DRILLING MACHINES

Serial 2219 Edition 1

CONSTRUCTION OF MACHINES AND ATTACHMENTS

DESCRIPTIONS OF DRILLING MACHINES

INTRODUCTION

1. Scope of Drilling Practice.—Besides the making of the holes themselves, drilling practice includes the operations of reaming, threading, boring, counterboring, facing, etc. The equipments for drilling include drilling machines, the cutting tools, and the devices for attaching them to the machines, and the work supports and holding devices. The examples of drilling machines described in this Section are selected from the numerous portable and stationary types built in the United States. For notices relating to the many other designs of similar types, see the advertising pages of periodicals devoted to machine shop practice.

2. Requirements of Drilling Machines.—The machine for the operation of the various cutting tools used to make and to finish holes in all kinds of products has been developed from the earliest and crudest devices to what today is one of the master tools of industry. Competition in production demands drilling machines that will produce the most holes per drill, per day, and per operator. This development of the drilling machine has been caused by the constant demand for greater and greater speeds and for more and more power. These two demands require heavier and stiffer machine frames so that the operation will be smooth and steady and free from spring and vibration. Furthermore, all the running parts must be in perfect balance and they must be supported by bearings that are as frictionless as possible, are capable of fine adjustments, and have means for adequate lubrication. The machines must be adapted to receive attachments that will relieve the operator from fatigue and at the same time produce duplicate work with the utmost precision. All the machine controls and the tool-holding and changing devices must be designed and located with unusual care. Therefore, the modern drilling machines have their hand levers and the electric switches and other controls in the best possible locations and have a means to protect the operator, the work, and the cutting tools from injury. Furthermore, there must be a solid support for the work, with safe, sure, and easily operated holding and clamping devices.

PORTABLE DRILLING MACHINES

3. Classification of Portable Drilling Machines.—The smallest and simplest drilling machines are the portable types, which are operated by hand or power. Most of these machines can be carried about by one man and operated on work that is too large to be taken to stationary drilling machines or handled on them. Portable drilling machines are known as *ratchet*, *air* or *pneumatic*, *electric*, and *flexible shaft drills*. Some of the larger, or stationary, drilling machines are also designed for portable use.

4. Ratchet Drilling Machines.—The hand-operated ratchet drilling machine of the type shown in Fig. 1 is the slowest kind of portable machine, but there are occasions where no power is available or where more expensive machines cannot be considered. A brace is needed to support a ratchet drill. This brace may consist of a base *a*, an upright *b*, and an adjustable arm *c* that is held by a binding screw *d*. The base is made fast to the work *e* by means of a bolt *f* or clamp *j*, as shown. The arm *c*, which has a number of center holes in its lower face, is set to such a height that the ratchet drill will go under it. The machine is either set square with the work, or so that it will lean slightly away from the upright *b* at the top, as the pressure upwards on the arm *c* tends to spring the upright backwards at the top and so draw the drill *g* into a perpendicular position. The chain attachment, Fig. 2, is largely used for supporting a ratchet drill, because it is quickly applied and adjusted to the work.

5. Operation of Ratchet Drilling Machine.—After setting the point of the drill *g*, Fig. 1, into a punch mark that locates

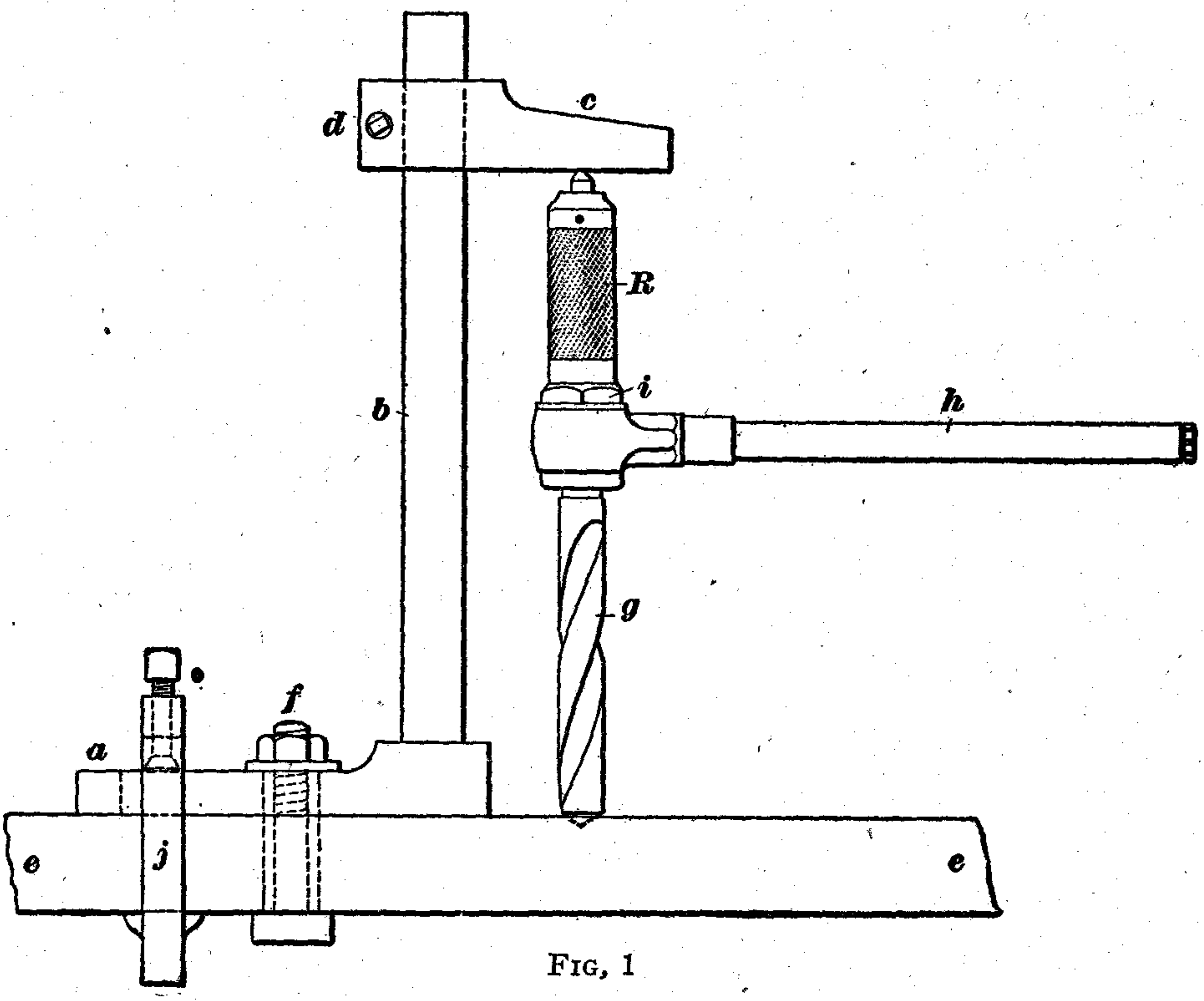

FIG. 1

the desired hole in the work *e*, the nurled sleeve screw *R* is revolved by hand until the center enters one of the center holes in the arm *c*, and the sleeve *R* is then turned slowly and continually while the machine is being operated so as to create the pressure that will feed the drill *g* into the work. The drill is operated by giving a back and forward motion to the handle *h*, which grips the drill socket *i* during the forward movement and thus revolves the drill *g*. On the backward motion of the handle *h* a ratchet in the socket *i* permits a free motion of the handle *h* without any action on the drill *g*. Then on the next forward motion the ratchet acts on the drill socket so as to give the drill *g* an additional part of a turn.

