

No. 860,826.

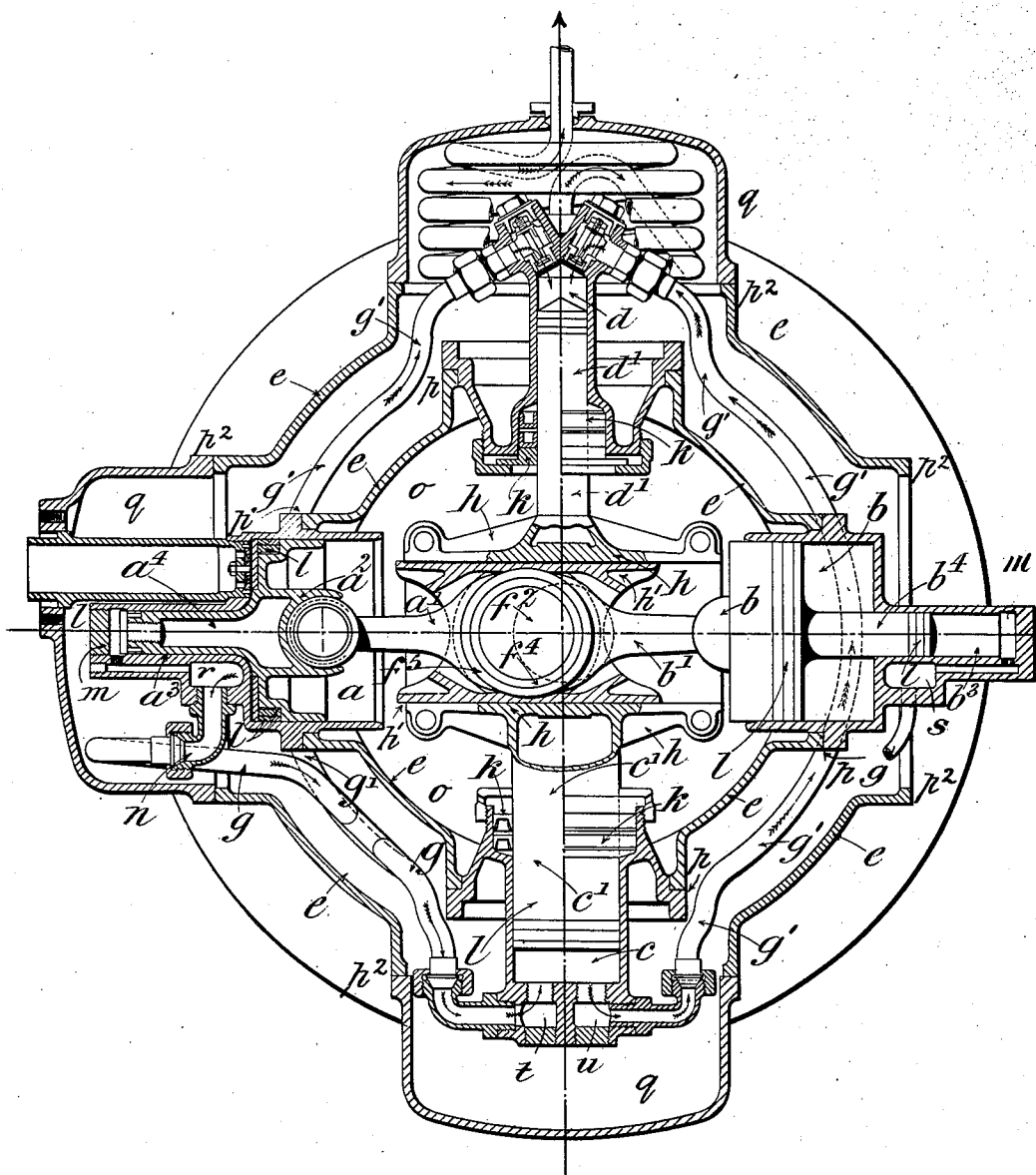
PATENTED JULY 23, 1907.

