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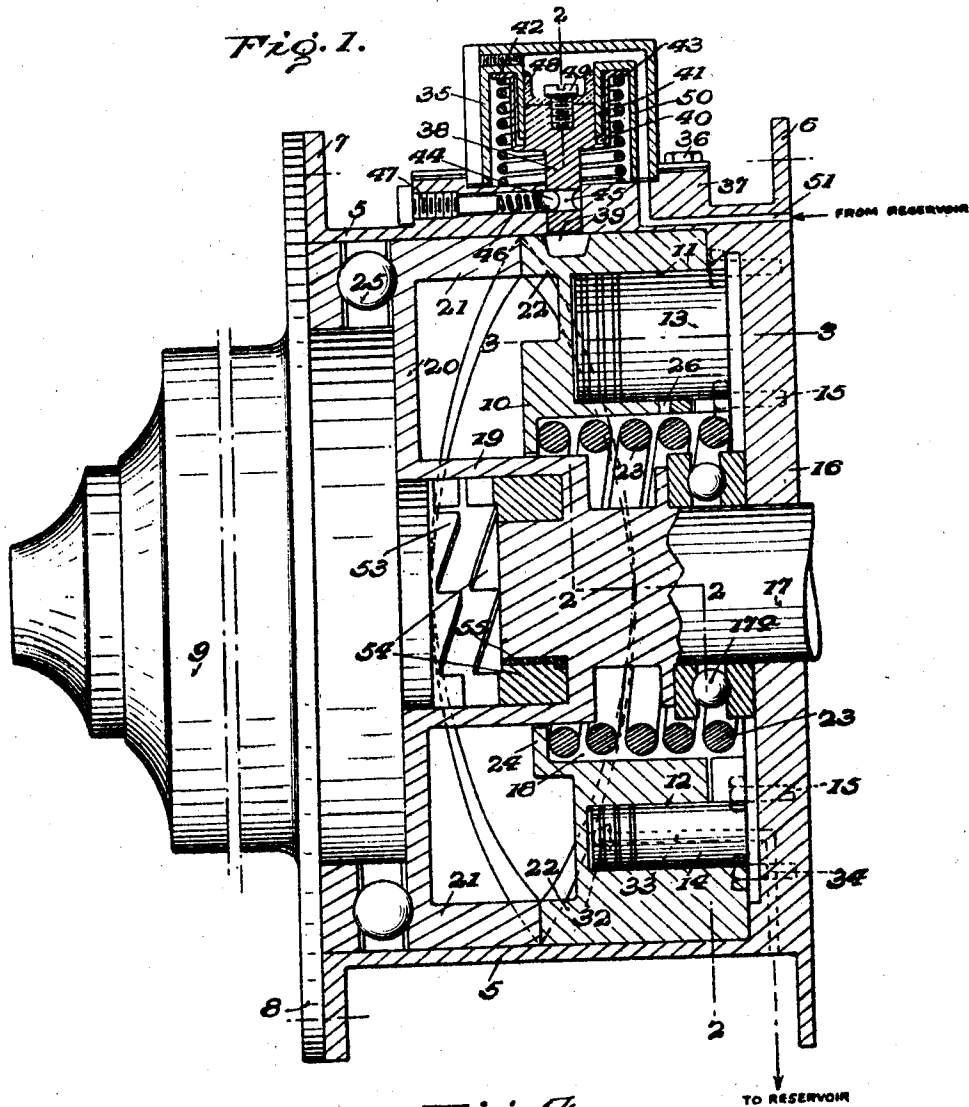
N. HERZMARK

1,900,284

AIR COMPRESSOR

Filed July 28, 1930

2 Sheets-Sheet 1



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Fig. 2.

