Dec. 23, 1941.

F. E. SMITH

2,266,820

ENGINE

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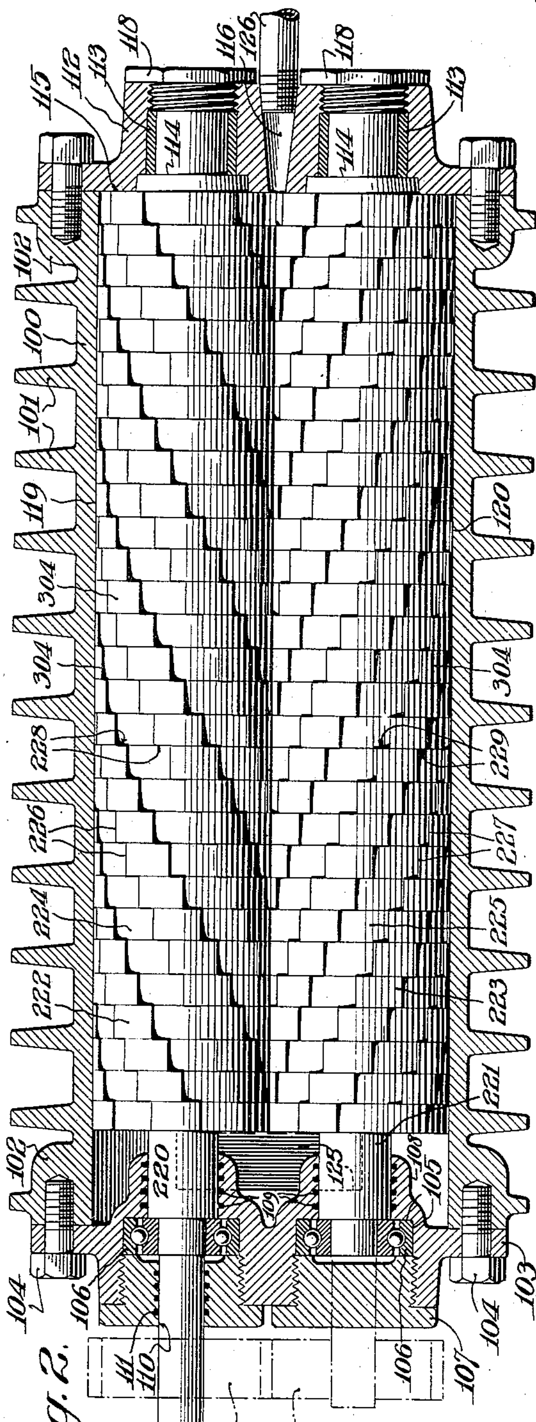

Fig. 2.

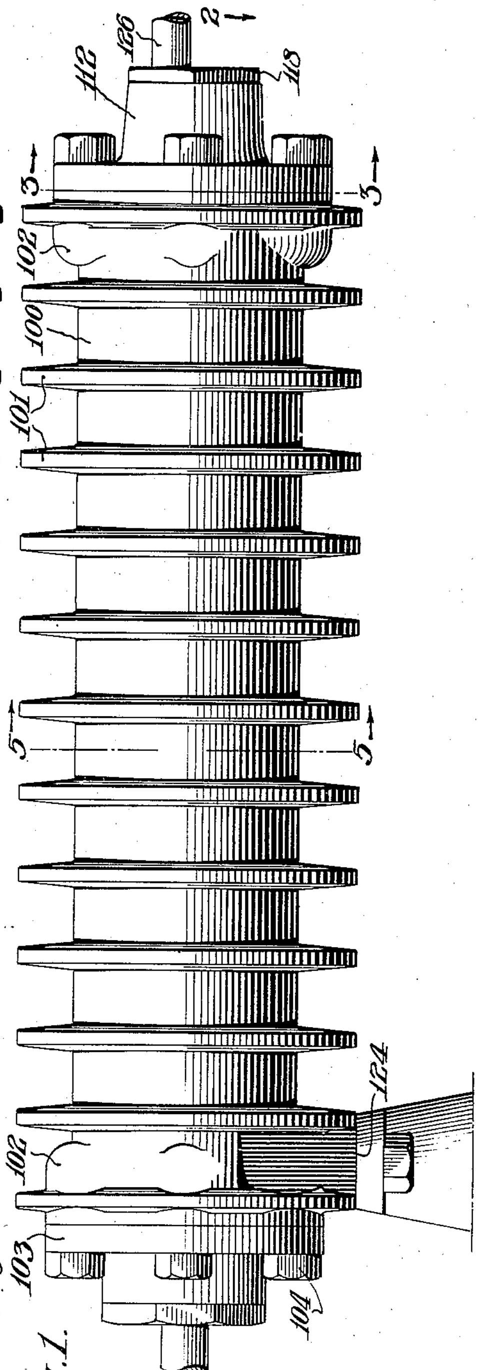

Fig. 1.

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ATTORNEY.

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Fig. 3.

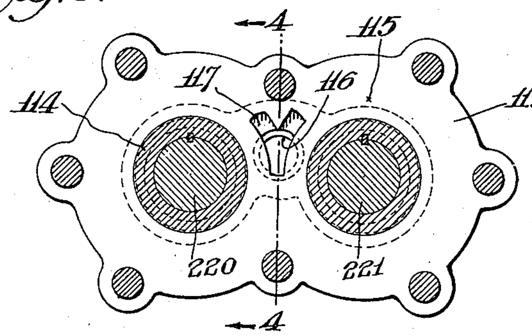


Fig. 4.

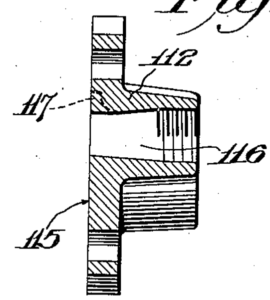


Fig. 5.

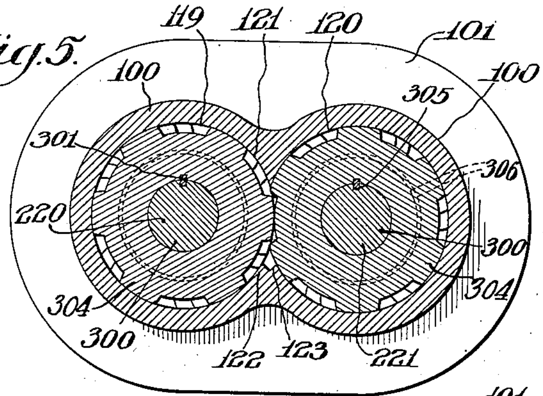


Fig. 8.

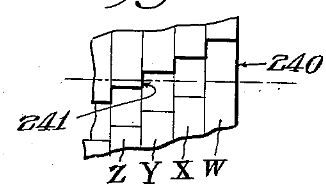


Fig. 9.

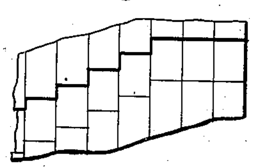
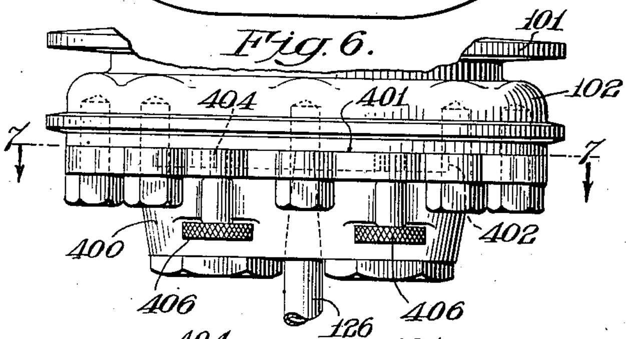


Fig. 6.