W. REAVELL.
AIR COMPRESSOR.

APPLICATION FILED SEPT. 15, 1904.

5 SHEETS—SHEET 1.

FIG. 1.



Witnesses

W^m Munn Andrew.
Henry J. Brockwell.

Inventor.

William Reavell,
by Fairfax & Metter,
Attorneys.

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5 SHEETS—SHEET 2.

FIG. 2.

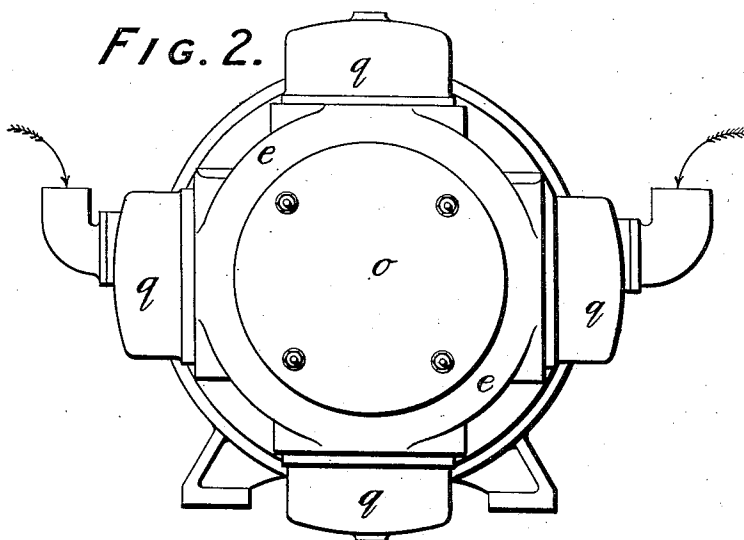
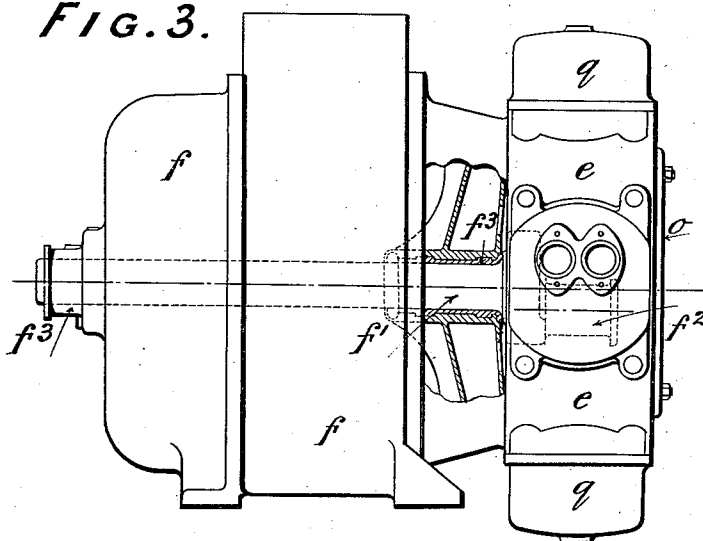


FIG. 3.



Witnesses.
Wm. Mann Andrew.
Henry J. Brockwell.

Inventor
William Reavell,
by *Fairfax & Metter,*
attorneys.

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5 SHEETS—SHEET 3.

FIG. 4.