6. Crank-Driven Portable Drilling Machine.—The crank-driven portable machine shown in Fig. 3 operates much faster than the ratchet machine but requires more room to set it up. It is clamped to the work, or bench *a*, and is operated by a crank *b* that gives a continuous motion to the drill *c*. The feed is operated by turning the hand wheel *d* with one hand, and the crank is turned by the other. The sleeve *e*, carrying the bracket *f*, may be adjusted to varying heights and positions on the upright *g*, being clamped in position by the screw *h*. The bracket *f* may be set to drill vertically or at any angle by adjusting the part *i* on its bearing, and clamping it in position by the handle *j*.

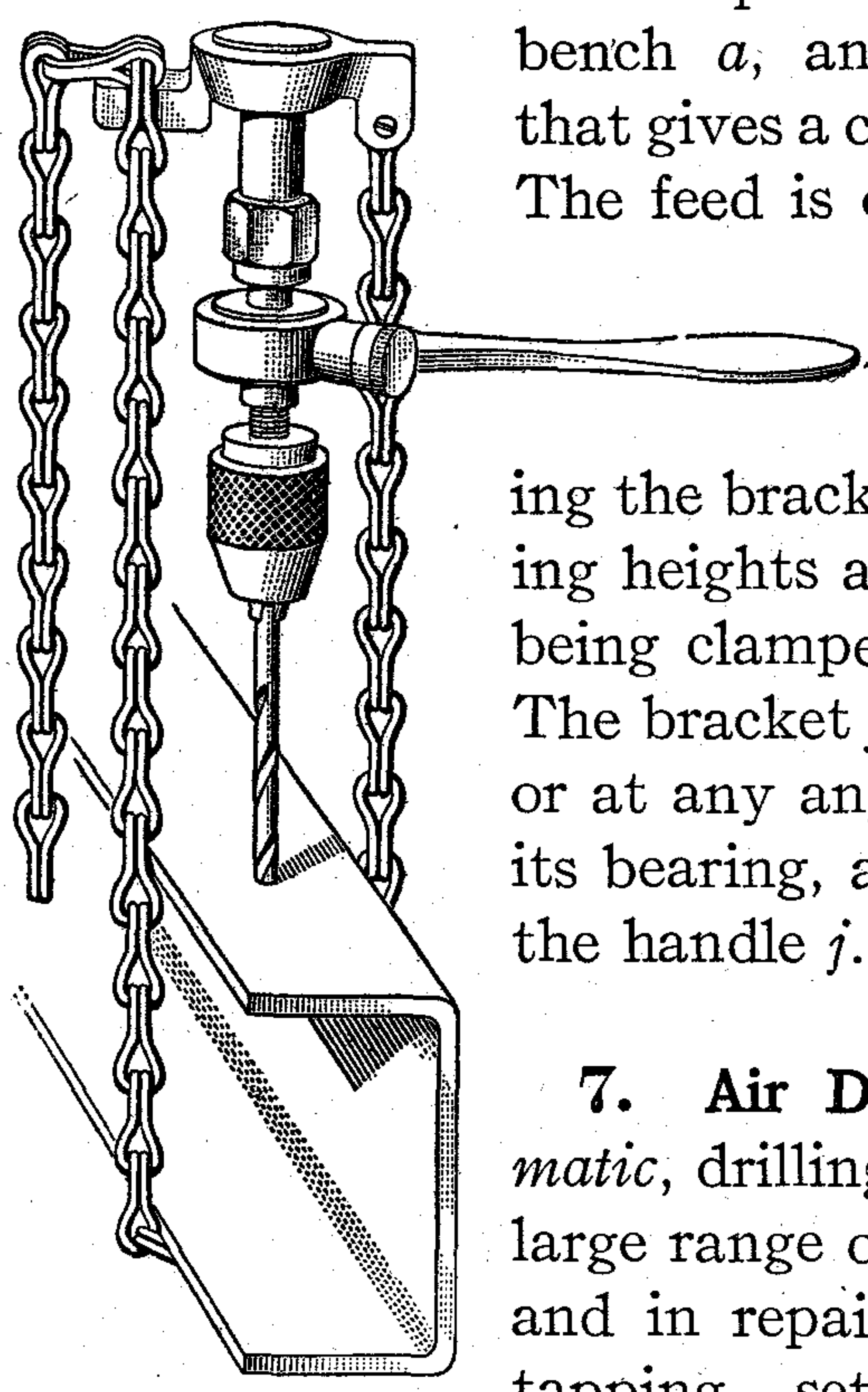

FIG. 2

7. Air Drills.—Portable air, or *pneumatic*, drilling machines are used for a very large range of work both in manufacturing and in repair shops for drilling, reaming, tapping, setting nuts and screws, etc. Air pressures of from 80 to 100 pounds per square inch are used in these machines. They vary in size from the single-hand and breast machines weighing 10 pounds or less up to the two-man ones that weigh 75 pounds or more. Aside from their size, these machines are made in two types known as the *reversible* and the *non-reversible*. The reversible type is required where the tool must be revolved backwards in order to take it out of the hole, as when tapping, removing screws, deep drilling where the drill sticks, and the like. One class of air drills operates by means of a rotor with one or more vanes to direct the air pressure in turning the spindle of the machine. The speed reduction, if any, to the tool spindle is by means of gears. The other class of air drills has either three or four single-acting pistons that drive a crank-shaft that is geared to the tool spindle. The gears run in grease.

8. Piston Air Drills.—Small piston-drive air drills are used on a great variety of light work, such as, for example, the running and the removing of capscrews as required in automobile engine erection and repairing. The four-cylinder sizes are applicable to the heavier machining operations.