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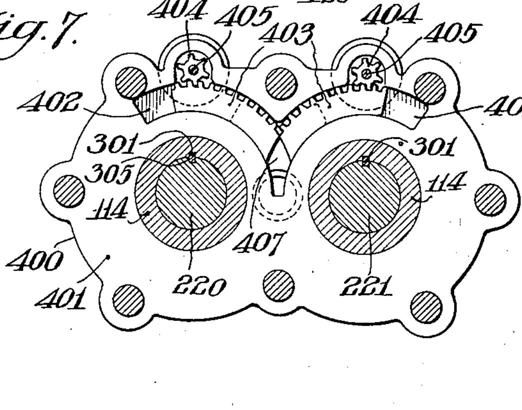
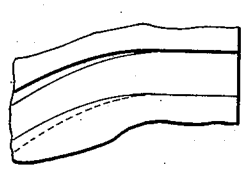


Fig. 10.



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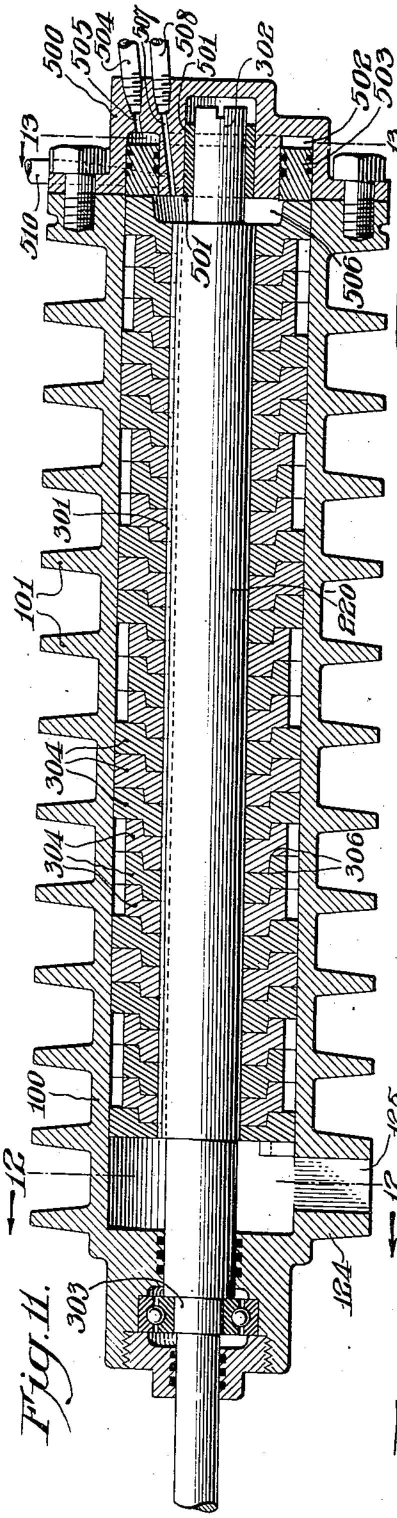
Fig. 11.

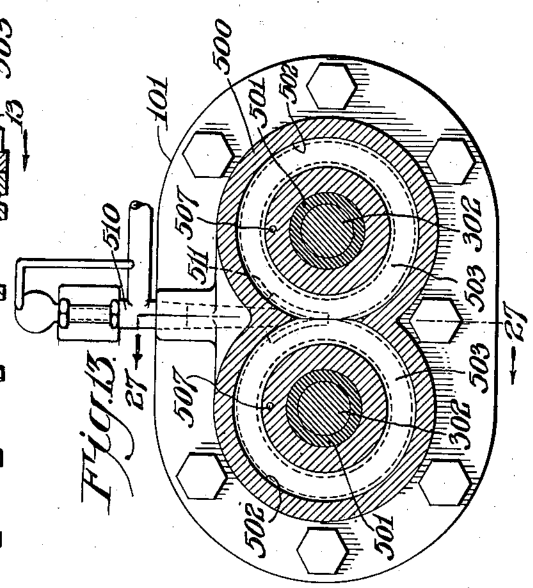
Fig. 13.

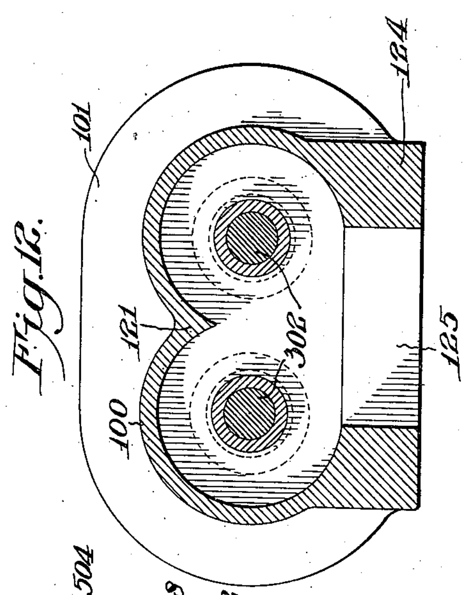
Fig. 12.

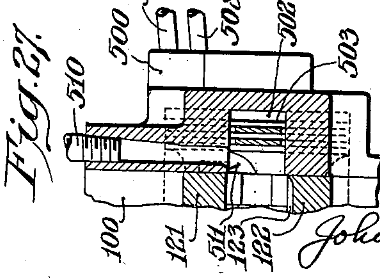
Fig. 27.

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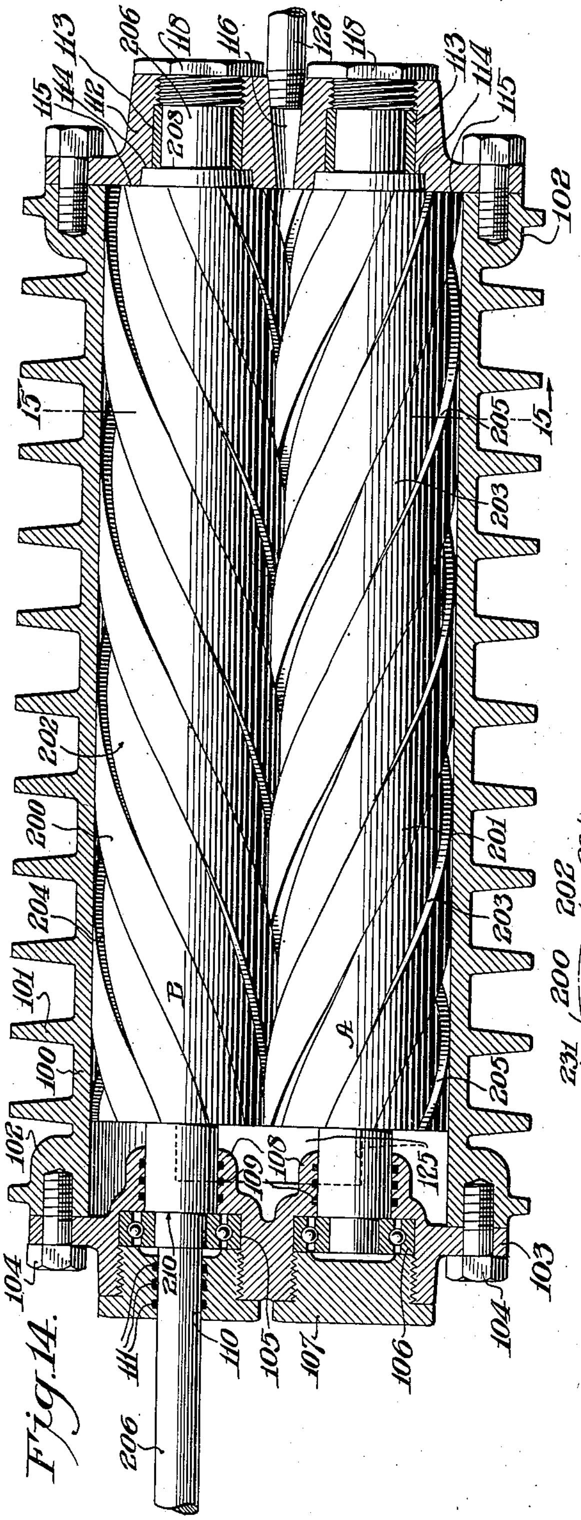

Fig. 14.