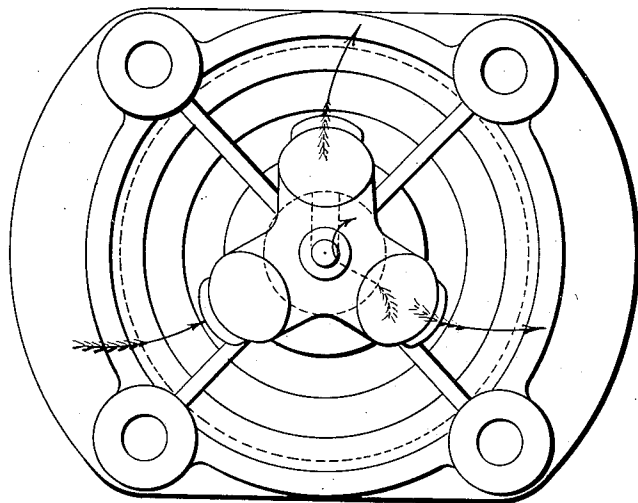
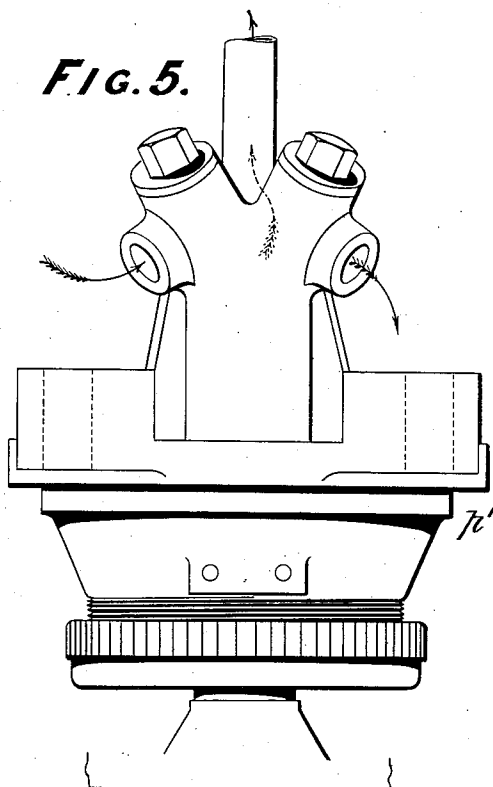


FIG. 5.



Witnesses.

W^m Munn Andrew.
Henry J. Brockwell.

Inventor

William Reavell,
by Fairfax & Metter,
Attorneys.

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5 SHEETS—SHEET 4.

FIG. 6.

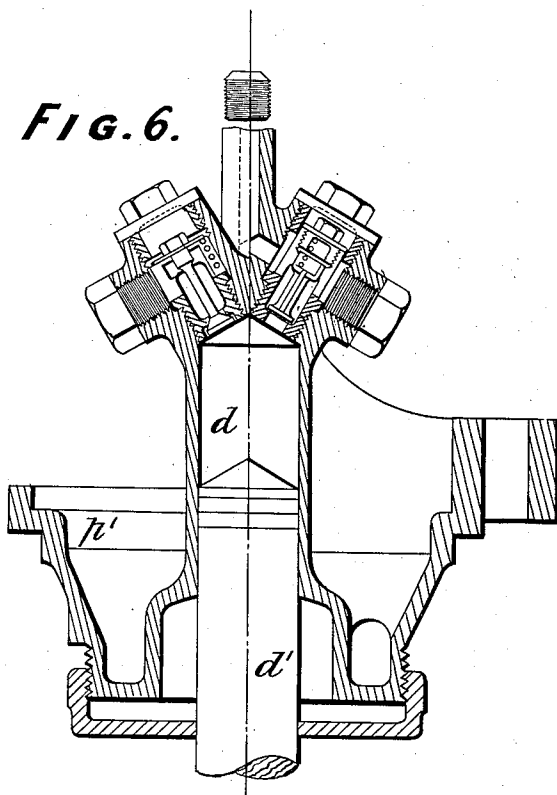


FIG. 7.



FIG. 8. FIG. 9.

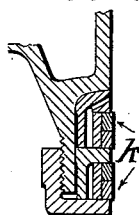
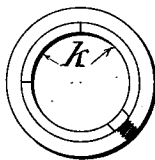
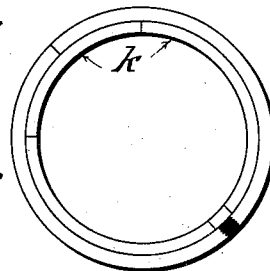


FIG. 10.