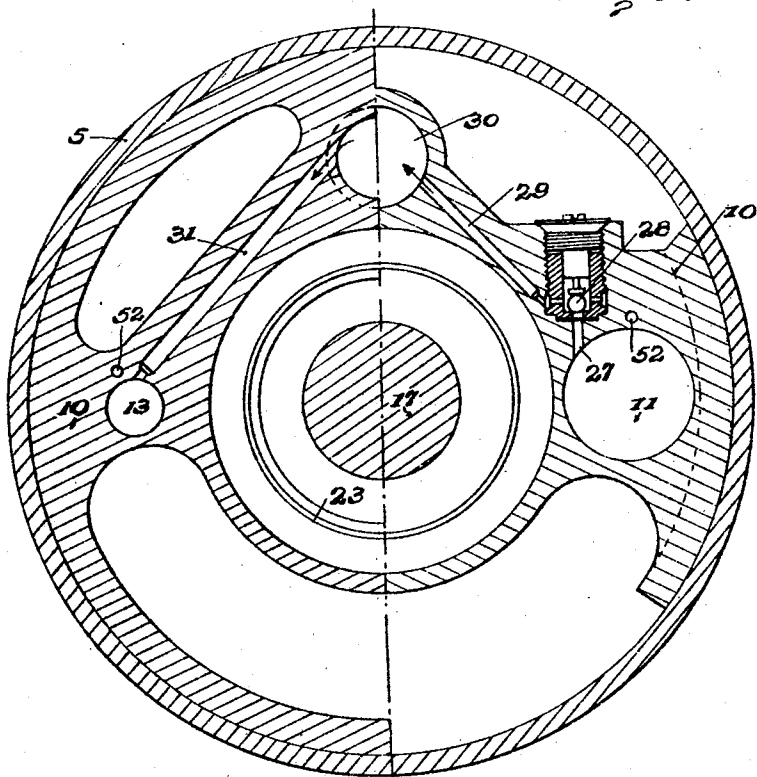
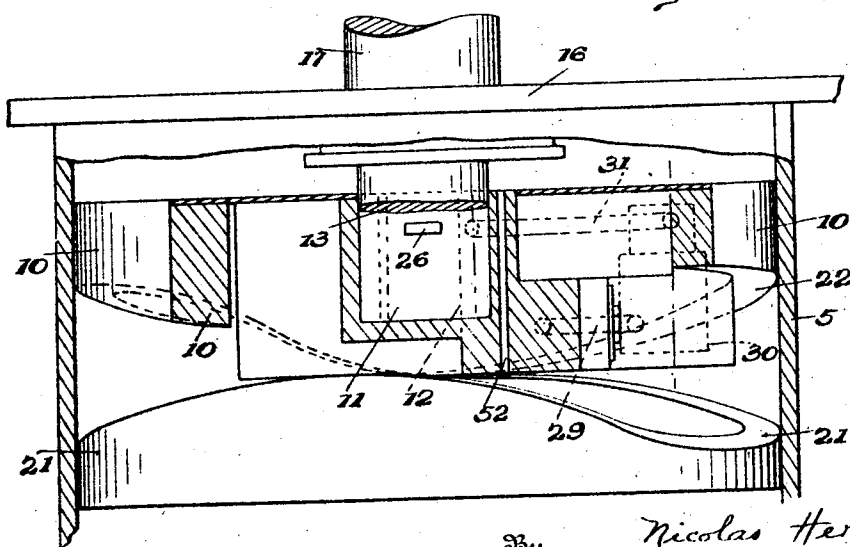


Fig. 3.



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AIR COMPRESSOR

Application filed July 28, 1930, Serial No. 471,336, and in France August 6, 1929.

This invention relates to air compressors and more particularly to those adapted for use in connection with compressed air starters for internal combustion engines.

5 One of the objects of the invention is to provide an air compressor which is simple and compact in structure, efficient and dependable in operation, and which embodies a minimum of moving parts.

10 Another object is to provide an air compressor of novel construction wherein the rotary movement of a driving cam transmits a rectilinear reciprocating movement to a cam-surfaced block within which are formed
15 a plurality of compressor cylinders adapted to receive a plurality of fixed pistons.

A further object is to provide a novel multi-stage compressor wherein the compression strokes of all stages occur simultaneously.

20 Still another object is to provide a novel air compressor of the cam driven type wherein two or more compression cycles are produced during one revolution of the driving cam.