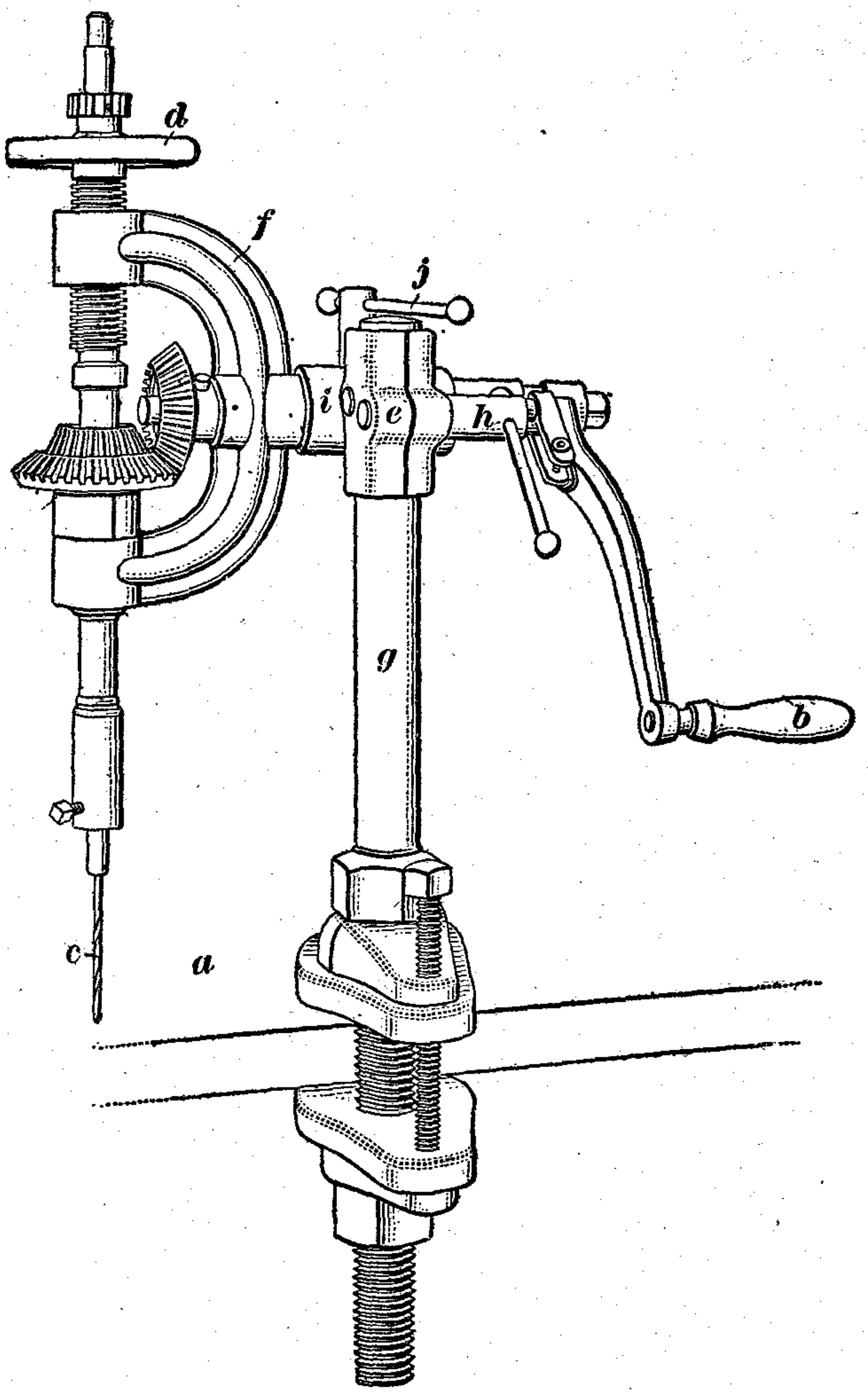

Fig. 3

The general appearance of a four-cylinder air drill is shown in Fig. 4. Two of the cylinders are shown at *a* and *b*, and the two opposing ones at *a′* and *b′* on the opposite side of the casing *c*. The four pistons are connected in pairs to two cranks on the shaft that drives the drill spindle *d* by means of a train of gears that operate the spindle at a lower speed than the crank-shaft. Air is conveyed to the machine by an armored rubber hose attached to the hollow handle *e*. The sleeve *f* that forms part of the handle controls the flow of air, being twisted in one direction to admit air and in the opposite direction to shut it off; an additional twist reverses the drill.

9. Mechanism of Four-Cylinder Air Drills.—The arrangement of the four-cylinder air drill, Fig. 4, is shown in Fig. 5. The four pistons *a*, *b*, *c*, and *d* in view (*a*) are connected in pairs to the two cranks of the shaft *e* that is mounted in the two ball bearings *f* and *f′*. A helical pinion *g* drives the large gear *h* and also the smaller gear *i* below and attached to *h*. The gear *i* causes the three equal pinions *j* to revolve, these pinions being set on pins attached to the spider *k* that is part of the spindle *l*. The pinions *j* mesh with a stationary internal gear like that shown in (*b*); the outside view of this gear is shown at *g* in Fig. 4. As the pinions *j*, Fig. 5, are forced to revolve by the central gear *i*, the pinions will travel around in the internal gear, carrying the spider *k* and drill spindle *l* with them, thus causing the drill or other tool set in the spindle to revolve. The type of gear train that consists of a central gear, as *i*, for its driver and a set of pinions *j* on a revolving spider or yoke *k*, and having the pinions meshing with a fixed internal gear is called a *differential train*. It gives a large reduction of speed between shafts, and is used where the space is very limited.