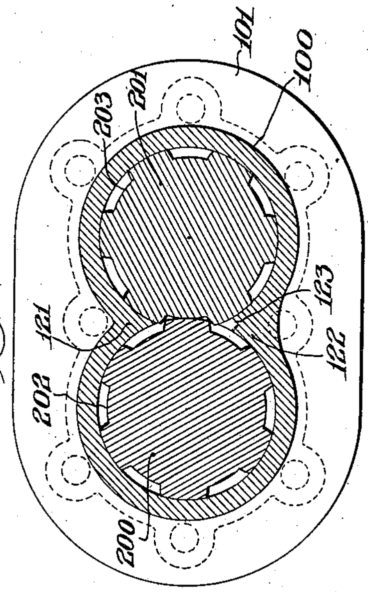

Fig. 15

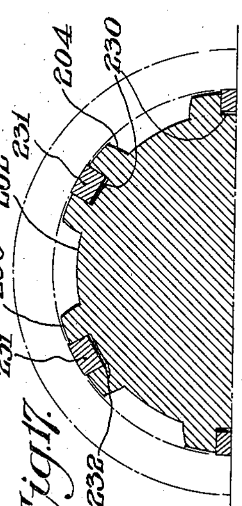

Fig. 17.

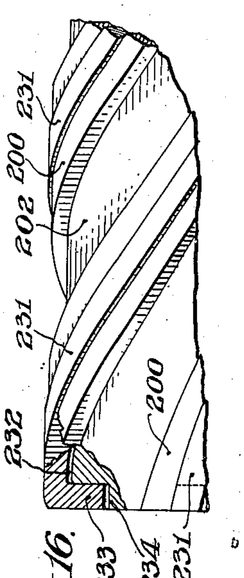

Fig. 16.

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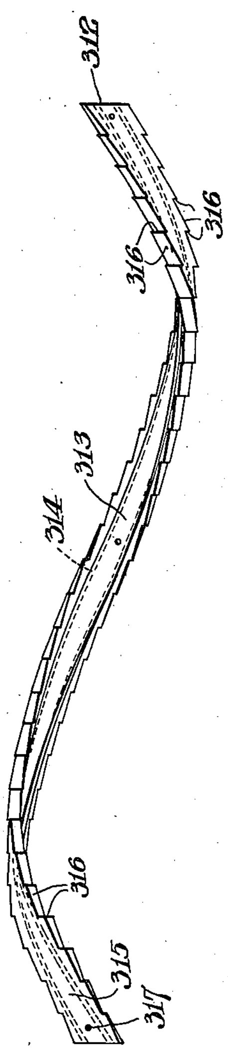

Fig. 22.

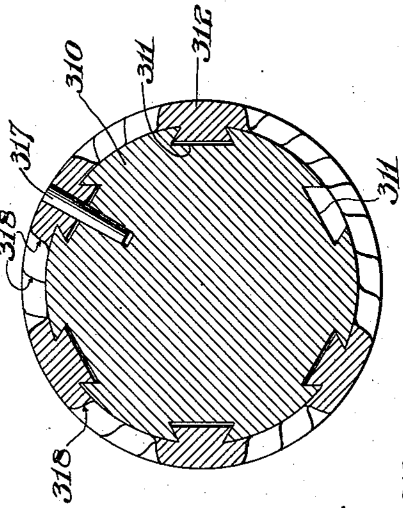

Fig. 24.

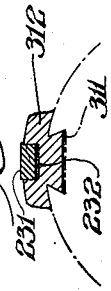

Fig. 18.

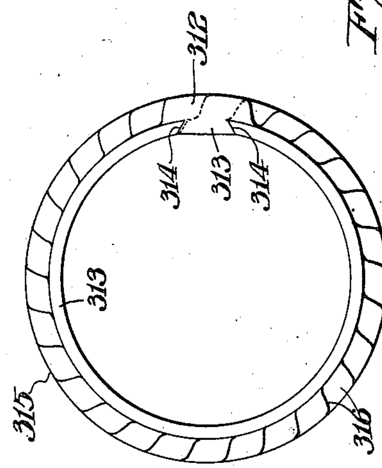

Fig. 23.

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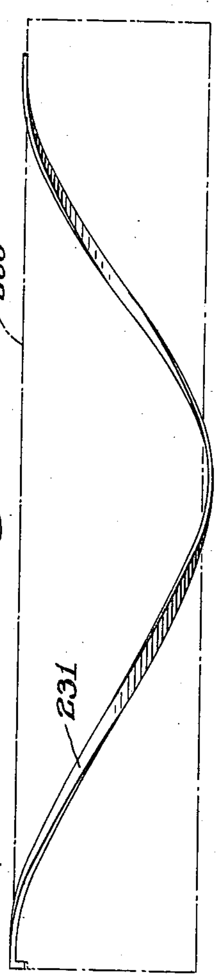

Fig. 21.

Fig. 19.

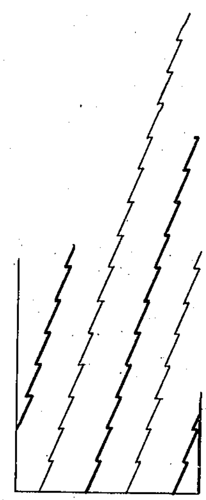

Fig. 20.

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Fig. 25.

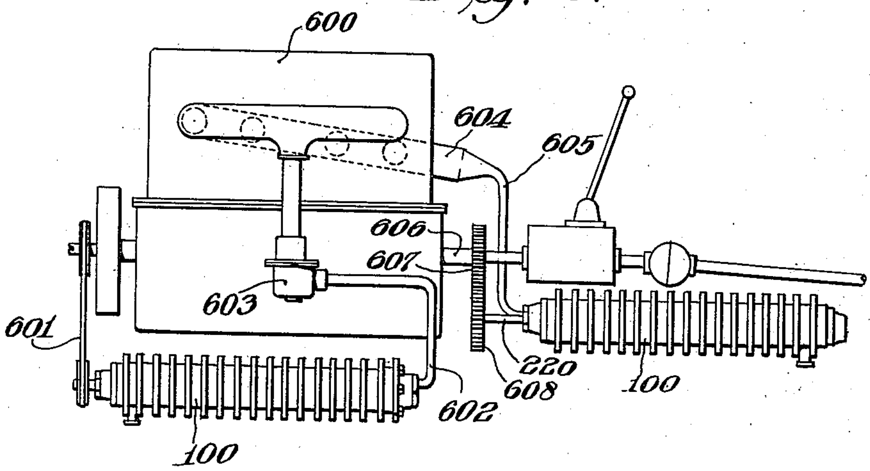
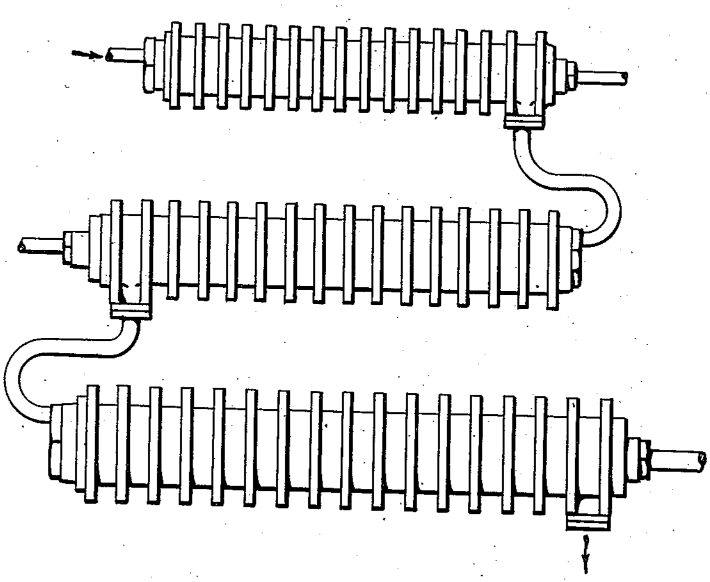


