance to the center of rotation of the central wheel and the limiting positions of said flywheel masses being adjustable.

14. A drive for operating machines including a reciprocable slide, a variable inertia flywheel operatively connected to the slide, reversible power transmission means for driving said flywheel including means for advancing the slide at one speed, and means for returning the slide at a slower speed than that at which it was advanced.

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