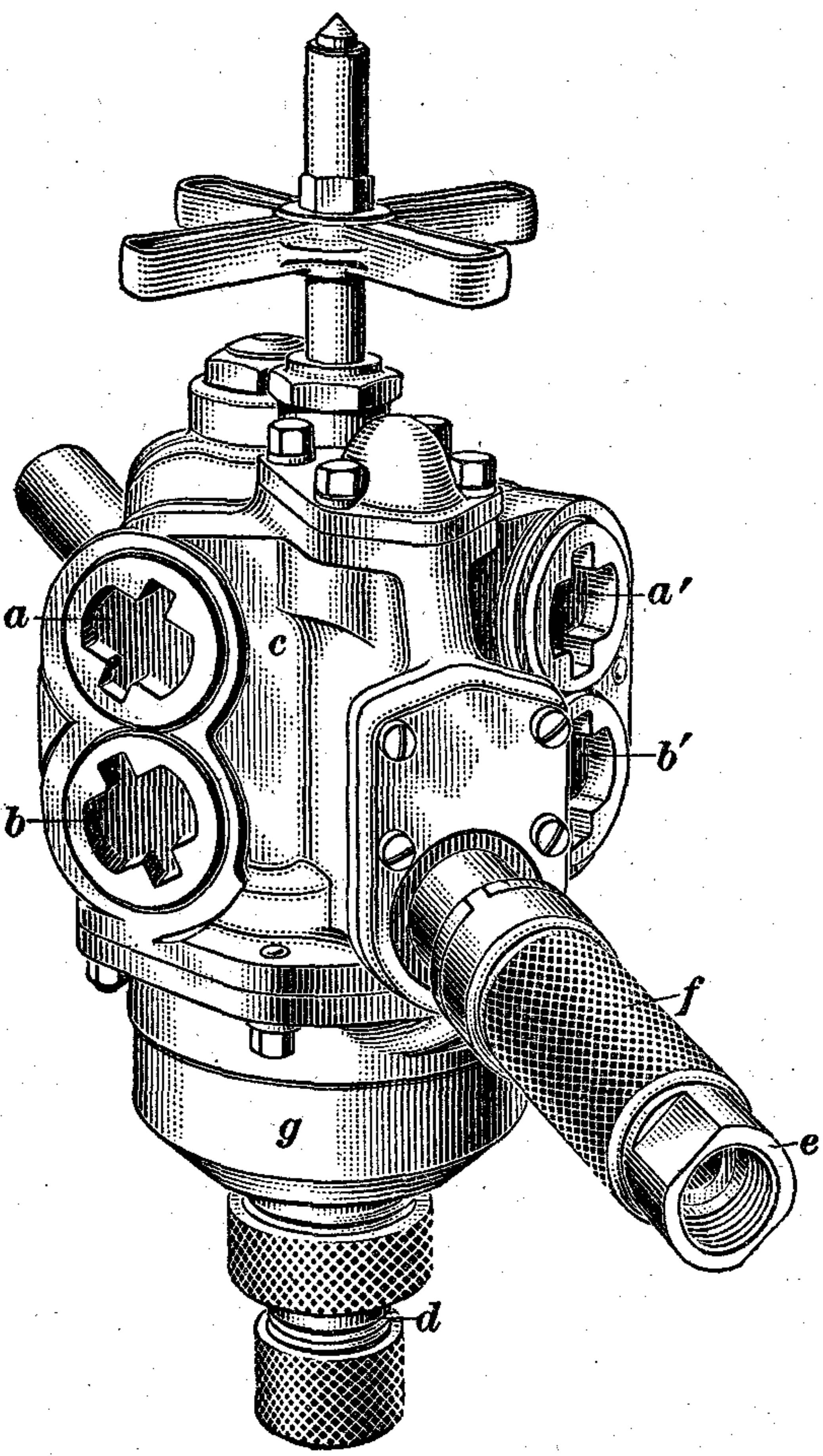

FIG. 4

On top of the gear *h*, Fig. 5, is a narrow gear *m* that drives the pinion *n* on the rotary valve *o* with its governor *p*. The valve *o* has rectangular openings *q* through it, and pockets *r* cut into its surface, for the purpose of directing the compressed air into the cylinders of the machine and exhausting it from them. The governor *p* has two circular arms *t* and *t′* hinged in *p* and held in a closed position by a coiled spring that is laid in a groove in the arms as shown. The inner edges of the arms form a cover for the hole *v* through which the air exhausts from the cylinders. The governor checks the speed of the drill when it is running under a light load or no load. The free ends of the arms *t* and *t′* move outwards from the action of centrifugal force as the speed of the governor increases. The coil spring limits the motion of the arms. The inner ends of the arms close the air opening *v* to whatever extent is necessary to speed the drill properly.

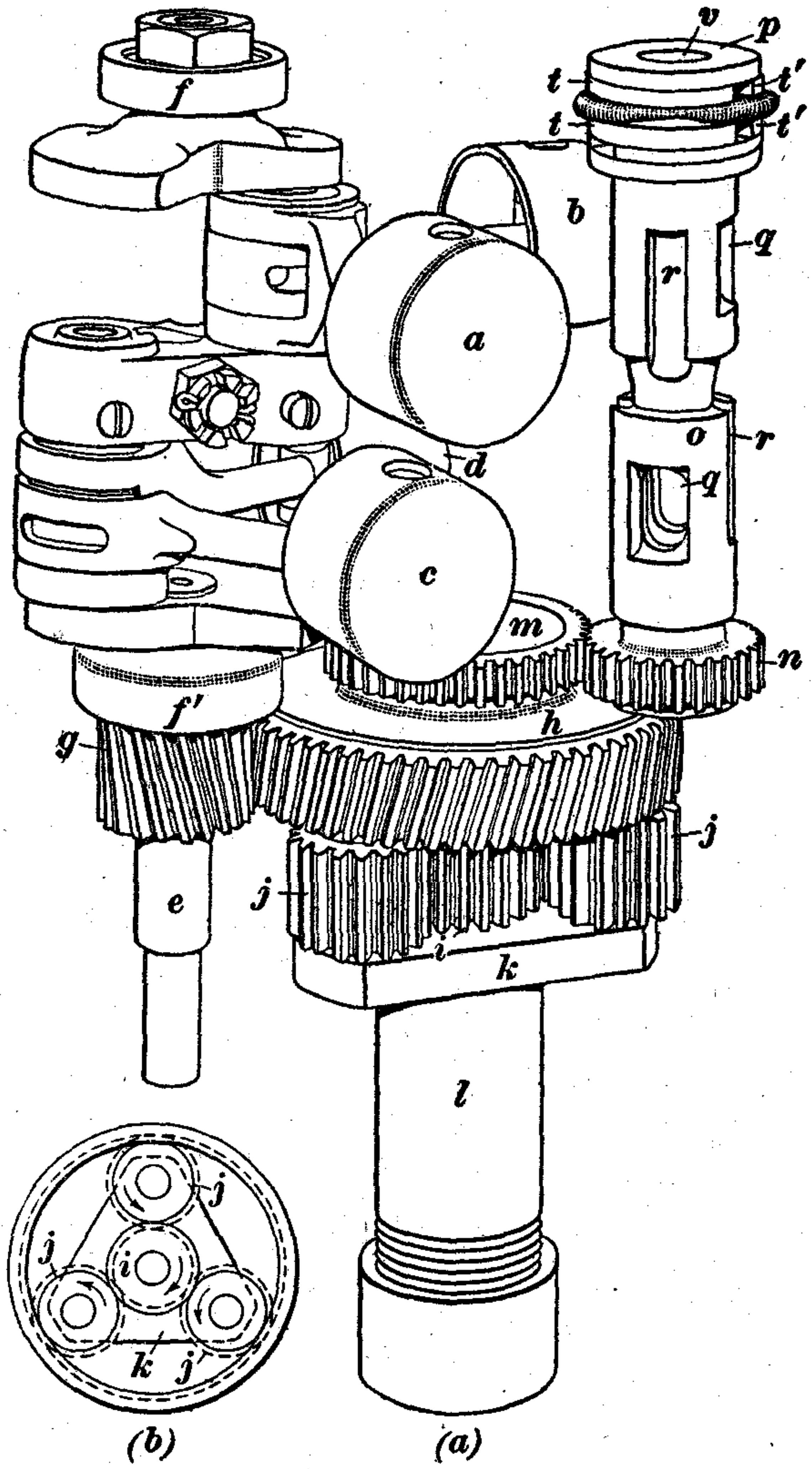

Fig. 5

10. Rotor Air Drills. The rotor class of air drills is reversible, light of weight, and operates at speeds that may range from about 500 to 1,500 revolutions per minute. The general appearance of one make of rotor drilling machine is shown in Fig. 6 (*a*). It consists of a rectangular casting *a* bored with a round hole and called the cylinder, a handle or breastplate *b*, two straight handles *c* on opposite sides of the bearing frame *d*, and a spindle having a No. 2 Morse taper socket *e* for holding the chuck or drills. The air hose is attached to one of the handles, as at *f*, and the rotary sleeve of this handle serves for a throttle valve.