Fig. 26



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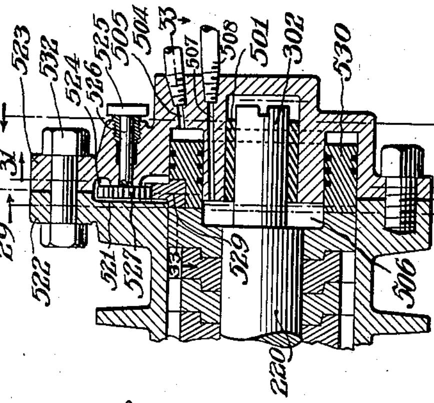


Fig. 28.

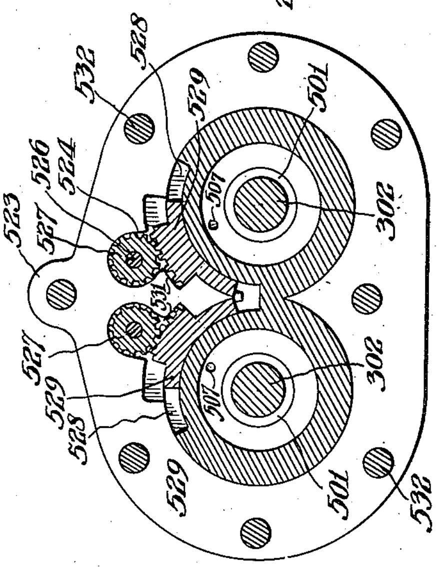
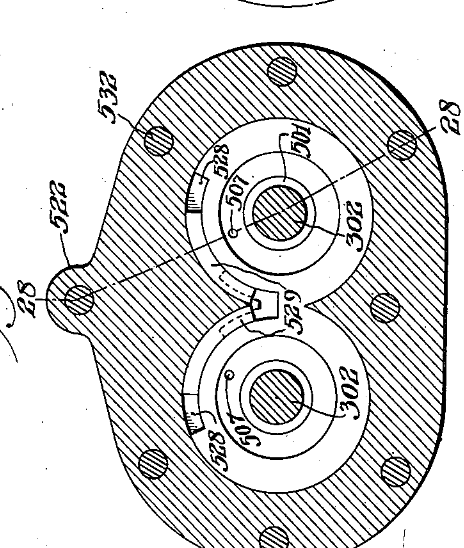


Fig. 30.



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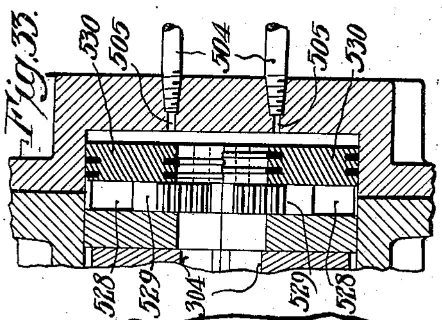

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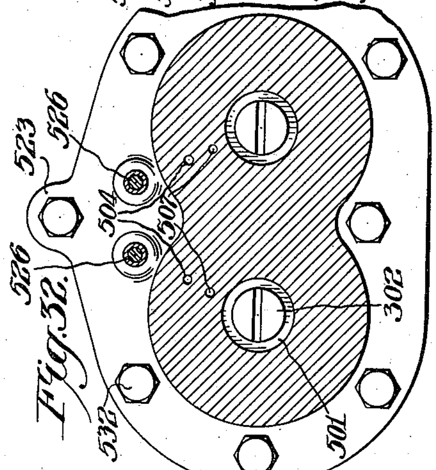

Fig. 32.

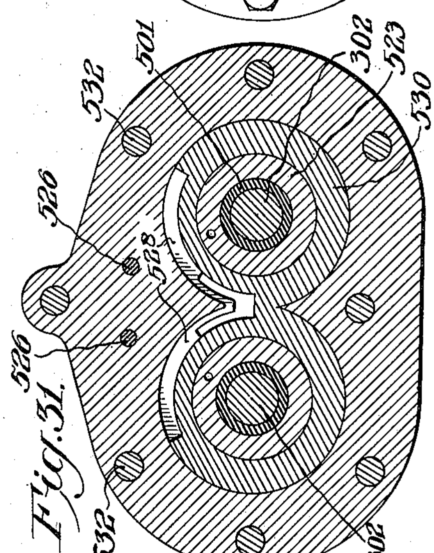

Fig. 31.

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Patented Dec. 23, 1941

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UNITED STATES PATENT OFFICE

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ENGINE

Frank E. Smith, Niagara Falls, N. Y.

Application July 13, 1938, Serial No. 218,959

9 Claims. (Cl. 121—70)

This invention relates to a mechanical motion, to a machine, to an engine, to a prime mover, to a compressor, to a method of transforming the energy of a compressed gas into mechanical motion, to a method of compressing a gas, to means and methods of making apparatuses which in themselves constitute a portion of this invention. This case is a continuation in part of my application Serial No. 150,893, filed June 29, 1937, since abandoned.

A typical four-cycle gasoline internal combustion engine of the present high development has twelve cylinders, a displacement of about 250 cubic inches, a normal operating speed of 2000 R. P. M., and when operating at that speed has a total displacement of 290 cubic feet per minute, only one quarter of which is power-delivering displacement, the remaining three quarters occurring as intake, compression, and exhaust. An engine which could deliver a continuous flow of power would occupy less space and would eliminate the coordinating mechanisms that make the internal combustion engine complicated and expensive. The mechanical efficiency of steam engines is fair but their weight per horsepower is so high and their fuel efficiencies so poor that internal combustion engines of various types are rapidly supplanting them. It is, consequently, apparent that there is much room for development in the field of prime movers.

The portable compressor unit that is used in street work is frequently a machine capable of compressing 200 cubic feet of free air per minute. An electrical compressor unit having a capacity of 2500 cubic feet of free air per minute is about 15 feet wide, 18 feet long, and 7 feet high, and sells for about $20,000.00. So enormous an outlay for so simple an operation, the compressing of a free gas, indicates that present compressor design can be improved.

It is an object of the invention to make a prime mover, an engine which is capable of delivering a continuous flow of power with great increase of efficiency, when compared to the types of engine now in existence. Another object of the invention is to produce a compressor capable of compressing far larger quantities of free gas than can be compressed by existing compressors of equivalent dimensions. Another object of the invention is to compress gases within a compressor, and to pressures of great intensity. Another object of the invention is to use the energy of expansion of a compressed gas to great advantage. Another object of the invention is to impart energy to a gas by great intensity of compression. Another object of the invention is to extract energy from a compressed gas with great efficiency. Another object of the invention is to make the apparatuses and machine which constitute a part of this invention by means which are practically and economically satisfactory. Another object of the invention is to eliminate all the losses found in reciprocating engines and compressors of the present day by means of rotary machines. Another object of the invention is to provide a rotary machine of the type described with a variable cut off.

The objects of the invention constituting a prime mover are accomplished, generally speaking, by the use of a turbine having twin wheels, and intermeshing helical lands and grooves with a one-turn pitch, and preferably with variable cut off. The objects of the invention are also accomplished by extracting the expansive energy from a compressed gas within the chamber expanding between an end wall and the receding point of intermesh of a rotary engine as herein described.