Witnesses

W^m Munn Andrew.
Henry J. Brockwell.

Inventor

William Reavell,
by Fairfax & Metter,
Attorneys.

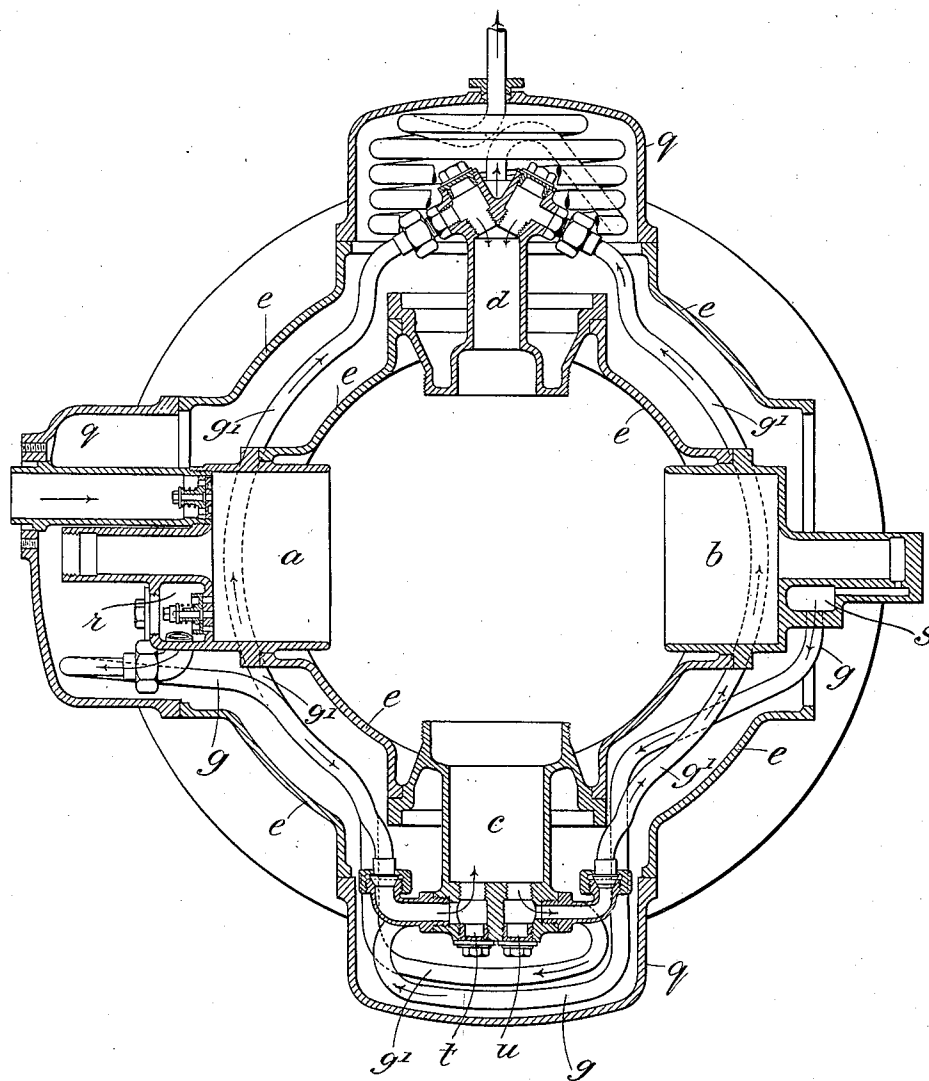
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AIR COMPRESSOR.
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5 SHEETS—SHEET 5.

Fig. 11.



WITNESSES:

H. J. Brockwell.

A. R. Forster.

INVENTOR:

William Reavell
G. Fairfax Wether
Attorneys

UNITED STATES PATENT OFFICE.

WILLIAM REAVELL, OF IPSWICH, ENGLAND.

