B. V. NORDBERG.

VARIABLE CAPACITY COMPRESSOR.

APPLICATION FILED SEPT. 8, 1903.

1,047,977.

Patented Dec. 24, 1912.

2 SHEETS—SHEET 1.

Fig. 1

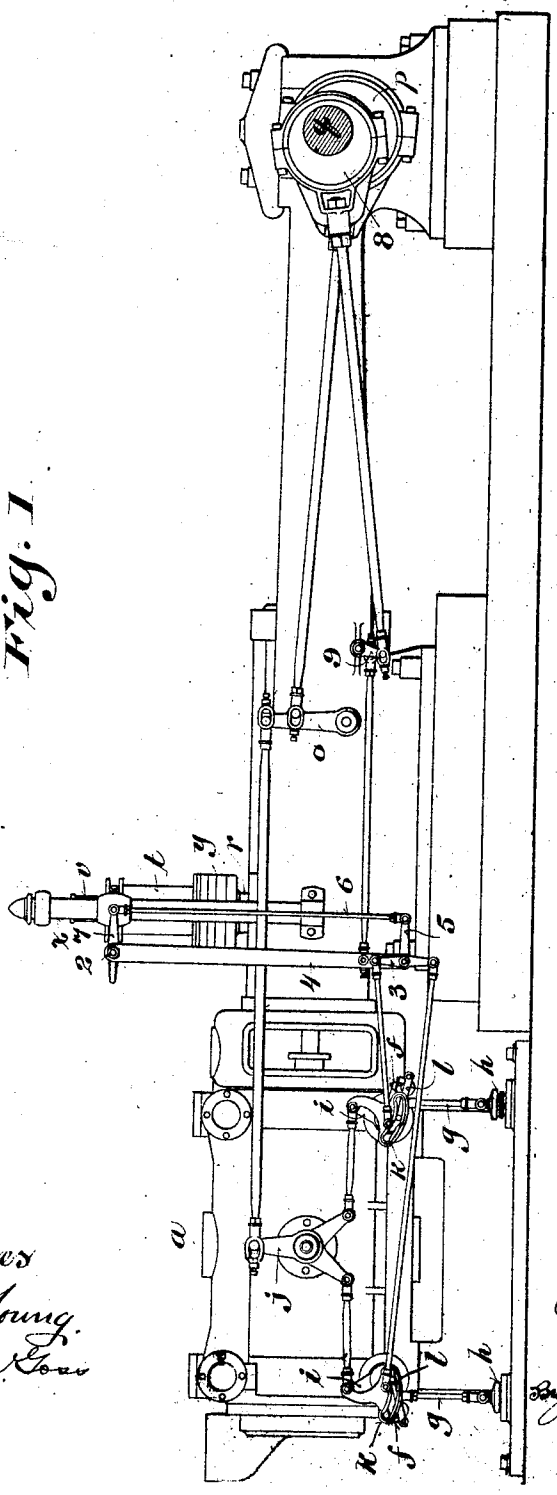
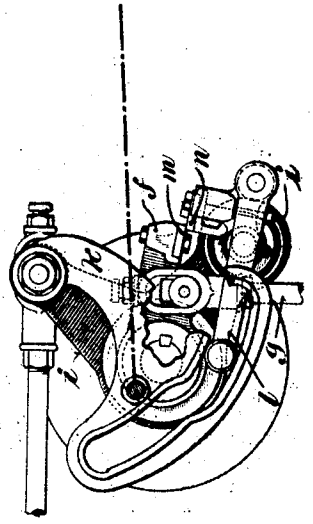


Fig. 2



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2 SHEETS—SHEET 2.