11. Mechanism of Rotor Air Drill.—The arrangement of the three moving parts of a rotor air drill is shown in views (*b*), (*c*), and (*d*) of Fig. 6. The moving parts are the spindle *g* with its two eccentric rotors *h* keyed to it in opposite positions, as shown in view (*b*), and the two rotor blades *i*. Views (*c*) and (*d*) are cross-sections through one of the rotors *h*. The

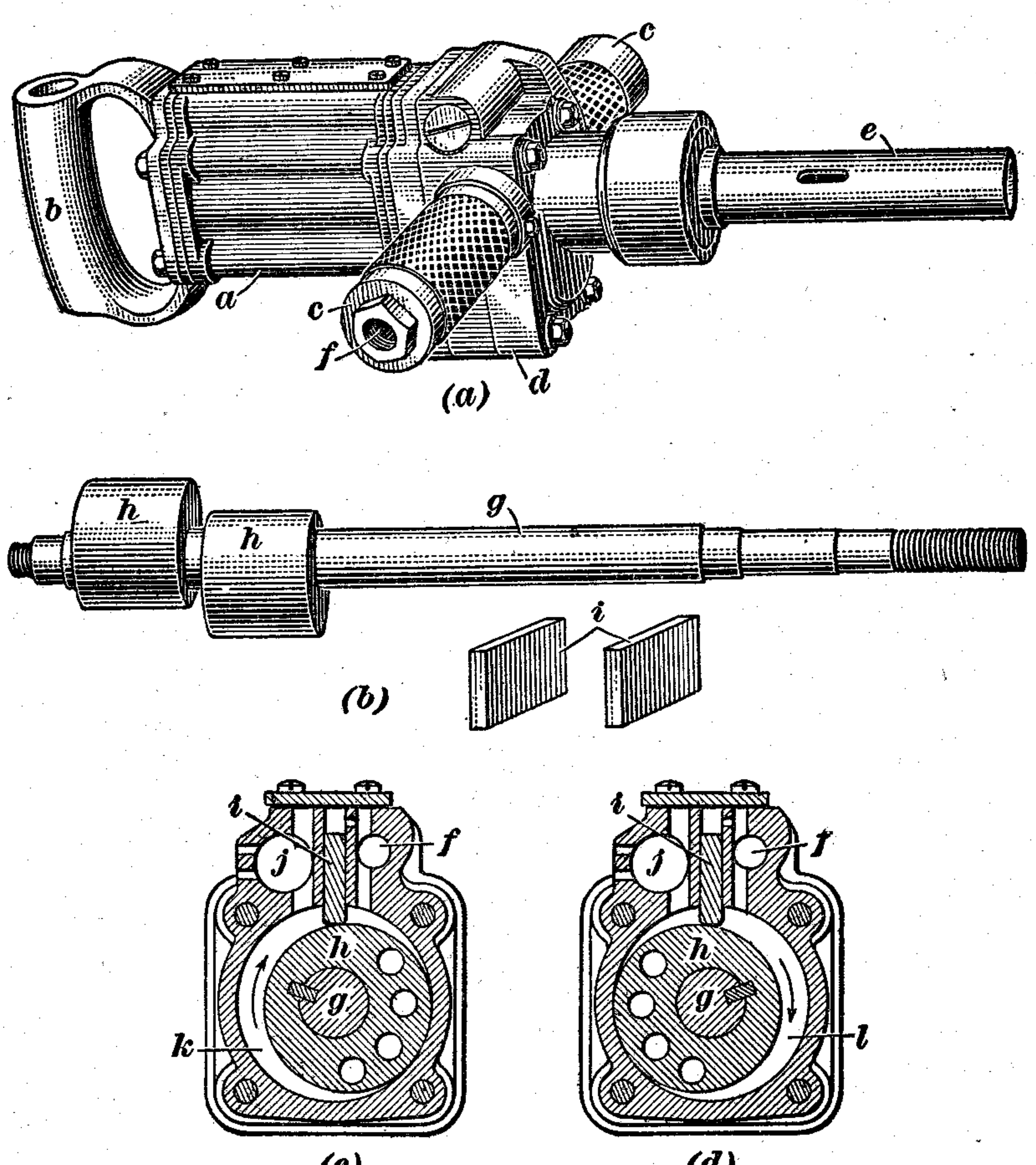

Fig. 6

compressed air enters through the top of the cylinder at *f* and fills the space above the blade *i* so that the blade always makes contact with the rotor *h* and prevents the air from escaping directly from the inlet *f* to the exhaust port *j*. As the long side of the rotor *h*, view (*c*), receives the air pressure, the rotor will start revolving to the right as indicated by the arrow. During this time the previous charge of air is being exhausted from the space *k*. View (*d*) shows the power stroke nearly completed with the full charge of compressed air in the space *l*. The other rotor acts in a similar way but in opposite order, so that there is a rotary effect on the spindle at all times. A centrifugal governor is used to prevent the spindle from racing.

12. Electric Drills.—Electric drills are the most used of any of the power-driven portable machines. They are made in sizes ranging from the tiny dentist's machine to the largest kind of portable. The electric motor is entirely enclosed in

FIG. 7

the frame of the machine and the handles are most conveniently arranged for holding and applying the machine to the work and for starting and stopping the motor.

In Fig. 7 is shown one form of portable electric drilling machine held by both hands of the operator while drilling a vertical hole, such as that in the frame of a motor truck. There is a breast plate *a* on the top of the case so that when drilling horizontal holes the machine can be supported and forced against the work by the body of the operator.