25 A still further object is to provide an air compressor driven by a continuously rotating cam which embodies novel means for automatically interrupting the compressing action independently of the driving cam whenever the pressure produced by the compressor reaches a predetermined amount, which means also restore the compressor to
30 action as soon as the pressure has fallen below this amount.

35 These and other objects will appear more fully from a consideration of the detailed description of the invention which follows. Although only one embodiment of the invention has been described and illustrated in the accompanying drawings, it is to be expressly understood that these drawings are for the purpose of illustration only and are not to be construed as a limitation of the scope of
40 the invention, reference being had for this purpose to the appended claims.

In the drawings, wherein like reference characters indicate like parts throughout the several views,

50 Fig. 1 is a longitudinal, sectional view of

one embodiment of the invention with certain parts shown in full;

Fig. 2 is an irregular, sectional view taken on line 2—2—2—2 of Fig. 1 and turned ninety degrees therefrom;

Fig. 3 is a sectional view taken on line 3—3 of Fig. 1; and

Fig. 4 is a development of the profile of the rotary cam.

Referring now more particularly to Fig. 1, there is shown therein a novel and compact form of air compressor adapted for ready attachment to an internal combustion engine and for cooperation with a compressed air starter therefor. As shown, a cylindrical compressor casing 5 houses and supports all parts of the compressor mechanism in a compact unitary structure, and is provided at one end with a flange 6 whereby attachment may be made in any suitable manner to the crank casing or other portion of an internal combustion engine. A similar flange 7 is provided at the other end of casing 5 to which may be secured a corresponding flange 8 formed on the casing of a compressed air starter 9 of any desired type which is adapted to be actuated by the compressed air produced by the mechanism within casing 5 and to start the engine with the cooperation of one or more parts of said mechanism.

The compressor mechanism itself is housed within the cylindrical bore of casing 5 and comprises, in general, a reciprocable block within which are formed a plurality of compressor cylinders, a plurality of pistons fixed to the compressor casing and extending into said cylinders, and novel cam driving means for imparting to said block a rectilinear reciprocating movement. In the embodiment herein disclosed, a block 10, cylindrical in periphery, is slidably mounted for reciprocable movement within casing 5 and is provided with a pair of cylinders 11 and 12 into which extend corresponding pistons 13 and 14. Cylinders 11 and 12 are both bored from the inner face of block 10 to the same depth and with their axes equidistant from and coplanar with the axis of said block. Pistons 13 and 14 are fixedly secured as by bolts 15

to the inner end plate 16 of casing 5, and not only act to compress the air within cylinders 11 and 12 upon reciprocation of block 10, but also guide the latter and prevents any rotational movement thereof.

In the form shown, the compressor is of the two-stage type, cylinder 11 and piston 13 being of larger diameter than cylinder 12 and piston 14 and constituting the low pressure stage, the latter forming the high pressure stage. It will be expressly understood, however, that the invention is not limited to a two-stage compressor, but that any suitable number of cylinders and pistons, either of varying or uniform diameters, may be substituted for those shown.

Although the compressor may be driven by independent means, it is preferable, in order to conserve weight, space and energy, that the source of driving power for the compressor be the internal combustion engine upon which it is mounted. Novel cam driving means have therefore been provided in the present invention for imparting to cylinder block 10 the reciprocating movement necessary for compressing action. As shown, a driving shaft 17, which is a prolongation of the crankshaft or starting shaft of the engine to which it is connected by any suitable coupling, rigid or elastic (not shown), is journaled in end plate 16 and in a combined thrust and anti-friction bearing 17a, and extends within casing 5 and through a central bore 18 formed within block 10, being provided at its outer end with an enlarged annular portion 19 having a collar or base plate 20, the periphery of which is provided with a backwardly turned flange 21 of varying length constituting a novel form of cam. The periphery of block 10 is provided with a cam surface 22 similar in profile to cam 21 and normally maintained in contact therewith by means of a strong coil spring 23 which is housed within central bore 18 of block 10 surrounding shaft 17 and exerts its force against an inwardly extending flange 24 formed integrally with said block.