AIR-COMPRESSOR.

No. 860,826.

Specification of Letters Patent.

Patented July 23, 1907.

Application filed September 15, 1904. Serial No. 224,602.

To all whom it may concern:

Be it known that I, WILLIAM REAVELL, a subject of the King of the British Dominions, residing at Ipswich, and whose post-office address is Ranelagh Works, Ipswich, in the county of Suffolk, England, have invented certain new and useful Improvements in Air-Compressors, of which the following is a specification.

This invention relates to air compressors, and constitutes improvements on the invention described in the specification to United States Letters Patent dated June 11th, 1901, No. 676,080, granted to me.

In the further description of this invention, reference is made to the accompanying drawings in which

Figure 1 is a sectional elevation of my improved four cylinder air compressor the sections of cylinders *a* and *b* being taken on different planes; Fig. 2 is an outer elevation of the same; Fig. 3 is an elevation of the said compressor at right angles to Figs. 1 and 2, and of an electric motor combined therewith to drive it, part of the frame being broken away to show the crank shaft and one of its two bearings, the other one being shown in outer elevation at the left hand end of the motor. Fig. 4 is a plan taken from above the high pressure cylinder *d*. Fig. 5 is an elevation of the inlet and outlet valves of cylinder *d*; Fig. 6 is a section through Fig. 5; and Figs. 7, 8, 9 and 10 are details of stuffing box packing rings, and Fig. 11 is a section of the cylinders and annular frame (similar to Fig. 1) showing the connection between the cylinders.

In this present invention four main cylinders, *a*, *b*, *c* and *d* are radially arranged in a ring shaped frame *e*, which is combined with an electric motor, turbine, or other suitable motive power *f*, the motor driving shaft *f*¹ extending into the compressor to drive the same by a crank-pin, *f*². The crank-pin in its revolutions transmits motion through intermediate devices to pistons within the several cylinders, which are adapted in succession to compress air, subsequently conveyed away through water cooled pipes *g* and *g*¹; the water being contained within the ring shaped frame, *e*. The air is preferably compressed in three stages in passing through the four main cylinders, two of them (*a*, *b*), acting as low pressure cylinders, from which the air, cooled as aforesaid, is passed to the remaining two cylinders (*c*, *d*), in succession to complete the process; a high degree of compression being thus made possible. In some cases I may modify this by compressing the air in four stages, the cylinders *a*, *b* being of suitable dimensions; or I may employ the cylinders as a two-stage compressor, without departing from the nature of the invention.

In connecting the improved air compressor to a high

speed engine, electric motor, or other source of motive power, it is found important to use but one driving shaft having a crank pin at one or both ends, so that the electric motor *f* (for example), is connected directly to the air compressor to practically form one combined machine; the armature shaft *f*¹ being prolonged into the compressor and adapted to drive the pistons at its own number of revolutions, or conversely, the crank shaft of the compressor being prolonged through the field magnets to receive the armature; or similarly arranged for any other motive power employed.

The center lines of the cylinders are all arranged upon the same plane converging at the point of intersection with the axial line of the shaft *f*¹, the said plane being that which is described by the center of the length of the crank pin *f*² in its revolutions; the outer centers of the cylinders being equally spaced apart, (or approximately so), around the ring shaped frame *e*. Consequently the cylinders are arranged in two pairs, as it were, a center line passing straight through two oppositely placed cylinders, and at right angles to a similar center line passing through the other pair of oppositely placed cylinders. In one pair, *a* and *b*, the opposite pistons are adapted to be acted upon by the revolutions of the crank pin *f*² through the intervention of two connecting rods *a*¹ and *b*¹; while the pistons of the other pair are formed like plungers *c*¹ and *d*¹, connected together by a yoke *h* forming a slotted cross-head, in which a slipper *h*¹ (which may be divided) is adapted to slide to and fro, as the crank pin *f*² revolves within the slipper *h*¹. Special arrangements are made to enable the crank pin end of each connecting rod to be combined with the slipper to allow of its free motion, while keeping a continuous thrust upon the crank-pin brass or bushing *f*⁴, and for a retaining ring *f*⁵; the other ends of the two connecting rods *a*¹ and *b*¹ are cylindrically formed at right angles with the line of the rod in each case to enable it to be seated in a suitable bearing in its piston *a*² or *b*², and provision is made for removing each rod sidewise from its corresponding piston.