13. Details of Portable Electric Drilling Machines.—The arrangement of the working parts of a portable electric drilling machine is shown in Fig. 8. The electric cable *a* is attached to the pistol grip and trigger switch handle *b*. The rotating armature *c* of the direct-current motor is supported in ball bearings *d* and *e* at each end of its shaft. As the armature of a small electric motor revolves at a much higher speed than the cutting point of a drill can stand, it is necessary to reduce the speed of the machine spindle, which is done by the use of six gears as shown. The pinion *f* on the armature shaft is quite small, as is each of the other driving gears *g* and *h*, while the driven gears, or followers, *i*, *j*, and *k* are much larger, giving gradual reductions in the shaft speeds. The armature pinion *f* drives the large gear *i*, which is on the same shaft as the small gear *g* that drives the large gear *j* on the second shaft. The gear *j* is attached to the small gear *h* that operates the gear *k*, which is the largest of the set, and which is on the machine spindle *l*. The spindle is supported in two plain bearings *m* and *n* and has a thrust ball bearing *o*, which carries the pressure that forces the cutting point of the drill into the work. The gearing is enclosed so that it can be lubricated with grease. A fan *p* operates at the armature-shaft speed and serves to keep the motor cool by ejecting the warm air and drawing in cool air through the openings *q*. The second handle consists of a piece of pipe *r* screwed into the frame opposite the pistol grip handle *b*, and the breast plate handle *s* is attached to the removable cover *t* of the commutator end of the motor. Alternating-current motors are also used in drilling machines.

14. Flexible-Shaft Drills.—A very convenient form of portable drilling machine is that in which the power is transmitted from the operating mechanism to the cutting tool by means of a *flexible shaft*. This shaft ranges in its use from that required on the smallest of drilling machines to the medium portable types. Flexible shafts are operated by electric motors, air motors, belt and rope drives, etc. In Fig. 9 (*a*) is shown a flexible-shaft drilling machine with a

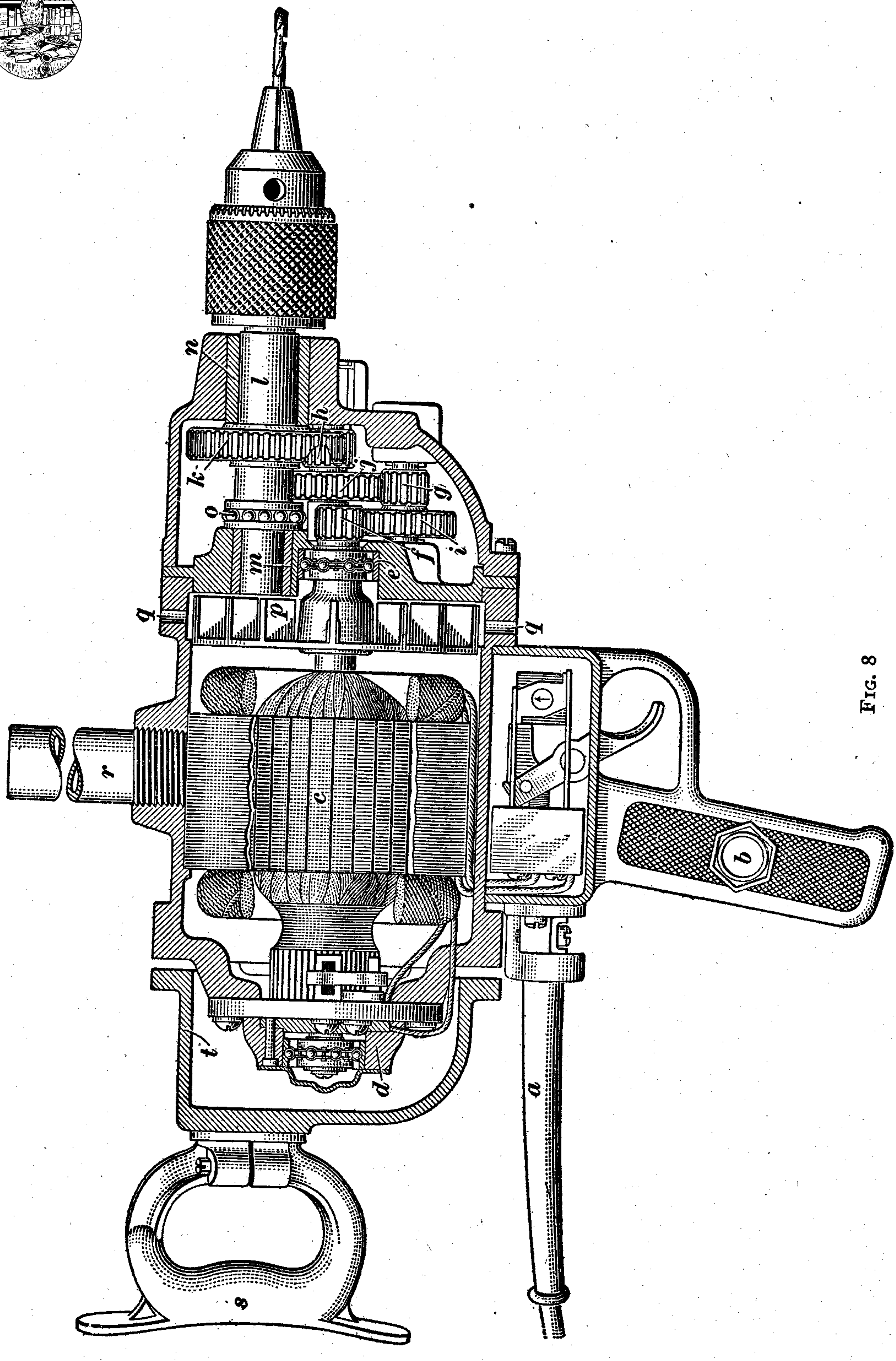

FIG. 8

direct-connected electric-motor drive that may have any form of movable support that is most convenient for the drilling operations. The motor *a* is pivoted in a ring *b* at the point *c* and a point opposite to *c*. The ring *b* is then pivoted in a sling *d*, the two pivots *e* being located 90 degrees from