The objects of the invention constituting a compressor are accomplished by entrapping a quantity of compressible fluid between the advancing line of intermesh of interfitting helical lands and grooves of an engine having integral grooved rollers of about one-turn pitch, and the end wall of the casing, discharge taking place after compression within the machine.

The objects of the invention are also accomplished by the means, methods, and details thereof which are more fully herein described.

In the accompanying drawings, wherein like numerals refer to like parts, Figure 1 is an elevation of the outside of an apparatus embodying features of my invention. Figure 2 is a partial section on the line 2—2 of Figure 1, looking in the direction of the arrows and showing the turbine wheels or rollers in their intermeshed relation. Figure 3 is a section on the line 3—3 of Figure 1, looking in the direction of the arrows. Figure 4 is a section on the line 4—4 of Figure 3, showing the port. Figure 5 is a section on the line 5—5 of Figure 1. Figure 6 is a fragmentary plan view of a modified high pressure end of the machine. Figure 7 is a section on the line 7—7 of Figure 6. Figures 8, 9, and 10 are diagrammatic views illustrating methods of arranging the working chambers of the apparatus. Figure 11 is a longitudinal section through a modified form of apparatus. Figure 12 is a section on the line 12—12 of Figure 11. Figure 13 is a section on the line 13—13 of Figure 11. Figure 27 is a section on line 27—27 of Figure 13. Figure 14 is a plan view partly in section of a modification of the apparatus shown in Figure 2. Figure 15 is a section on the line 15—15 of Figure 14. Figure 16 is a detail view showing the lands and grooves of the apparatus of Figure 14 with compression rings in their seats. Figure 17 is a partial section of the apparatus of Figure 16. Figure 18 is a cross section through a land of the type shown in Figure 22, showing a compression ring in place. Figures 19 and 20 are diagrams showing spiral cut teeth with a spiral less than the lead and spiral cut teeth greater than the lead, respectively. Figure 21 is a view of a compression ring, showing in dotted lines the roller to which it is applied. Figure 22 is a perspective view of a removable land with teeth. Figure 23 is an enlarged end view of Figure 22, showing an overlap of the ends. Figure 24 is a cross section through a wheel showing some removable lands in place and a method of keying them. Figure 25 is an elevation of an internal combustion engine furnished with a motor and compressor of this design. Figure 26 illustrates a method of combining a series of engines or compressors to secure high efficiency. Figure 27 is a detail. Figure 28 is a section on the line 28—28 of Figure 29. Figures 28 through 33 show a construction of adjustable inlet ports and movable sealing rings; Figure 29 is a section on the line 29—29 of Figure 28; Figure 30 is a section on the line 30—30 of Figure 28; Figure 31 is a section on the line 31—31 of Figure 28; Figure 32 is a section on the line 32—32 of Figure 28; Figure 33 is a section on the line 33—33 of Figure 28. All the said sections are taken in the direction of the arrows.

In this specification those terms are selected and used which are well calculated to produce a clear comprehension of the invention; false analogies must not be drawn between the structure of this invention and other structures on the basis of mere similarity in terms.

Referring now to the numerals of the drawings, 100 is a casing; 101 are ribs on the casing which serve to give it strength and to dissipate heat; 102 are screw threaded portions in the ends of the casing; 103 is a head at the low pressure end of the casing; 104 are bolts adapted to hold the head in sealing contact with the casing by screw threaded contact with portions 102 of the casing; 105 are bearing seats in the casing head; 106 are thrust bearings seated in said bearing seats; 107 are screw threaded nuts which cooperate with screw threads in the casing head to hold the bearings in position; 108 are cylindrical extensions in the casing head; 109 are packing rings, or packing, in circular grooves in said extensions; 110 is a hole through a said nut; 111 is packing, or are packing rings, in internal circular grooves in said nut; 112 is a cylinder head for the high pressure end of the apparatus drilled in two places to receive bearings 113; 114 are annular shoulders in said cylinder head; 115 is an inwardly directly, accurately machined face of said cylinder head, a face which the wheels to be hereinatfer described abut; 116 is a port in the cylinder head having a substantially circular outer orifice which is developed to a substantially Y-shaped inner orifice 117 and the outer end of the port is screw-threaded as is indicated in Figure 4; 118 are nuts which seal the drillings in cylinder head 112.

The casing 100 is accurately drilled and machined to form twin cylinders opening into each other throughout their length. This structure we call for convenience "cylinders conjoined in parallel." In the drawings 119 is one cylinder and 120 is the other cylinder; 121 is a depending fin wedge-shaped in cross section and extending the operable length of the casing; 122 is a substantially wedge-shaped lower fin extending the operable length of the casing. 123 is a channel formed by removing the peak of said wedge-shaped lower fin and opening into the low pressure port and preferably decreasing in size toward the high pressure end, its size at the high pressure port being either minute or non-existent. The rollers may be considered to have positive and negative portions, the positive being that where work is being done by the expansion or compression of a gas, the negative being substantially idle. The channel is provided in the wedge-shaped fin of the negative portion. 124 is a portion of the casing forming the low pressure port; 125 is the low pressure port; 126 is a pipe screw-threaded into orifice 116 of the high pressure port, through which gas under pressure is delivered.

In the cylinders formed within the casing are mounted rollers, otherwise called wheels or rotors, which have projecting from their ends shafts for mounting in the bearings of their casing heads and whose operating surfaces are formed by alternating lands and grooves in the form of helices which have a pitch not substantially greater than one turn to the length of the roller. For convenience these are called rollers having helical lands and grooves of one-turn pitch. These helices intermesh along the line between the fins and seal the upper against the lower central portion of the cylinders along a line approximately formed by a plane passing through the axes of the rollers. The floors of the lands are machined on the arcs of circles of radius substantially identical with that of the cylinders, only enough clearance being allowed in the form of the invention depicted in Figures 2 and 14 to permit the existence of an oil film between the land and the wall of the cylinder. A clearance of .005 inch is deemed satisfactory for this purpose. Where a compression ring is used, a much greater clearance is permissible. The floors of the grooves are also accurately machined on the arc of a circle so that the floor of a land of one wheel rolls upon the floor of the groove of the other wheel at the point of intermeshing, forming in the prefered form of the invention a substantially perfect seal from end to end of the rollers. The invention will be most readily comprehended by first considering the modification of the invention disclosed in Figure 14.

200—201 are wheels machined to within .005 inch of the true radius of the cylinders and contacting each other along a center line whereby to form a seal. In the surface of each cylinder are grooves 202—203 of uniform depth and width having accurately machined edges 204—205. The edges, otherwise called faces or shoulders, of the grooves of one roller are designed to make sealing contact along the line of intermeshing by abutting the corresponding face of the corresponding land of the other roller. This structure forms a series of alternating lands and grooves of equal width and depth which form a tight seal along the line of intermeshing throughout the length by making sealing contact through the abutment of the floor (upper surface) of the lands and the floor of the corresponding groove, and the abutting of the corresponding sides or faces of the corresponding lands and grooves.

The drilling of the high pressure cylinder head for the reception of the bearings and the shafts of the wheels is of such size that the face 115 of the cylinder head is of greater extent than the depth of the grooves throughout the entire circumferences of the cylinders except at the discharge port 117. The ends of the wheels at the high pressure end are accurately machined so that they abut the face 115 of the cylinder head. This structure seals the ends of the grooves during the greater part of their circular motion, they being free to discharge only when they communicate with the port 117.

The pitch of the helices is about one turn to the length of the roller. The pitch can be less than one turn to the length, but should not be substantially greater than that, although an overlap of one or two lands is sometimes permissible. In the cases where a pitch less than one turn is used, it is necessary to relocate the exit port. In the form of the invention herein chosen for exemplification, the pitch of the helices is about one turn.