It will be seen from the structure thus far described, that any rotation of cam 21 imparted thereto from the engine through driving shaft 17 will, through the cooperation of cam surface 22 and fixed pistons 13 and 14, be converted into rectilinear reciprocating movement of block 10, spring 23 continually exerting a thrust against flange 24 so as to maintain cam surface 22 in contact with cam 21. The thrust of spring 23 is taken up in a combined thrust and anti-friction bearing 25 interposed between base plate 20 of shaft 17 and the inner face of flange 8 of the starter casing.

When, as previously mentioned, the compressor disclosed herein is of the two-stage type, means must be provided not only for supplying air at atmospheric pressure to the

low pressure stage and for collecting in a suitable manner the compressed output of the high pressure stage, but also for connecting the output of the low pressure stage with the input of the high pressure stage in a novel manner so as to permit simultaneous compression in both stages, a method of operation which makes possible the novel compact arrangement of the parts previously described. As shown, the cylinder 11 is provided adjacent its inner end with an inlet 26 through which air at atmospheric pressure is provided to the low pressure stage when, through the cooperation of cams 21 and 22 and the action of spring 23, block 10 moves to the left, as viewed in Fig. 1, on its suction stroke and permits said inlet to be uncovered by piston 13. Upon the return or compression stroke of block 10, towards the right as viewed in Fig. 1, the air thus admitted into cylinder 11 is compressed between the latter and piston 13, and discharged from said cylinder through an outlet 27 (Fig. 2) and a ball valve 28, passing through a passageway 29 bored through block 10 and discharging into an intermediate expansion chamber 30.

Chamber 30 is formed in block 10 with its axis parallel to those of cylinders 11 and 12 but located in a radial plane of said block at right angles to a plane passing through the axes of said cylinders. Chamber 30 is of varying diameter, the outer portion, into which passageway 29 discharges, being of slightly smaller diameter than cylinder 11, and the inner portion, from which a second passageway 31 leads to cylinder 12, of slightly larger diameter than the latter. The compressed air which is delivered to the outer portion of chamber 30 through passageway 29 from the low pressure cylinder 11 expands slightly within said chamber and is thereby cooled.

During the following suction stroke of the cylinder block, this air, now slightly compressed, is drawn from the inner portion of chamber 30 through passageway 31 into the high pressure cylinder 12. During the succeeding compression stroke, the air is again compressed to a higher degree, and escapes from cylinder 12 through a ball valve 32 (Fig. 1) into a passageway 33, both of which are formed in the body of fixed piston 14, and thence into a passageway 34 formed in end plate 16 of casing 5. The latter passageway may be connected with a suitable conduit (not shown) leading to a compressed air reservoir wherein air is stored for future use by the starter 9.

It has been proved by experiment that the novel arrangement of intermediate chamber 30 and passageways 29 and 31, placed between the low and high pressure stages, prevents overheating of the compressor and is conducive to higher efficiency in operation. This arrangement also allows the pistons 13

and 14 to be fixed, and therefore provides simultaneous compression in both stages of the compressor as distinguished from the usual type of compressor wherein alternate operation of the stages is required. Furthermore, by providing a suitable number of such intermediate chambers, it would be possible to employ any number of pistons and cylinders all operated by a common driving cam.

As is best illustrated in Figs. 3 and 4, the profiles of cams 21 and 22, which are identical, are so formed that for each revolution of driving shaft 17 and cam 21, cam 22 receives two inward impulses from cam 21 and two outward impulses under the influence of spring 23; that is, cylinder block 10 performs two complete reciprocations during a single revolution of cam 21, thus producing two suction or intake strokes and two compression strokes in cylinders 11 and 12. As shown in Fig. 4, which represents a development of the profile of cam 21, the first suction stroke takes place from I to II, the first compression stroke from II to III, the second suction stroke from III to IV, and the second compression stroke from IV to I. It will also be seen from Fig. 4 that the profile of the cam is different during the suction and compression strokes so as to insure long compression strokes which gradually, rather than suddenly, compress the air.

It is also to be noted that cams 21 and 22 are always in contact with one another at two diametrically opposite points in such a manner as to prevent wedging or binding of cylinder block 10 during its reciprocating movement.