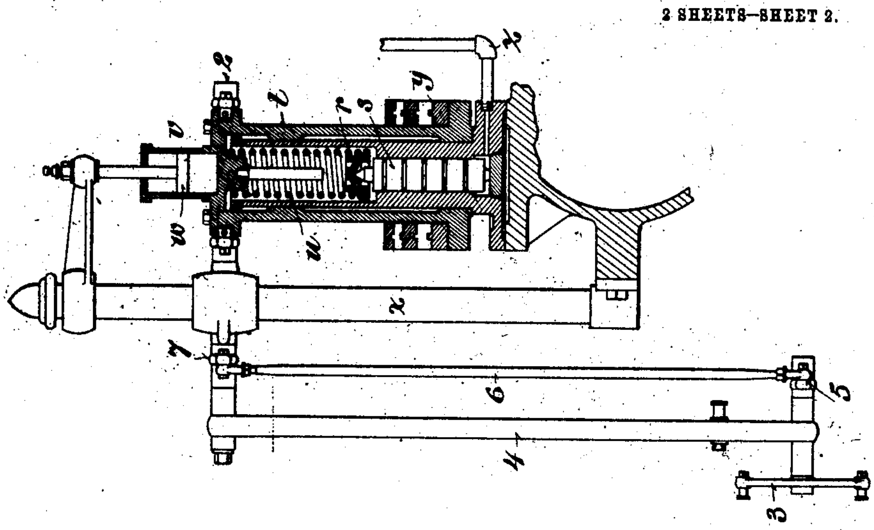

Fig. 4.

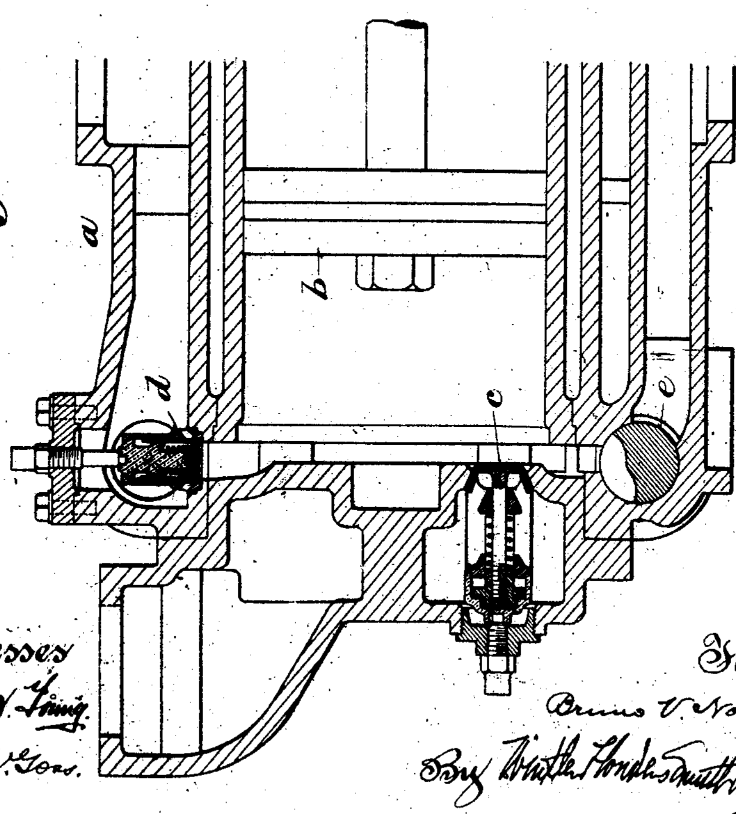

Fig. 3.

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UNITED STATES PATENT OFFICE.

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VARIABLE-CAPACITY COMPRESSOR.

1,047,977. Specification of Letters Patent. Patented Dec. 24, 1912.

Application filed September 8, 1903. Serial No. 172,367.

To all whom it may concern:

Be it known that I, BRUNO V. NORDBERG, a citizen of the United States, residing at Milwaukee, in the county of Milwaukee and State of Wisconsin, have invented certain new and useful Improvements in Variable-Capacity Compressors, of which the following is a specification, reference being had to the accompanying drawing, forming a part thereof.

The main object of this invention is to automatically vary the volume of air compressed and discharged by a compressor running at a constant speed, according to fluctuations in the demand for compressed air or gas.