206 is a shaft which is mounted in the bearings of the cylinder heads, having circular shoulder 208 which conforms to annular shoulder 114 or the wheel; 210 is a shoulder abutting the bearing 105 and forming a thrust bearing at the low pressure end. The bearing at the low pressure end has been shown to be a ball thrust bearing because in normal use the working thrust will be toward that end. The shaft 206 is extended through the cylinder head to form a means of transmitting power from or to the wheels of the engine. The other roller is similarly formed, except that in Figure 14 it is not shown extending through the casing. In the modification of the invention shown in Figures 14 and 15, the wheels and their shafts have been turned out of one piece of metal but, as hereinafter indicated, they can be otherwise formed. The power take-off can be extended through the casing head in either direction and from either wheel.

The invention, as illustrated by the modification of Figure 14, operates substantially as follows, when the machine is used as a compressor. The low pressure port is presumed in this instance to be open to the air, although it could be open to the discharge of other compressors, and the air finds its way freely into the grooves of the wheels. These grooves form helical chambers from end to end of the roller. These chambers are sealed at their top by the contact of the adjoining lands with the cylinder, and at the high pressure end by the contact of the ends of the rollers with the abutting face 115 of the cylinder head. Assuming the shaft 206 to be turned in a clockwise direction (looking from the low pressure to the high pressure end), the groove A will be filled with air from the low pressure port substantially throughout its length, but it will not be open to the gas from the high pressure end because that end will be beneath the discharge port and sealed by the face 115. As rotation continues, an instant later the leading face of the land B will make contact with the leading face of the groove A, the leading point of the floor of land B will make rolling contact with the leading face of the floor of groove A, and the groove A will be progressively sealed by rolling contact with the land. As the low pressure end of the groove passes the point of intermesh, it becomes in effect a different chamber open to low pressure air as far as the progressing line of compression. At that time, however, a more advanced point on the said land and groove (for instance a point beneath the third rib 101) will, by turning, have reached sealing position. Thus the chamber A is progressively decreased in size and the gas entrapped is correspondingly decreased in volume and increased in pressure. Inasmuch as the high pressure end of the chamber A is sealed during the greater part of its rotation by the face 115, substantially the whole compression takes place within the machine, and not against the back pressure at the port of the high pressure end for, as the chambers are sealed against the discharge port, so is the discharge port sealed against the chambers. As the rotation continues the size of the chamber A decreases, the gas is compressed, its pressure is increased until the leading edge of the chamber rotates into contact with the upper arm of Y-shaped port 117 and, having been compressed to approximately the pressure existing in the high pressure port, it is forced out through the port by the advance of the line of intermesh until the chamber is wholly exhausted, and the gases are transported by tube 126 to their point of use. The shape of the port furnishes a quick cut-off when discharge has been accomplished. In the meantime a substantially complete revolution has taken place, the chamber is again filled with free air and the cycle begins again. In the device illustrated each wheel is furnished with six helical chambers and six cooperating lands so that a supply of compressed gas is being furnished continuously. The number of chambers can be varied to suit the needs of the designer.

Assuming now that the device is to be used as an engine, gas under pressure will be furnished through the pipe 126 and the port 116—117. The gas pries the abutting faces of the lands and grooves apart, rotating the shaft 206 in a counterclockwise direction (looking from the low pressure to the high pressure end of the machine). The passing of the high pressure ends of each chamber beyond communication with port 117 entraps within the chamber a quantity of gas which continues to turn the wheels by expanding. When a complete rotation has been completed the chamber has been revolved until it is unsealed at the low pressure end and the expanded gases are discharged into the low pressure port. These expanded gases can be used in other apparatus of similar design as shown in Figure 26, or for other purposes.

The form of the device which has just been described and which is illustrated in Figure 14 has this disadvantage, that the sealing of the apparatus is imperfect, the rotation of the wheels requiring that the helical lands be provided with a certain amount of clearance in order to mesh and unmesh without conflict. This clearance, particularly at low speeds, permits pressure to escape from the high pressure side of the seal to the low pressure side and from groove to groove longitudinally of the apparatus, a leakage which, except at very high speeds, is sufficient to materially lower the efficiency of the apparatus.

I have overcome this deficiency in the preferred form of my inveniton, wherein the helices are formed with stepped faces. This form of the invention is illustrated in Figures 2, 8, 9, 19, and

20. In this, the preferred, form of the invention sealing contact is not made between helical faces which require clearance for engagement and disengagement, but is made between the faces of the steps which are cut on planes perpendicular to the axes of the wheels. Sealing contact in this form of the invention is, consequently, made by the rolling of the floors of the lands upon the floors of the grooves and by sealing contact between abutting side faces of the steps of the lands and grooves. The faces of the lands which are substantially parallel to the axes of the rollers still require some clearance, but this is of negligible importance since the effectiveness of the seal does not depend upon a close fit between those faces. In fact, when exterior gears are used to coordinate the rollers, the faces of the lands parallel to the axis of the roller need not make contact.

In Figure 2, **220**—**221** are rollers which may be assumed, in general, to be constructed similarly to the rollers of Figure 14 insofar as their mounting in the cylinders is concerned. **222**—**223** are helical lands having about a one-turn pitch and **224**—**225** are corresponding helical grooves; **226**—**227** are faces of the lands and grooves substantially parallel to the axes of the wheels. As illustrated in Figures 19 and 20, these faces need not be parallel but can have a helical pitch, the pitch of Figure 19 being less than the lead and the pitch of Figure 20 being greater than the lead. The lead is defined as the pitch of the main helix. **228** are faces of the helix which are perpendicular to the axis of the wheel and which, by making contact with the corresponding face **229** at the point of intermesh, perform a portion of the sealing operation. By this device the losses of pressure between the high pressure and low pressure sides of the seal is made insignificant compared to the losses which are sustained in the device of Figure 14.

For simplicity of illustration the devices of Figures 2 and 14 have been shown composed of wheels the floors of whose lands make sealing contact with the interior of the cylinders. This form of the device is effective but requires extremely accurate machining both in the cylinders and the wheels.

In Figures 16 and 17 is shown a structure which will very frequently be used and which permits a considerable clearance between floors of the lands and the cylinder wall. In this form of the invention **230** are helical grooves cut in the lands, preferably approximately midway thereof; **231** are spring-pressure helical sealing strips carried in the grooves by the said wheels. In Figure 21 pressure strip **231** is shown in perspective. It is in helical form which substantially fits the groove but which, when slid into position, projects beyond the groove sufficiently to make sealing contact with the walls of the cylinder. These strips will be made of spring metal and designed by their own resilience to make firm contact with the cylinder walls. At the same time an amount of clearance, as illustrated diagrammatically at **232**, is provided to permit the strip to be compressed substantially level with the floor of the land when making sealing contact with the corresponding roller. In the drawings, the lug **233** on the strip fits a socket **234** in the high pressure end of the cylinder, and being accurately machined to the face of the roller, prevents the strip from being dislodged by longitudinal motion. A plurality of strips may be used where exteremely high pressures are to be attained. The strip is made to have sealing contact with the groove it fits by making it so close a fit that the oil film used for lubrication will prevent escape of gas.

The use of strips to prevent the gases from passing between a revolving member and a cylinder involves many unique features, exemplary of which are that a strip is constructed with substantially parallel sides, and a curved top finished to an arc having the approximate radius of the cylinder; and that a spiral groove in the roller has substantially parallel sides finished to receive the strip; the spiral strip is made on a larger diameter than the casing to have a natural spring effect which holds it to the casing, and permits the rollers to be cut clear of the casing. With such a construction, enough clearance can be provided in the casing to prevent the roller from touching the cylinder and imposing heavy friction loads on it. The compressibility of the strips is such that the reactive load from the unbalanced pressures on the roller are carried directly to the bearings. A very important feature is that, in most heavy units, high temperatures are encountered, which cause the rollers to expand faster than the casing, which may be air or water-cooled. These strips permit the building of required clearances to handle these temperatures and still prevent binding and heavy friction resistance. The strip is also unique in its method of application and anchoring.