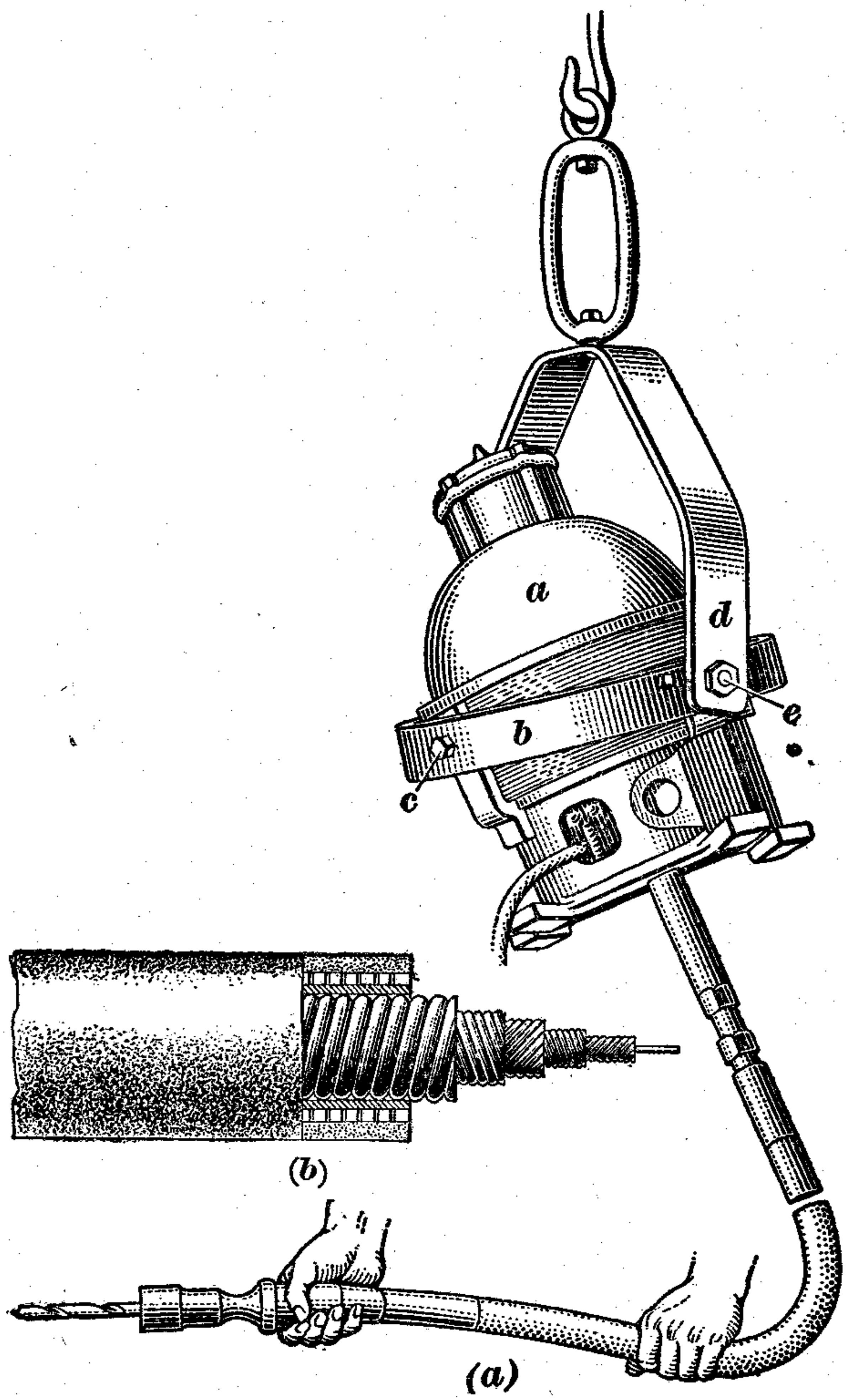

FIG. 9

those of the motor. This arrangement permits swinging the balanced motor in any direction most convenient for the drilling operation. The construction of the flexible shaft is shown in (*b*). The shaft is made up by winding successive layers of steel wire in opposite directions about a center wire. It is enclosed by a leather or metal shield.

STATIONARY DRILLING MACHINES

15. Introduction.—Stationary drilling machines include a great variety of designs that are either belt-driven with speed changes by the use of cone pulleys, motor driven with gear-box speed changes, or driven by variable speed motors. A single motor may be used for the whole machine, but on some of the larger types an individual motor is used on each division of the mechanism.

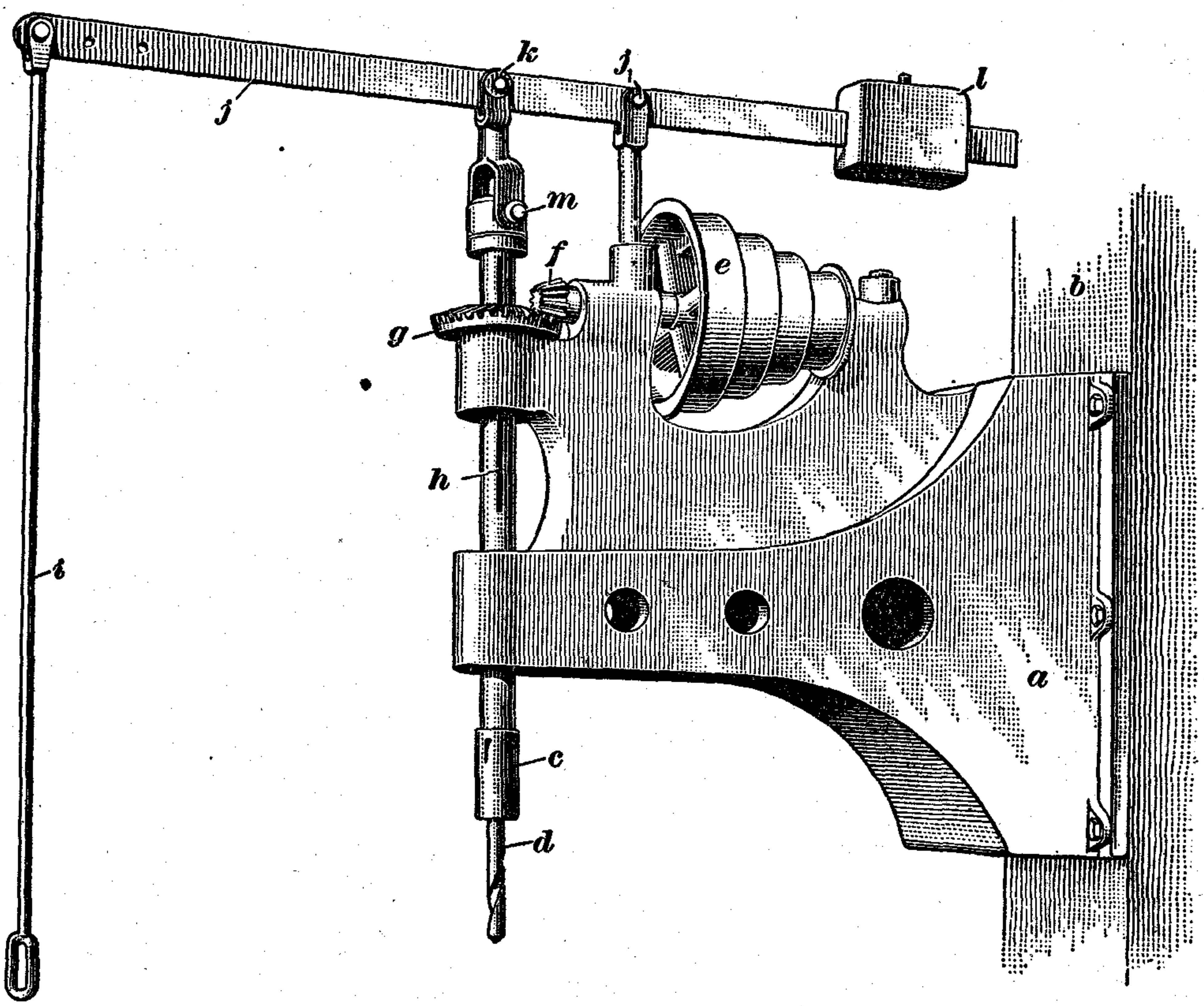

FIG 10

16. Post Drilling Machines.—Post drills are the simplest form of stationary machines. One form of post drill is shown in Fig. 10. The frame *a* of the machine is fastened to a post *b* by bolts, and the spindle *c*, in which the drill *d* is held, is driven by a cone pulley *e* that is belt-connected to a similar cone pulley on an overhead drive shaft. The purpose of the cone pulleys is to permit changing the speed of the spindle. The bevel gears *f* and *g* connect the horizontal cone-pulley shaft to the vertical spindle *c*. The gear *g* has a large hub and bearing in the top of the machine frame. In order that the spindle may slide through the gear *g*, so as to follow the cutting point of the drill and at the same time be revolved by the gear *g*, the spindle has a long keyway, or *spline*, *h*. There is a driving key attached to the gear *g* and the spline has an easy sliding fit on this key.