The two largest bore cylinders *a* and *b* are placed oppositely as shown in Fig. 1, each of their pistons being acted upon by the crank pin *f*² through the connecting rods *a*¹ and *b*¹ as aforesaid, and the first stage of compressing air takes place within these cylinders in the well known manner. The air, as compressed, passes from the delivery belts *r* and *s* of these cylinders through non-return valves, into the pipes *g* leading from the two cylinders *a* and *b* to the valve box or inlet *t* of the next largest cylinder *c*, where it is subjected to the second compression. From thence it passes through

the delivery valve box or chamber *u* into two pipes *g*¹ situated behind those marked *g* and leading to the fourth cylinder, *d*, where it receives the third stage of compressing, and from thence, through a delivery valve, the highly compressed air passes through the cooling coil above cylinder *d*, and is conveyed by a suitable pipe or pipes wherever required.

Fig. 1 shows the inlet valve of the cylinder *a*. An ordinary outlet valve is situated between the cylinder *a* and the delivery belt *r*, but not shown. The cylinder *b* is arranged like cylinder *a*. The valves of the cylinders *b* and *c* are of ordinary construction and therefore not shown in the drawing.

The pipes *g* and *g*¹ pass to and fro from the several cylinders within the annular space, forming a water jacket, in the ring shaped frame *e*; thus cooling the air immediately on its exit from each cylinder to the next, after each stage of compression. In addition to this, the principal portion of the outside wall of each cylinder is exposed to the cooling water, to avoid heating, and therefore expanding the entering air, thus obtaining the utmost efficiency in supplying air of sufficient density for the compressing pistons to act upon. A pump or other suitable means should be provided for supplying and circulating the cooling water.

Special packing rings *k* of metal are used in some cases, instead of leather, the latter being unsatisfactory in stuffing boxes when opposed to a high degree of compression, but sometimes metal rings are combined with leather as shown in the stuffing box of *c*¹. The piston rings *l* are of metal, shown in section in cylinder *a*, Fig. 1, and comprise two narrow outer rings cut into segments, being backed up by a wide spring follower inner ring, the narrow rings being turned to fit the bore of the cylinder so that the distortion of the rings and unequal wear of the cylinder is avoided; and in some cases I admit air under pressure behind both kinds of packing rings.

The largest or first stage compression cylinders, *a*, *b*, are each combined with a small outside cylinder called a pilot cylinder, *a*³, and *b*³, respectively, into which the main piston extends like a plunger, these plunger pistons *a*⁴ and *b*⁴ are also provided with similar packing rings *l*, to those already described. A space *m* at the back of each pilot piston is connected to the first stage air delivery or receiver space, thus constantly exerting a thrust upon its corresponding piston *a*⁴ or *b*⁴ and connecting rod, *a*¹ and *b*¹, always keeping the inner end of the rod pressed upon its crank pin bearing or bush *f*⁴ so that no lost motion takes place. Constant pressure and silent working are also insured on the second and third stage plunger pistons *a*⁴ and *b*⁴, because they are subjected to the air pressure in the receiver or pipe from which they obtain their supply of air, and on the crank pin through the yoke *h* and slipper *h*¹ cross-head connection between the second and third stage pistons, *c*¹ and *d*¹; so that efficiency is secured in compressing by the cooling of cylinders and pipes, and silent working thus obtained even when working at five hundred revolutions per minute.