In Figure 8 the dotted line shows the line of sealing passing along the face of one roller. The roller is shown as composed of a series of rings which will be called W, X, Y, and Z for convenience. Sealing between ring W of the roller and its corresponding segment of the cooperating roller is made by the floor of the land making contact with the floor of the groove shown in Figure 8. This sealing contact is continued into ring X at a more advanced point in the groove by the contact of the floor of the land, and at a yet more advanced point it is carried into the ring Y so that between the edge **240** of ring W and the face **241** of ring Y sealing contact is made by the rolling of the floors of the helical land on the floors of the helical groove. This point of sealing contact continues between rings Y and Z by the contact of face **241** with the corresponding face in the cooperating roller, which by abutting one another prevent the escape of gases. This line of contact then continues between the face of the land of ring Z and its abutting ring by contact with the floor of the corresponding groove in the other roller.

In Figures 9 and 10 is shown a means of obtaining a quick initial compression, wherein the initial compression stage is made longer than in the type shown in Figure 8. Thus in Figure 9 three rings are shown in one, the closing of which by rotation of the cylinders compresses in one unit of time three times as much gas as is compressed by the device of Figure 8 or, where the apparatus is used as an engine, three times the initial torque and a larger intake is provided. These initial advantages can be varied by the engineer to suit the necessities of particular use.

The necessity of machining the faces parallel to the axes to obtain a minimum of clearance and yet prevent locking is somewhat costly and in Figure 2 in dotted lines is indicated a method by which a coarser machining of these faces can be permitted. In this modification the shafts of rollers **220** and **221** are continued through the cylinder head and have mounted thereon intermeshing fine gears **130—131**. These gears are very accurately machined, are keyed to the shafts of the roller, prevent the interlocking of the intermeshing faces even when the machining has been comparatively coarse, and relieve the lands of the driving strain.

In Figures 14 and 15 are shown rollers which are unitary, the rollers, lands, and shafts being integral. In Figures 16 and 17 the rollers are unitary except for the sealing strips which are made and inserted as previously described.

In Figures 2, 5, and 11 is shown a structure wherein **220** is a shaft; **301** is a key mounted in a slot running lengthwise of the shaft, or alternatively, formed in the shaft itself; **302—303** are portions of the shaft journalled in appropriate bearings in the cylinder heads. **304** are rings of identical shape, shown in diametrical section in Figure 11 and in cross section in Figure 5, which differ from one another only in the location of a slot **305** which fits the key **301**. These rings have a hole in the center which is slightly smaller than the normal diameter of the shaft. The hole has a slot for engagement with the key **301** but, as shown in the respective left-hand and right-hand rollers of Figure 5, the slots are accurately placed about the circumference of the hole so that the teeth of succeeding rings will be given, with minute accuracy, a proper lead. This is illustrated in Figure 5 where, through the grooves, are seen the leading edges of the teeth of successive rings. The rings are assembled by cooling the shaft with dry ice or in any other suitable way and heating the rings. The rings are then assembled with complete accuracy as to their placement on the length of the shaft and the assemblage is allowed to reach normal temperature, thus forming in effect a single unit. It will be observed in Figure 11 that the center portions of the rings are off-set, the edges of this off-set being indicated in Figure 5 by the dotted lines **306**. The faces of the off-set are bevelled to make easy the seating of the rings.

Another satisfactory method of making the wheels is shown in Figures 22, 23, and 24. In these figures, **310** is a shaft turned down to the floor diameter of the grooves. **311** are helical grooves in the shaft or roller **310** having about a one-turn pitch and extending the working length thereof. These grooves are undercut as is clearly shown in Figures 24 and 18. **312** is a metal land; **313** is an integral key on the inside of the land **312** having undercut edges **314**; **315** is the floor of the land, which is of a diameter conforming to that of the cylinder; **316** are stepped faces on the land. Figure 23 is an enlarged end view of the land shown in Figure 22, showing a slight overlap of the ends. The undercut key **313** is just too large to fit the undercut groove **311**. However, by shrinking the one and heating the other, as heretofore indicated in regard to the assembly of the ring built roller, the undercut key may be readily slid into the undercut groove, accurately alined lengthwise of the roller, and held in position with a pin **317**. The pin may be omitted in some circumstances because, upon return to size, the helical lands become substantially integral with the rollers. In Figure 18 is shown the mounting of a pressure ring **231** in a land **312**.

In Figures 23 and 24 the faces of the lands and grooves substantially parallel to the axis, indicated by numbers **318**, are shown cut on a curve which conforms to the most desirable operating conditions for that face of the land.

In Figure 11 it will be observed that only one cylinder head is made removable; the other is not removable but is made integral and is simply drilled to permit passage of the supporting shaft **220**.

In Figures 6 and 7 is shown a modified high pressure cylinder head. In these figures, **400** is the head; **401** is a face machined for abutment against the face of casing **100**.

In Figures 3 and 7 the rings **114** are shown not integral with, but keyed to, the shafts **220—221**. The shafts **220—221** are mounted in bearings in the head **400** as indicated in other figures. **402** are curved slots conforming in arc to the chambers of the wheels; **403** are curved gear-toothed segments slidably mounted in the slots in guides **402**. The faces of the segments **403** conform accurately to the face **401** and furnish a seal against the escape of gases within the chambers; **404** are gears mounted on shafts **405** which project through the head and bear at their outer extremities knurled knobs **406**. By rotating the knobs **406** the pinions **404**, which are in mesh with the gear teeth of the segment **403**, can be made to move the segments and open or close the port **407**. By this construction there is made an adjustable port which permits the operator to select his instant of discharge (or when working as an engine, his instant of cut-off) at will within the degree of adjustability permitted by the length of the guides.

Means of oiling the apparatus are shown in Figure 13 for the sake of illustration. The oiling means is of pressure type utilizing pressure from pipe **510** behind the oil to balance the pressure before it, so that it is carried into the engine by the incoming gases. Other units, pressure or otherwise, will admit lubricant at any other desired point of the casing. The details of pressure and non-pressure lubricating systems of one type are set forth in Catalogue #52, page 450 of the Crane Co., Chicago, Ill. Other types are well known to the art of lubricating devices.

In Figures 11, 13, and 27 is shown yet another high pressure head, a form designed to furnish an adjustable sealing means for the chambers. In these figures, **500** is the head; **501** are bearings in the head; **302** are shafts seated in the bearings, the bearings being mounted in recesses in the head; **502** are circular recesses in the head corresponding in diameter to the diameters of the cylinders and being in width greater than the depth of the chambers; **503** are integral rings provided with packing to prevent the escape of gases passing into the recess **502**; **504** is a high pressure tube connecting through a drilling **505** to the recess **502** behind the rings. By applying pressure thus to the rings, the rings are continuously forced into sealing contact with the faces of the rollers. In order to prevent the building up of pressure in the recess **506** formed between the head and the off-set in the outermost ring, a drilling **507** connects with an exhaust tube **508** and allows the escape of gases therein imprisoned. **510** is a high pressure port; **511** is a Y-shaped port in the face of the rings in communication with the outlet port **510**. When the chambers of the wheels are in communication with the port and the rings, the pressure gas is in communication both with the chambers and with the port, cut-off occurring as soon as the chamber has proceeded past the port. This modification, which is not bound up with the other structure shown in Figures 11 and 12, permits a sealing of the chambers even should a wearing of the thrust bearing eventually permit what would in other forms of the invention be a slight disengagement between the head and the chambers, and takes care of the expansion of the rollers which, in less flexible forms of the invention, might cause excessive friction.