In apparatus of this type where the compressor is adapted to be driven by a continuously moving member of the engine, it is desirable that means be provided for disconnecting the compressor from its driving means when the pressure produced thereby attains a predetermined amount, and thus relieving the engine at such times of the added load imposed thereon by the compressor. Accordingly, there is provided by the present invention a novel pressure-actuated device for automatically stopping and starting the operation of the compressor dependent upon the pressure produced thereby.

As shown in Fig. 1, a housing 35 is detachably secured as by screws 36 to a boss 37 formed on compressor casing 5, and encloses a latch member 38 slidably mounted therein, the lower end of which extends within a radial opening in casing 5 which is opposite a recess 39 formed in the periphery of block 10 when the latter is at the end of the compression stroke. Recess 39 is slightly larger than the lower end of latch 38 and is provided with sloping walls to facilitate engagement and disengagement of the latch member. The upper portion of latch member 38 is enlarged in size and provided with an

annular groove 40 into which extends a downwardly directed guiding collar 41 formed integrally with the interior of housing 35. Latch member 38 is also provided with a flange 42 formed at its upper end, a coil spring 43 being provided between the bottom of said flange and the upper face of boss 37 for the purpose of normally maintaining latch member 38 in its upper position out of engagement with recess 39. Suitable means may also be provided to assist spring 43 in maintaining the latch member in this position, such as retaining ball 44 which is resiliently urged into engagement with a groove 45, formed in the surface of latch member 38, by means of a spring 46 the tension of which may be adjusted by a screw threaded plunger 47.

The upper surface of latch member 38 within guiding collar 41 is adapted to be subjected to the pressure created by the compressor, and for this purpose is provided with a suitable cup leather 48, secured thereto as by a screw 49, against which the pressure of oil or air, led to the interior of housing 35 through passageways 50 and 51, formed in the housing and in casing 5, respectively, may be exerted. Passage 51 may be connected to a tube (not shown) dipping into a layer of oil at the bottom of the compressed air reservoir, or this passage may be directly connected with passages 33 or 34 leading from the high pressure stage of the compressor, by means of a suitable channel or passageway formed in end plate 16.

Novel means are also provided for lubricating the moving parts of the compressor, and particularly for providing an oil seal between cylinders 11 and 12 and their respective pistons 13 and 14. In the embodiment shown, the bearing surfaces of cams 21 and 22 are lubricated by introducing a quantity of oil into casing 5 and supplying it between said cams by any suitable means. In order that some of this oil may be supplied to pistons 13 and 14, however, a plurality of oil passageways or ducts 52 (Figs. 2 and 3) are bored through cylinder block 10 from the surface of cam 22 inward to the height of the open ends of cylinders 11 and 12, each of said passageways being close to one of the cylinders and so placed that oil issuing therefrom will fall upon one of the pistons. Due to the rapid rotation of cam 21, the oil which is supplied between cams 21 and 22 is fed by centrifugal force into passageways 52 and supplied thereby to pistons 13 and 14 twice for each revolution of cam 21, thus lubricating the frictionally engaging surfaces of said pistons and their respective cylinders, and forming an oil seal therebetween to prevent the leakage of air and consequent loss of compression.

The operation of the above described apparatus is as follows: Assuming that the engine

with which the compressor is adapted for use is running and that the pressure produced by the compressor is below the predetermined standard which it is desired to maintain, driving shaft 17 and cam 21 will be continuously rotated by the crankshaft or starting shaft of the engine through a suitable coupling, and spring 43 will be effective to maintain latch member 38 in its upper position, retaining ball 44 engaging groove 45 under the action of spring 46. Coil spring 23 is effective to maintain cam surface 22 of block 10 in contact with cam 21, and under the combined action of cams 21 and 22 and spring 23, a rectilinear reciprocating movement is transmitted to block 10, cylinders 11 and 12 sliding over their respective pistons 13 and 14.