Suitable suction and delivery valves, are provided at the required points for their duty; lubrication takes place by splashing from the central chamber formed

by inclosing that part of the frame by the outer cover *o*. Large openings, *p* and *p*² are formed in the frame and faced to facilitate construction, those in the inner wall of the frame are indicated by *p*, and are all one size to provide for the interchange of cylinders, the latter being adapted by flanges, *p*¹ more or less extended, to be seated therein; the other holes, *p*², in the outer wall of the frame, being also of one size, (but larger than *p*), adapted to receive on the face of the flanges a bonnet or cover *q* screwed in position over each cylinder, as shown in Fig. 1 over *a* *c* and *d*, the fourth cover being omitted. These covers *q* are of domical form, and give sufficient room for a coil of pipes, a pilot cylinder, or valve and pipe connections, as may be; and provide also for a large body of cooling water surrounding the cylinders and air pressure pipes to insure sufficient water cooling, and promote efficiency in compressing air.

What I claim and desire to secure by United States Patent is:—

1. A multiple stage air compressor having in combination a hollow ring shaped frame with radial openings at equal distances apart concentrically arranged through its inner and outer walls; a pair of main cylinders oppositely placed in openings of the inner wall each having a pilot cylinder, and a piston common to said main and pilot cylinders; a connecting rod pivoted to each main piston; a pair of smaller cylinders oppositely placed in the remaining openings of the inner wall; plunger pistons connected by a yoke adapted to work in said smaller cylinders; a slipper crosshead; and a revoluble crank shaft and pin, said pin being adapted to work in said slipper and transmit its motion through said yoke and connecting rods to said pistons, substantially as described.

2. A multiple stage air compressor having in combination a hollow ring shaped frame with radial openings at equal distances apart concentrically arranged through its inner and outer walls; a pair of main cylinders oppositely placed in openings of the inner wall each having a pilot cylinder, and a piston common to said main and pilot cylinders; a connecting rod pivoted to each main piston; a pair of smaller cylinders oppositely placed in the remaining openings of the inner wall; plunger pistons connected by a yoke adapted to work in said smaller cylinders; a slipper crosshead; a revoluble crank shaft and pin, said pin being adapted to work in said slipper and transmit its motion through said yoke and connecting rods to said pistons; and an electric motor having said crank shaft arranged as its armature shaft, substantially as described.

3. A multiple stage air compressor having in combination a hollow ring shaped frame with radial openings at equal distances apart concentrically arranged through its inner and outer walls; a pair of main cylinders oppositely placed in openings of the inner wall each having a pilot cylinder, and a piston common to said main and pilot cylinders, a connecting rod pivoted to each main piston; a pair of smaller cylinders oppositely placed in the remaining openings of the inner wall; plunger pistons connected by a yoke adapted to work in said smaller cylinders; a slipper crosshead; a revoluble crank shaft and pin, said pin being adapted to work in said slipper and transmit its motion through said yoke and connecting rods to said pistons; an electric motor adapted to drive said crank shaft; covers to said openings in said outer wall; means for connecting said cylinders, and transmitting air between the inner and outer walls of the ring shaped frame, substantially as described.

4. A multiple stage air compressor having in combination a hollow ring shaped frame with openings at equal distances apart through its inner and outer walls; a pair of main cylinders oppositely placed in openings of the inner wall each having a pilot cylinder, and a piston

common to said main and pilot cylinders; a space *m* at
the back of each pilot piston communicating with an air
pressure space; a connecting rod pivoted to each main
piston; a pair of smaller cylinders oppositely placed
5 in the remaining openings of the inner wall; plunger
pistons connected by a yoke adapted to work in said
smaller cylinders; a slipper crosshead, a revoluble crank
shaft and pin, said pin being adapted to work in said
slipper and transmit its motion through said yoke and
10 connecting rods to said pistons; means for driving said

crank shaft; means for covering said openings in said
outer wall; and means for transmitting air between said
cylinders, substantially as described.

In testimony whereof I have signed this specification in
the presence of two subscribing witnesses.

WILLIAM REAVELL.

Witnesses:

H. D. JAMESON,
F. L. RAND.