It consists in certain novel features of construction and in the peculiar arrangement and combinations of parts hereinafter particularly described and pointed out in the claims.

In the accompanying drawing like characters designate the same parts in the several figures.

Figure 1 is a side elevation of a compressor embodying the invention; Fig. 2 is a detail view on an enlarged scale of automatic valve gear for operating the exhaust or auxiliary outlet valves; Fig. 3 is a vertical longitudinal section on an enlarged scale of one end of the compressor cylinder and of one set of valves, the valves being duplicated at the other end of the cylinder; and Fig. 4 is a vertical medial section on an enlarged scale of the pressure regulator.

Heretofore in some instances the volume of air or gas delivered by a compressor running at a constant speed has been varied either by throttling the whole volume of air before it enters the cylinder, thereby reducing its density, or by unloading the compressor, which has been accomplished either by establishing communication between the interior of the cylinder and the atmosphere, or by establishing communication between the ends of the cylinder, thereby stopping the delivery of air altogether. The first method is objectionable because by throttling the air, the work of compression is increased above that necessary to compress the same quantity of air from atmospheric pressure to the required pressure. The second method is objectionable because the whole load of the compressor is put on or thrown off, thereby subjecting the motor, which in most cases is either an electric motor or a water wheel, to extreme variations of load, it being very difficult, if not impossible, to govern the speed of such motors under such extreme variations of load. By the method and means of regulation herein shown and described the load is increased or decreased in exact proportion to the demand for compressed air or gas, the compressor running at a constant speed.

Referring to Fig. 3, which illustrates a construction and arrangement of compressor cylinder and valves suitable for the attainment of the above stated object, *a* is the cylinder, *b* the piston, *c* one of the automatic suction valves, *d* one of the automatic discharge valves, and *e* one of the exhaust or auxiliary outlet valves. The suction and discharge valves *c* and *d* are of the ordinary or any suitable type of spring seated puppet valves, and the outlet valves *e* are preferably of the semi-rotative Corliss type. The exhaust valves *e* may be operated by any full stroke automatic valve gear of the Corliss type, such for example as is shown in United States Letters Patent No. 680,667, granted to me August 13, 1901. I have shown for the purpose, and will briefly describe, valve gear essentially like that shown and described in my former patent in principle and mode of operation, but slightly modified to adapt it to my present purpose.

Referring to Figs. 1 and 2, *f* are the valve closing arms fixed on the stems of the valves *e*, and connected by rods *g* with the pistons of dash pots *h*. *i* are the valve opening arms loosely mounted on the valve stems and connected by rods with a wrist lever *j*. *k* are trip cams pivoted to the arms *i*, and *l* are trip arms also pivoted to said arms *i* and having crank pins engaged by said cams. *m* and *n* are latch blocks attached to the arms *f* and *l* respectively. The wrist lever *j* is connected by a rod with a rocker arm *o*, which is in turn connected by a rod and strap with an eccentric *p* on the crank shaft *q*. The trip cams *k* are operated, and the times or points of closing the exhaust valves *e* with relation to the movements of

