(No Model.)

# F. F. NICKEL.

## DIRECT ACTING ENGINE.

No. 451,132. Patented Apr. 28, 1891.

Fig. 1.

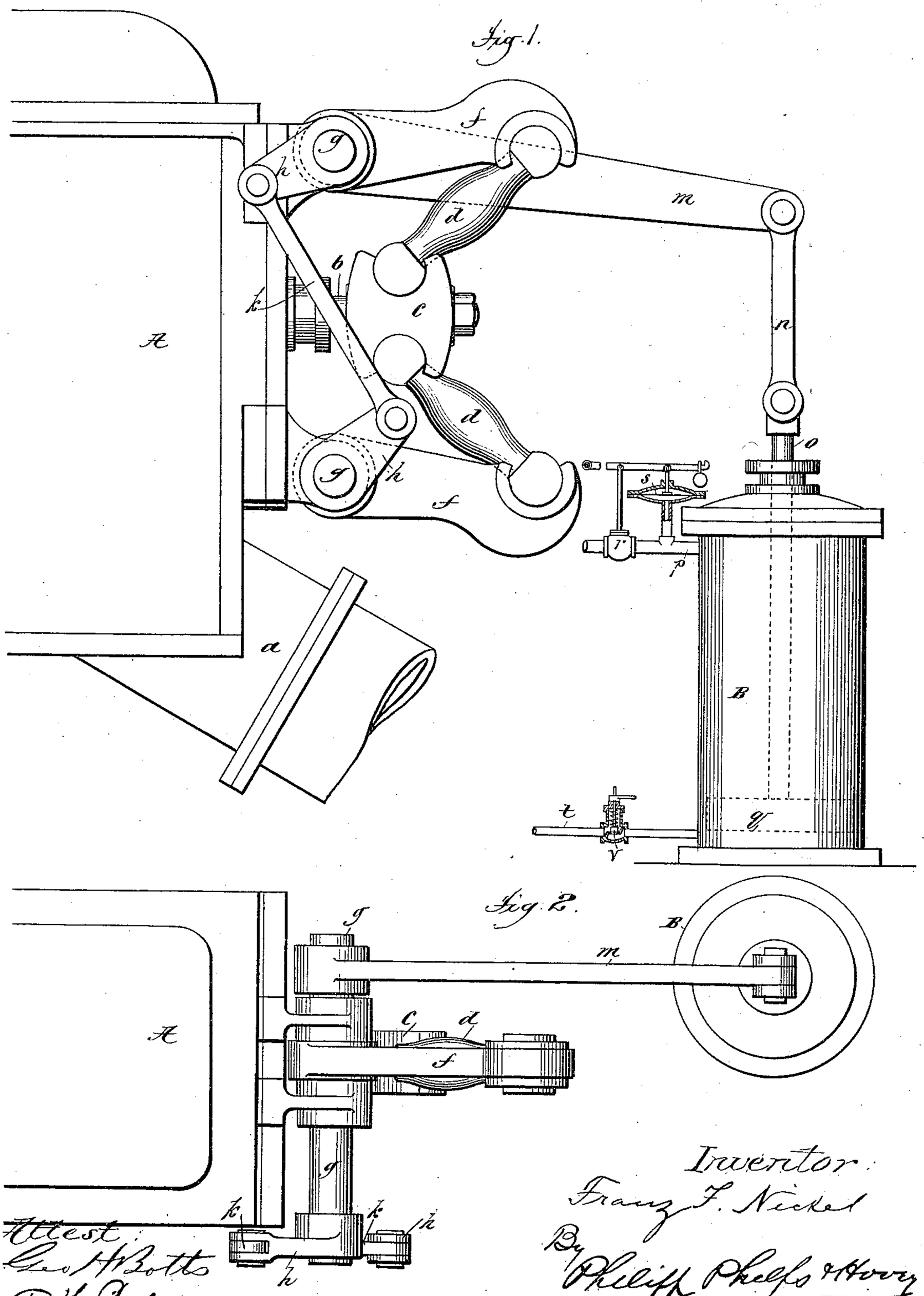


Fig. 2.




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# UNITED STATES PATENT OFFICE.

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## DIRECT-ACTING ENGINE.

SPECIFICATION forming part of Letters Patent No. 451,132, dated April 28, 1891.

Application filed February 4, 1889. Serial No. 298,554. (No model.)

*To all whom it may concern:*

Be it known that I, FRANZ F. NICKEL, a citizen of the United States, residing at Brooklyn, county of Kings, and State of New York, have invented certain new and useful Improvements in Direct-Acting Engines, fully described and represented in the following specification and the accompanying drawings, forming a part of the same.

This invention relates to that class of direct-acting engines in which one or more compensating cylinders and pistons are employed which act in opposition to the main piston during the first part of the stroke and in conjunction therewith during the last part of the stroke, thereby permitting the steam to the main cylinder to be cut off after a part of the stroke has been made, the stroke being completed by the expansive force of the steam in the main cylinder aided by the gradually-increasing assistance offered by the compensating-piston or pistons. Examples of engines of this class are shown in United States Letters Patent Nos. 292,525, 309,676, 332,857, and 341,534.