As block 10 moves to the left, as viewed in Fig. 1, during a quarter revolution of cam 21, under the action of spring 23, air at atmospheric pressure is supplied to low pressure cylinder 11 through inlet 26 as soon as the latter is cleared by piston 13. During the next quarter revolution of cam 21, block 10 is moved to the right and the air within cylinder 11 is compressed and discharged through outlet 27 and ball valve 28, through passageway 29 to intermediate chamber 30 where a slight expansion takes place and a consequent reduction in temperature of the air. On the next quarter revolution of cam 21 another suction stroke takes place during which the now partially compressed air from intermediate chamber 30 is supplied through passageway 31 to high pressure cylinder 12. The last quarter revolution of cam 21 produces a second compression stroke during which the air in cylinder 12 is highly compressed and discharged through ball valve 32 and passageways 33 and 34 to a suitable reservoir wherein it is stored for subsequent use.

When the pressure of the air thus produced by the compressor reaches a predetermined amount, it is effective through passageways 50 and 51 to force latch member 38 downward, overcoming the resistance of spring 43 and retaining ball 44, until the lower end of said latch engages recess 39 formed in cylinder block 10 and retains the latter against further reciprocation. Cam 21 is then free to rotate without being subject to the load imposed thereon by driving block 10. When the pressure in the reservoir or in passageways 50 and 51 falls below the predetermined amount, spring 43 again forces latch member 38 upward out of engagement with recess 39 and the reciprocating movement of block 10 is renewed.

One of the purposes to which the compressed air produced by the compressor can be put is for starting the engine, and the structure of the compressor disclosed herein is especially well adapted for a compact assembly with a starter adapted to utilize this

air. As shown, starter 9 is provided with a suitable jaw 53 which, during the starting operation is adapted to engage a similar jaw 54 which is drivably secured to shaft 17 as by a key 55. Since shaft 17 is directly coupled to the crankshaft or starting shaft of the engine, it will be seen that rotation of starter jaw 53 under the action of the air which has been compressed by the compressor will be effective to crank the engine.

There is thus provided by the present invention a novel form of air compressor which is adapted to be driven by the engine with which it is associated and to store compressed air for use by the engine in starting or for any other desired purpose. The structure of the compressor is simple and compact, and although embodying a minimum of moving parts, is efficient and reliable in operation. The reduction of the number of these moving parts is accomplished by the provision of a novel form of compressor wherein the cylinder block is reciprocated under the combined action of a pair of cam surfaces, one of which is continuously driven by the engine and the other formed on said cylinder block, and the pistons are fixed to the compressor casing so as not only to compress the air but also to guide the cylinder block and prevent it from rotating. Simultaneous compression is thus produced in all cylinders, and the cams are so shaped as to afford two complete compression cycles for each revolution of the driving cam. Novel means have also been provided by this invention which automatically maintain the compressor in inoperative position whenever the pressure produced thereby reaches a predetermined amount, restoring the compressor action when the pressure falls below this amount. The compressor also embodies novel means for lubricating the various parts.

It will be obvious that the invention is not limited to the form shown in the drawings, but is capable of a variety of mechanical embodiments. For example, a number of cylinders greater than two may be utilized, as also may the number of pressure stages be increased to any desired amount. Likewise, cams 21 and 22 may be replaced by others giving different degrees of compression, or giving a different number of compression strokes per revolution of the driving shaft. Various other changes, which will now appear to those skilled in the art, may be made in the form, details of construction and arrangement of the parts without departing from the spirit of the invention, and reference is therefore to be had to the appended claims for a definition of the limits of the invention.

What is claimed is:

1. An air compressor comprising a casing, a plurality of pistons secured to said casing, a cylinder block reciprocable within

said casing and having a plurality of cylinders within which said pistons extend, a rotatable cam within said casing, a cam having a contour similar to that of said rotatable cam and formed integrally with said cylinder block, and resilient means tending to maintain said last named cam in contact with the rotatable cam whereby the rotary motion of the latter is converted into rectilinear reciprocating movement of the cylinder block.

2. An air compressor comprising a fixed casing, a piston secured to and projecting within said casing, a cylinder block reciprocable within said casing and having a cylinder within which said piston extends, a rotatable cam within said casing, and means for converting the rotary motion of said cam into rectilinear reciprocating movement of said cylinder block.