The spindle is raised or lowered by hand by the pull rod *i* jointed to the lever *j* that fulcrums at j_1, and which is attached to the spindle *c* by the link pinned at *k* and *m*. A counterweight *l* balances the weight of the spindle and the rod *i* and holds the cutting tool clear of the work when the operator is not pulling down the rod *i*. A table or some support must be provided to hold the work while the drilling is being done.

17. Column Drilling Machines.—The column, or upright, drilling machine, or drill press, one form of which is shown in Fig. 11, is used on a very large variety of work. The column *a* forms the main part of the machine. It is held upright by a heavy floor plate *b* that is used also as a support for large work. An arm *c* is carefully fitted on the lower part of the column and carries a table *d* on which the work is held. The arm may be swung around the column; also, it may be moved up or down by turning the crank *e*, which drives a small pinion that meshes with the rack *f*. The rack is free to slide around the column as the arm is swung, but it is prevented from moving up or down by the shoulders between which it fits. The table can be turned on a pin by which it is held in the end of the arm *c*. Both the table and the arm may be held in position by clamping screws.

The machine is driven from a countershaft or a line shaft by a belt that runs on the pulley *g* on the same shaft as the cone pulley *h*. This belt is shifted to the loose pulley *i* when the drill is to be stopped. From the cone *h* a belt runs to a similar cone *j* at the top. When the belt is on the largest pulley of the lower cone and the smallest pulley of the upper cone, the drill spindle *k* has its greatest speed; and it runs at its slowest speed when the belt is on the smallest pulley of the lower cone and the largest pulley of the upper cone. The upper cone drives the spindle *k* through a short horizontal shaft *l* and the bevel gears *m*.

18. Back Gearing of Column Machine.—The driving shaft *l*, Fig. 11, is made in two parts that may be connected

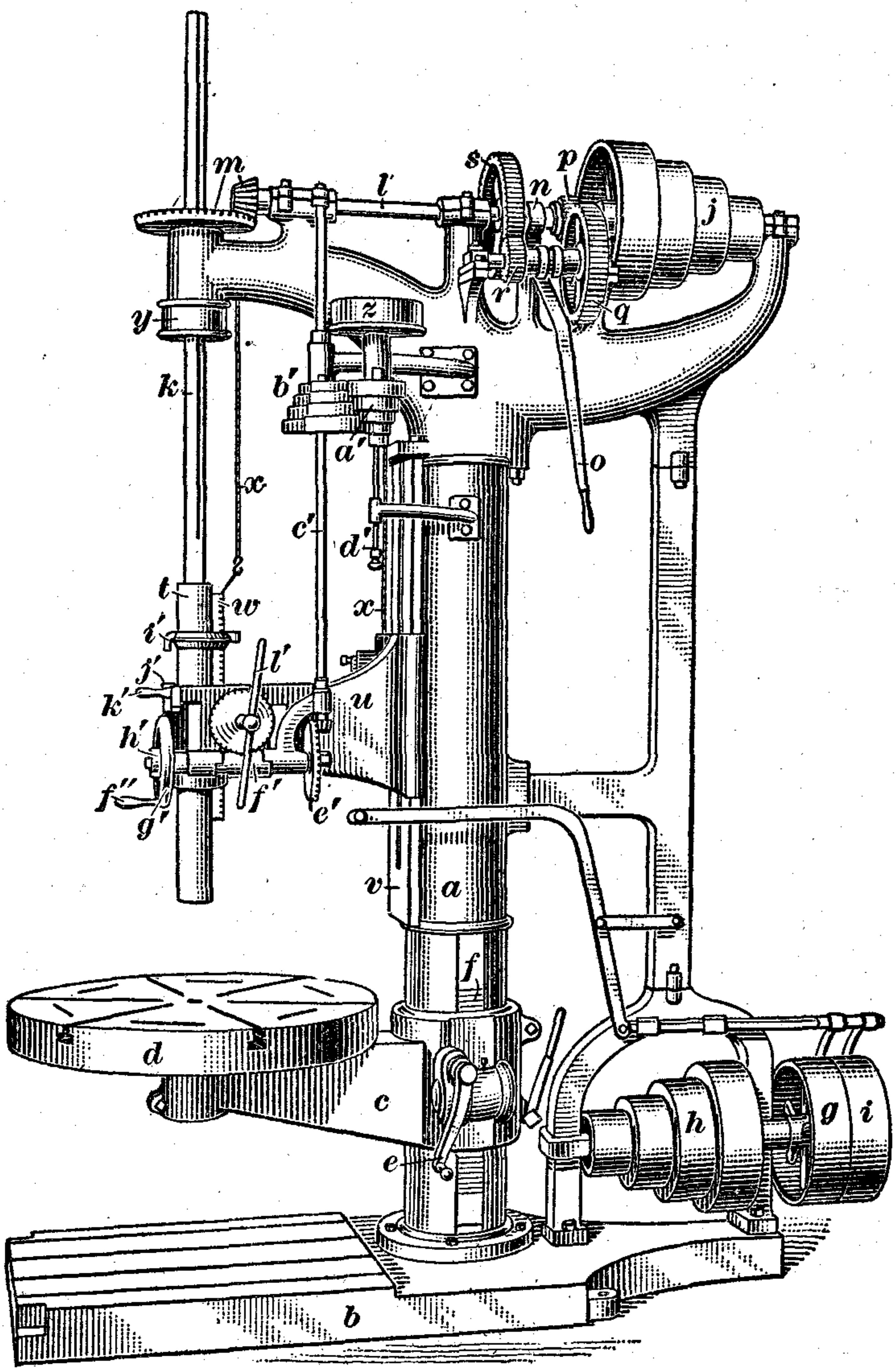

Fig. 11

or disconnected by moving the clutch *n* by means of the handle *o*. A small gear *p* is fastened to the driving shaft near the cone pulley and meshes with the large back gear *q*, which thus turns at a slower speed than the gear *p*. The back gear *q* is fixed on a quill, or sleeve, that has a small gear *r* at its other end, and the gear *r* meshes with a gear *s* on the shaft *l*. The