One feature of the present invention relates particularly to a system of connections by which the power developed by the compensating piston is communicated to the main piston-rod of the engine. In the engines of this class as heretofore operated the pressure of the motor-fluid upon the piston or pistons of the compensating-cylinder or cylinders has been uniform or practically uniform throughout the entire stroke of said piston or pistons in both directions, and from this it has resulted that the decrease and increase in the resistance and assistance offered to the main piston of the engine during the different parts of its stroke has been due entirely to the construction and arrangement of the connections through which the power developed by the compensating piston or pistons was transmitted to the main piston-rod. In practice, however, it is sometimes desirable that the pressure of the motor-fluid upon the compensating piston or pistons should be varied during different parts of its or their stroke in order to produce the best propulsive effect on the engine. Another feature of the present invention relates to a means by which this result can be accomplished.

In the accompanying drawings, Figure 1 is a side elevation, partly in section, of so much of an ordinary direct-acting pumping-engine as is necessary to illustrate the application of the present invention thereto. Fig. 2 is a plan view of the same.

Referring to said figures, it is to be understood that A represents a portion of the water end or pump proper of the engine, *a* being the suction-main. The piston-rod *b* of the engine is extended and passes through the rear end of the water-cylinder, and is provided with a head *c*, having bearings for a pair of arms *d*, the opposite ends of which rest in similar bearings formed in a pair of arms *f*, extending from rock-shafts *g*, mounted in bearings secured to the end of the pump. The shafts *g* are provided with arms *h*, which extend in opposite directions, and are connected by a link *k* in such manner that the two arms *f* move to and from each other simultaneously and that any movement imparted to one of the shafts *g* is communicated equally to the other. One of the shafts *g* (the upper one as shown in the present case) is provided with an arm *m*, which is connected by a link *n* with the piston-rod *o* of a compensating-cylinder B, which is supplied through an induction-pipe *p* with a motor-fluid, the tendency of which is to constantly force the piston *q* of the cylinder downward. The motor-fluid which acts upon the piston *q* may, as explained in the prior Letters Patent before referred to, be steam or air, or may be a liquid, such fluid being supplied under proper pressure in any suitable manner—as, for example, in any of the ways described in said Letters Patent.

The operation of the mechanism as thus far described is as follows: Assuming the parts to be in the position shown in the drawings, and that the engine is about to commence its stroke from left to right, during the first part of the stroke the power developed in the main steam cylinder or cylinders (not shown) will be resisted by the load upon the engine, and also by the pressure of the motor-fluid acting upon the piston *q*, which will be communi-

cated to the main piston-rod *b* through the connections which have been described. This opposition developed by the compensating-piston will, however, owing to the constantly-changing angle of the arms *d*, which form in effect a toggle-lever, gradually decrease until the engine has made one-half its stroke, at which point the arms *d* will be brought into line, and thus offer no opposition to the piston-rod *b*. As the engine proceeds upon its stroke the operation will be reversed, and the pressure upon the compensating-piston will offer a gradually-increasing assistance to the engine. Upon the return-stroke of the engine the operation will be the same. By this means it becomes possible to cut off the admission of steam to the main cylinder or cylinders of the engine after a part of the stroke has been completed and allow the remainder of the stroke to be made by the expansive force of the same, aided by the power developed by the compensating-piston.

In the operation which has been described it will be observed that during the first part of the stroke of the engine the compensating-piston *q* is raised in the cylinder B, thereby tending to expel the motor-fluid from the cylinder, while during the last part of the stroke of the engine the motor-fluid re-enters the cylinder, moving the compensating-piston downward. If the pressure of the motor-fluid which acts upon the piston *q* is uniform, the decrease and increase of the resistance and assistance of the compensating-piston to the engine during different parts of the stroke of the engine will be only such as is due to the change in the angle of the arms *d* or connections through which the piston *q* acts upon the main piston-rod. It is, however, sometimes desirable that the resistance and assistance offered by the piston *q* should vary to a greater extent or in a different manner from the variation produced by the angle of the arms *d*, and to accomplish this it is desirable that the pressure of the motor-fluid upon the piston *q* should be varied during different parts of the stroke of the piston. This can be accomplished in a variety of ways. Two of the simplest ways of effecting this result are, however, illustrated in the present case. In this organization it will be assumed that the motor-fluid which acts upon the piston *q* is air or other elastic gas. The pipe *p*, instead of being permanently open to allow the motor-fluid to flow freely into and out of the cylinder above the piston *q*, is provided with a valve *r*, which is controlled by an ordinary diaphragm-regulator *s*, the diaphragm of which is exposed to the pressure of the motor-fluid in the cylinder B and is connected with the valve *r* in the usual manner, so as to maintain the valve closed and prevent the entrance or escape of the motor-fluid to or from the cylinder B so long as the pressure in the cylinder does not fall below the minimum for which the regulator is adjusted. As soon, however, as the pressure within the cylinder B falls below the minimum for which the regulator is adjusted, the regulator will operate to open the valve *r* and permit the motor-fluid to enter the cylinder from the source of supply until the pressure is restored to the proper point, when the valve will be again closed. From this it will be seen that as the piston *q* is moved upward during the first part of the stroke of the engine the motor-fluid in the cylinder above the piston instead of being forced out of the cylinder, and thereby offering uniform or practically uniform resistance to the piston, is confined in the cylinder, and is consequently compressed by the piston, thereby offering a gradually increased resistance to the piston, and by varying the amount of clearance space in the cylinder above the piston the extent to which the motor-fluid will be compressed, and consequently the variations in its pressure during different parts of its stroke, can be regulated to any extent required. As the piston *q* is moved downward during the last part of the stroke of the engine, the motor-fluid above the piston will expand in the cylinder, thereby exerting a gradually-decreasing pressure upon the piston. The variations in the effective pressure of the motor-fluid upon the piston *q* can be still further increased by so forming the lower end of the cylinder B that a partial vacuum will be formed therein upon the upward movement of the piston, thus gradually decreasing the pressure upon the under side of the piston as it ascends and increasing the pressure as it descends. In some cases this latter means may be all that will be necessary to accomplish the desired variation in the effective pressure of the motor-fluid acting upon the piston *q* during the different parts of its stroke, and in such case the motor-fluid may be allowed to circulate freely into and out of the upper end of the cylinder.