the piston *b* are determined, by an automatic pressure regulator, which consists generally of a vertical cylinder *r*, fixed to the compressor frame, a plunger *s* fitted in the lower end of said cylinder, a sleeve *t* fitted and movable vertically upon said cylinder, a spring *u* between the plunger *s* and the upper end of said sleeve, and a check or retarding device which is opposed to the movement of said sleeve and may consist of a dash pot *v*, formed in or attached to the upper end of said sleeve, and a plunger *w* fitted in said dash pot and fixed to a stand *x*, which is attached to the compressor frame. The sleeve *t* is adjustably weighted by divided rings *y*, which determine the pressure to be produced and maintained by the compressor and said weighted sleeve constitutes a weight for determining said pressure. The lower end of the cylinder *r* is connected by a pipe *z* with the discharge chest of the compressor or the compressed air reservoir. The sleeve *t* is connected by crank arms with a rocker shaft 2, which is supported by the stand *x*. A T-lever 3, which is suspended by a bar 4 from the shaft 2, has its opposite arms connected by rods with the cams *k* and its intermediate arm 5 connected by a rod 6 with a corresponding arm 7 on the shaft 2. The bar 4, rod 6 and arms 5 and 7 form a jointed parallelogram, which is swung to and fro by an eccentric 8 on the crank shaft *q*, connected by a strap and rod with a rocker arm 9, which is in turn connected by a rod with the bar 4. The eccentric *p* operates to swing the arms *i* back and forth between constant limits, and to open the valves *e* when the piston starts on its compressing strokes, if the trip cams are in position to permit the engagement of the latch blocks; otherwise, said valves will not be opened. The eccentric 8 operates to swing the trip cams *k* back and forth and to disengage the latch blocks, thus permitting the sudden closing of the valves *e* at different points in the compressing strokes of the piston according to the position of the plunger *s* of the regulator. An increase in pressure which causes said plunger to rise, produces a later closing of said valves, while a fall in pressure which allows the plunger to descend, produces an earlier closing of said valves.

The operation of the compressor as herein shown and described may be explained as follows: Assuming that the plunger *s* of the regulator is in a position to trip the exhaust valves *e* at the middle of the compressing strokes of the piston, the piston during the first half of each compressing stroke will discharge the air ahead of it through the open exhaust valve at the end of the cylinder toward which the piston is advancing, the suction and discharge valves *c* and *d* at that end of the cylinder being closed. The continued advance of the piston from mid stroke where the exhaust valve closes, compresses the air ahead of it from atmospheric pressure up to a pressure equal to or slightly above that in the pressure chest. The discharge valve *d* will thereupon open and compressed air will be delivered into the discharge chest up to the end of the stroke of the piston. As the piston moves in the opposite direction, the same operations will take place in the opposite end of the cylinder, while at that end from which the piston is receding the discharge valve *d* and the exhaust valve *e* being closed, air will be admitted to the cylinder behind the piston through the suction valve *c*. If the pressure rises in the discharge chest or reservoir, the plunger *s* of the regulator will be lifted and thereby shift the cams *k* so as to release and cause the exhaust valves *e* to close later with reference to the compressing strokes of the piston, so that air will be discharged from the cylinder ahead of the piston for a greater portion of its compressing strokes, and a smaller volume will be compressed and delivered into the discharge chest. If on the other hand, the pressure falls, allowing the plunger *s* to descend, the valves *e* will be released and closed earlier with respect to the compressing strokes of the piston, and a greater volume of air will be entrapped in the cylinder and compressed. In this way the volume of air compressed on each stroke of the piston may be varied from zero, when the exhaust valves are not tripped and remain open to the end of the compressing strokes of the piston, up to the entire capacity of the cylinder, when the exhaust valves are tripped at the beginning of, and remain closed during, the entire compressing strokes of the piston, according to the demand on the compressor. The weight applied to the sleeve *t* of the regulator determines the discharge pressure, an increase in weight increasing such pressure.

The spring *u*, which forms an elastic connection between the plunger *s* and the weighted sleeve *t*, and the dash pot *v* and plunger *w*, which check or retard the movement of the weighted sleeve *t*, prevent the trip cams *k* from responding to momentary fluctuations or pulsations in the discharge pressure, since the plunger *s* lifted only for an instant by a sudden and temporary increase of pressure, will compress the spring *u* and resume its original position before the weighted sleeve *t* has time to overcome the resistance of the dash pot *v* and plunger *w;* and in like manner, a momentary depression of the plunger will extend the spring for an instant without moving said sleeve.

Various changes in details of construc-

tion and arrangement of parts may be made without materially affecting the operation of the compressor, and without departing from the principle and intended scope of the invention.