In Figures 28 to 33 the numerals which have already been described refer to similar parts. Of the other numerals, **530** are movable sealing rings for the ends of the roller grooves, being in this instance made integral, although could be separate and provided with machined faces at their point of contact. **528** are grooves cut in the inner faces of the rings; **529** are sliders provided with machined faces to accurately fit the grooves and to form a continuous face against the rollers. The inner face of the sliders projects within the cylinders as is shown in Figure 28. Cut through the ring is a Y-shaped port, as is shown in full and dotted lines in Figure 29 and in full lines in Figure 31. The sliders **529** are operated from outside the casing by knobs **525**, shafts **526** and gears **527** which mesh with the gears **531** on the sliders. The depth of the recess **528** makes it possible for the rings and sliders to move axially of the rollers. The rings are held against the face of the rollers by fluid pressure through pipe and drilling **504–505**. This pressure passes through the Y-shaped orifice into the grooves if the apparatus is used as an engine. If it is being used as a compressor, the discharge takes place through the Y-shaped orifice. The degree of cut-off or moment of discharge, respectively, is determined by the position of the sliders **529**; when in open position the sliders give a later cut-off or an earlier discharge than in closed position. Conversely, when the apparatus is used as a compressor, an open position of the sliders produces an earlier discharge and, consequently, a discharge at a lower compression. If it is desired, steel springs can be placed behind the rings **530** within the cylinder head **523** to insure the existence of greater pressure behind the rings than before them. The bolts **532** hold the head and the flange **522** together.

In Figure 25 is shown a method of applying this invention as a booster to a standard automobile. In this figure, **600** is a typical gasoline engine; **100** is a compressor, of the type which has just been described, driven through a belt **601** as a supercharger, the high pressure air being forced through tube **602** to a carburetor **603** and then into the engine. **604** is an exhaust port which is connected by pipe **605** to the high pressure end of another unit **100**. **606** is the drive shaft of the automobile; **607** is a pinion thereon; **608** is a driving pinion on the shaft of the engine. The rotating air compressor or supercharger could force the air into the reciprocating engine at 2 atmospheres pressure instead of one, which would provide for twice the charge and for compression ratios of 14 instead of 7 in a given engine, making possible the burning of fuels that can not now be readily burned. In these cases the exhaust pressures, due to the greater charge, would be considerably higher than in an unsupercharged engine, but the energy of this higher pressure would be recovered in the rotating engine unit geared to the shaft **606**. Thus an automobile engine of a given type will be doubled in its own horsepower output, which would be increased 3 or 4 times by the use of a booster engine of my design.

Figure 26 illustrates the staging of engine units. For example, it is assumed that the first unit receives gas at about 600 pounds sq. in. pressure, which is expanded through the unit, discharged at a pressure of 200 lbs., goes to the second stage, exhausts there at 65 lbs., goes to the third stage and exhausts at 15 lbs. The volume of the gas being approximately proportional to the pressure and temperature, the volume entering the first unit is about 1/30 of the volume exhausting from the third unit, or, if running as a stage compressor unit, the volume would be reduced to 1/30 at the exhaust of the high pressure unit.

In this invention I have achieved the principle of displacement and expansion found in the reciprocating engine and have achieved them with rotary motion, so that there is no reciprocating loss. In reciprocating motions, as the speed goes up the losses mount to the point where all of the energy used is absorbed in the reciprocating work. With rotary motion no such losses exist and far higher speed can be achieved.

It has been the practice, generally, to drive machines in shops or industrial plants with electric motors because of the great problem involved with belts and because of the large engines required if reciprocating engines are used. A unit of my invention operated by steam and mounted on a lathe occupies less space than a corresponding electric motor. Steam at about 100 pounds per square inch is brought to the unit in one and one-half inch pipes and the exhaust is taken away in pipes at 20 to 30 pounds pressure and used for other purposes. The speed of the device is at the command of the operator.

Any gas can be compressed by this apparatus, and any compressed gas can be used to drive it as an engine. Among such gases are steam, air, products of hydrocarbon combustion, products of explosion, and the like.

As many apparently widely different embodiments of this invention may be made without departing from the spirit and scope thereof, it is to be understood that I do not limit myself to the specific embodiments thereof except as defined in the appended claims.

I claim:

1. In a machine a casing comprising cylinders and cylinder heads; rollers journalled in said casing having sealing contact with said cylinders, and having intermeshing helical lands and grooves of one turn pitch; a port in the casing in operative connection with the low pressure ends of the grooves; integral movable pressure rings having a Y-shaped port abutting the pressure ends of said grooves; a port in the casing operatively connected to the said Y-shaped port; means to vary the extent of the said Y-shaped port comprising arcuate guides in the rings, sliders in the guides abutting the port and the groove ends, and means operable from outside the casing to move the sliders; helical sealing strips of greater free diameter than said rollers mounted in said lands; means to press the said rings against the ends of the grooves; means to relieve the roller ends of gas pressure; means to bleed gas from the negative part of the rollers; and means to oil the rollers.

2. In a machine a casing comprising cylinders and cylinder heads; rollers therein with intermeshing helical lands and grooves of one-turn pitch having sealing contact with said cylinders

and with one of said cylinder heads; a port having operative connection with the low pressure ends of the grooves; a Y-shaped port in the said sealing cylinder head connecting with the high pressure ends of said grooves close to the line of intermesh; and means to vary the cut-off of the said port comprising movable arcuate slides abutting the ends of the grooves.

3. In a machine a casing comprising cylinders and cylinder heads; rollers therein with intermeshing helical lands and grooves of one-turn pitch having sealing contact with said cylinders and with one of said cylinder heads; a port having operative connection with the low pressure ends of the grooves; and a port in said sealing cylinder head connecting with the high pressure end of said grooves; and means for varying the cut-off of said port.

4. In a machine a casing comprising cylinders and cylinder heads; rollers therein having sealing contact with said cylinders and having intermeshing helical lands and grooves of one-turn pitch; a port having operative connection with the low pressure ends of the grooves; a port abutting the high pressure end of said grooves; means to seal the high pressure end of the grooves except at said port; and means to relieve pressure accumulating at the high pressure ends of the rollers.

5. In a machine a casing comprising cylinders and cylinder heads; rollers therein having sealing contact with said cylinders and having intermeshing helical lands and grooves of one-turn pitch; a port having operative connection with the low pressure ends of the grooves; a port abutting the pressure end of said grooves; means sealing the pressure end of the grooves except at said port; said intermeshing rollers comprising rollers with helical grooves and machined helical lands mounted therein, said lands having helical grooves and helical sealing strips of greater free diameter mounted therein.

6. A machine comprising parallel, conjoined cylinders; revoluble rollers therein; motion transmitting means attached to a said roller; said rollers having intermeshing helical lands and grooves with about a one-turn pitch; and a port at each end of said cylinders; said conjoined cylinders comprising a removable head having bearings for the rollers; movable pressure means in said head to seal the high pressure ends of the grooves of the rollers during a portion of each revolution, and a port through the said head connecting with the ends of the grooves.

7. An engine having rotatable complementary means comprising a series of helical grooves and a series of helical lands in interfitting relation, an end of said lands and grooves abutting a sealing element having a port, means to vary the cut-off of the port, and means to fill said grooves in succession through said port with gas under pressure whereby to force said lands progressively and in succession out of said grooves, said sealing element acting to confine the gas within the grooves and against the lands through substantially one complete revolution.

8. In an apparatus of the type described having intermeshing helical rollers, means at the ends of the rollers for charging and discharging, and means to vary the time during which gas is admitted to the chambers of the apparatus.

9. In a compressor comprising a casing and intermeshing helical chambers, means to charge the chambers with a gas, means to compress the gas within the chambers, and means to vary the time of discharge.

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