For the purpose of producing the partial vacuum in the lower end of the cylinder as the piston *q* ascends, the lower end of the cylinder is provided with a pipe *t*, having a check-valve *v*, which is so arranged as to allow the air to pass freely out of the cylinder upon the descent of the piston, but to prevent the entrance of air into the cylinder as the piston ascends. The valve *v* will preferably be provided with means by which it can be raised and held permanently away from its seat, so as to permit the air to flow freely into and out of the lower end of the cylinder as the piston ascends and descends when it is not desired to utilize the partial vacuum in the lower end of the cylinder.

What I claim is—

1. The combination, with the main piston-rod *b*, of the arms *d*, acting upon the opposite sides of said rod and against arms *f*, extending from rock-shafts *g*, arms *h*, extending in opposite directions from said rock-shafts and connected by a link *k*, and a compensating

cylinder B, having a piston acting to oppose the movement of the arms *f* from each other, substantially as described.

2. The combination, with the direct-acting engine, of a compensating cylinder having a piston which acts in opposition to the movement of the piston of the engine during one part of the stroke and in conjunction therewith during another part of the stroke, the motor-fluid being admitted to the compensating cylinder on one side of the piston and confined therein during the return-stroke of said piston, and a check-valve located on the opposite side of the piston, opening outwardly to allow the air to pass freely out of the cylinder as the piston moves toward the check-valve, but to prevent the entrance of air on the return-stroke, substantially as described.

3. The combination, with a direct-acting engine, of a compensating cylinder having a piston which acts in opposition to the movement of the piston of the engine during one part of the stroke and in conjunction therewith during another part of the stroke, the motor-fluid being admitted to the compensating cylinder on one side of its piston only, and means for controlling the motor-fluid, whereby the pressure upon the piston is varied at different points of the stroke, substantially as described.

4. The combination, with a direct-acting engine, of a compensating cylinder having a piston which acts in opposition to the movement of the piston of the engine during one part of the stroke and in conjunction therewith during another part of the stroke, the motor-fluid being admitted to the compensating cylinder on one side of its piston only and controlled to exert a gradually-decreasing force on the piston during one stroke of said piston and a gradually-increasing force during the return-stroke, substantially as described.

5. The combination, with a direct-acting engine, of a compensating cylinder having a piston which acts in opposition to the movement of the piston of the engine during one part of the stroke and in conjunction therewith during another part of the stroke, and means for controlling the motor-fluid of the compensating cylinder, whereby a gradually-decreasing force is exerted by the motor-fluid upon the piston of the compensating cylinder during one stroke of said piston and a gradually-increasing force during the return-stroke, substantially as described.

6. The combination, with a direct-acting engine, of a compensating cylinder having a piston which acts in opposition to the movement of the piston of the engine during one part of the stroke and in conjunction therewith during another part of the stroke, and means for confining the motor-fluid in said compensating cylinder, so as to be permitted to expand during one stroke of its piston and compressed by said piston during the return-stroke, substantially as described.

7. The combination, with a direct-acting engine, of a compensating cylinder having a piston which acts in opposition to the movement of the engine during one part of the stroke and in conjunction therewith during another part of the stroke, the motor-fluid being admitted to the compensating cylinder on one side of its piston only, a valve controlling the motor-fluid supply, and a regulator controlled by the pressure in the cylinder to normally close the valve to confine the motor-fluid in the cylinder, but operated to open and admit the motor-fluid when the pressure falls below the point desired, substantially as described.

In testimony whereof I have hereunto set my hand in the presence of two subscribing witnesses.

FRANZ F. NICKEL.

Witnesses:
B. W. PIERSON,
J. F. HOLLOWAY.