I claim:

1. In a variable capacity compressor, mechanism for compressing to a constant pressure by varying the closing of an exhaust valve controlled by the demand on the compressor consisting of the combination with the compressor cylinder and piston and with suction and discharge valves, of a rotative exhaust valve, means for positively opening the exhaust valve at the beginning of the compression stroke, automatic variable valve-operating and releasing gear comprising a closing arm, an opening arm provided with a latch, and a trip cam arranged to release and close said exhaust valve at different points in the compression stroke of the piston, and an automatic pressure regulator operated by the discharge pressure of the compressor and connected with said cam to vary the point of closing the exhaust valve according to variations in the demand upon the compressor, substantially as described.

2. In a variable capacity compressor, mechanism for compressing to a constant pressure by varying the closing of an exhaust valve controlled by the demand on the compressor consisting of the combination with the compressor cylinder and piston and self acting suction and discharge valves, of rotative exhaust valves at the ends of the cylinder, means for positively opening the exhaust valves at the beginning of the compression stroke, an automatic variable valve-operating and releasing gear comprising closing arms, opening arms provided with latches and trip arms operatively connected with said exhaust valves to positively release and close the same at different points in the compression strokes of the piston, and a pressure regulator actuated by pressure from the compressor and connected with said cams, substantially as described.

3. In a variable capacity compressor, mechanism for compressing to a constant pressure by varying the closing of an exhaust valve controlled by the demand on the compressor consisting of the combination with the cylinder and piston and with suction and discharge valves, of an independent exhaust valve, automatic variable valve-operating gear comprising a trip cam and arranged to close said exhaust valve at different points in the compression stroke of the piston, and an automatic pressure regulator consisting of a pressure cylinder, and a plunger fitted in said cylinder and connected with the trip cam through the medium of means comprising a spring, a pressure controlling weight and retarding device opposed to the movement of the weight, said pressure regulator being controlled by pressure from the compressor, substantially as described.

4. In a variable capacity compressor, mechanism for compressing to a constant pressure by varying the closing of exhaust valves controlled by the demand on the compressor consisting of the combination with a cylinder and piston, of inlet and outlet valves and independent exhaust valves, automatic valve gear including tripping mechanism arranged to actuate the said valves to vary the volume of air or gas compressed, and a pressure regulator for effecting a constant pressure comprising a weight and connection between it and tripping mechanism for said valve gear, and a retarding device co-acting with said pressure regulator, substantially as described.

5. In a variable capacity compressor, mechanism for compressing to a constant pressure by varying the closing of an exhaust valve controlled by the demand on the compressor consisting of the combination with the compressor cylinder and piston, of inlet and outlet valves, automatic valve gear arranged to vary the volume of air or gas compressed by said piston in said cylinder, and an automatic pressure regulator comprising a weight and connections between it and the tripping mechanism of said valve gear, an expansion chamber connected with a source of pressure and provided with a movable part having an elastic connection with said weight, and a checking device opposed to the movement of said weight, said pressure regulator being controlled by pressure from the compressor, substantially as described.

6. In a variable capacity compressor, mechanism for compressing to a constant pressure by varying the closing of an exhaust valve controlled by the demand on the compressor consisting of the combination with the compressor cylinder having a piston and inlet and outlet valves, of automatic valve gear adapted to vary the volume of air or gas compressed and an automatic pressure regulator comprising an adjustable weight and connections between it and the tripping mechanism of said valve gear, an expansion chamber having a movable part, and a spring connection between said part and weight, said pressure regulator being controlled by pressure from the compressor, substantially as described.

7. In a variable capacity compressor, mechanism for compressing to a constant pressure by varying the closing of an exhaust valve controlled by the demand on the compressor consisting of the combination with the compressor cylinder having a piston and inlet and outlet valves, of automatic valve gear adapted to vary the volume of

air or gas compressed, and an automatic regulator comprising a weight and connections between it and the tripping mechanism of said valve gear, an expansion chamber having a movable part, a spring connection between said part and weight, and a fluid checking device opposed to the movement of said weight, said pressure regulator being controlled by pressure from the compressor, substantially as described.

In witness whereof, I hereto affix my signature in presence of two witnesses.

BRUNO V. NORDBERG.

Witnesses:

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ALICE E. GOSS.