3. An air compressor comprising a casing, a rotatable driving cam within said casing, a reciprocable driven block having a cam surface adapted to engage the rotatable driving cam, compressor cylinders formed in said block, pistons secured to said casing and extending within said cylinders, and means disposed between said pistons for maintaining axial pressure on said reciprocable block to insure continuous contact between the engaging surfaces of said block and driving cam.

4. In an air compressor, a reciprocable cylinder block having a plurality of cylinders formed therein, a plurality of fixed pistons extending within said cylinders, and means for imparting a rectilinear reciprocating motion to said block comprising a rotatable cam, a cam having a contour similar to that of said rotatable cam and formed integrally with said cylinder block, and resilient means for normally maintaining said cams in engagement with one another.

5. An air compressor comprising a rotatable driving cam, a reciprocable cylinder block having a cylinder formed therein, a fixed piston extending within said cylinder, and means including a cam surface formed on said cylinder block for converting the rotary motion of the driving cam into rectilinear reciprocating movement of the cylinder block, said cams being so formed that two or more cycles of the cylinder block occur during a single revolution of the driving cam.

6. An air compressor comprising a casing, a plurality of pistons secured to said casing, a cylinder block reciprocable within said casing and having a plurality of cylinders within which said pistons extend, a rotatable cam within said casing, a cam having a contour similar to that of said rotatable cam and formed integrally with said cylinder block, and resilient means tending to maintain said last named cam in contact with the rotatable cam whereby the rotary motion of the latter is converted into rectilinear reciprocating

movement of the cylinder block, said cams being so formed that two or more cycles of the cylinder block occur during a single revolution of the driving cam.

7. In an air compressor, a driving cam having a continuous rotating movement, a driven cam having a rectilinear reciprocating movement, the profiles of said cams being so formed that a plurality of reciprocations of the driven cam occur during a single revolution of the driving cam, said driven cam being recessed to form a plurality of compression chambers each of which is disposed in a plane passing through the axis of rotation of said driving cam, and means including an expansion chamber for effecting communication with said compression chambers alternately during each revolution of the driving cam.

8. In an air compressor, a rotatable driving cam, a reciprocable cylinder block, means for converting the rotary motion of said driving cam into rectilinear reciprocating movement of said cylinder block, a low pressure cylinder formed in said block, a high pressure cylinder formed in said block, fixed pistons extending into said cylinders, and an intermediate chamber connected to both of said cylinders.

9. In an air compressor, a low pressure cylinder, a high pressure cylinder, a fixed piston in each of said cylinders and actuating means for imparting rectilinear motion to said cylinders to produce the compression strokes in both cylinders simultaneously.

10. In an air compressor, a reciprocable cylinder block, high and low pressure cylinders formed in said block, all of said cylinders being formed in the same side of the block, fixed pistons extending within said cylinders, a cam surface formed on the side of the block opposite to that in which said cylinders are formed, a rotatable driving cam, and means for maintaining said cam surface in contact with said driving cam whereby the rotary motion of said driving cam is converted into rectilinear reciprocating movement of the cylinder block and the compression strokes in all cylinders are produced simultaneously.

11. In an air compressor, a reciprocable cylinder block, a low pressure cylinder formed in said block, a high pressure cylinder formed in said block, fixed pistons extending within said cylinders, an intermediate chamber formed in said block and connected to both of said cylinders, and means for reciprocating said cylinder block and producing the compression strokes in both cylinders simultaneously.

12. In apparatus of the class described, a fixed casing, a block reciprocable within said casing and having a plurality of cylinders formed therein, a plurality of pistons secured to said casing and extending within

said cylinders, a rotatable member having a shaft extending centrally through said block, a cam surface formed on said rotatable member, a cam surface formed on said block and resilient means surrounding said shaft for maintaining said cam surfaces in contact with each other whereby the rotary motion of said rotatable member is converted into rectilinear reciprocating movement of said block.

13. An air compressor comprising a continuously rotating driving cam, a reciprocable driven block having a cam surface adapted to contact with the driving cam, means for normally maintaining said cam surface in contact with the driving cam, compressor cylinders formed in said block, pistons extending within said cylinders, and means for holding said cam surface out of contact with the driving cam whenever the pressure produced by the compressor cylinders reaches a predetermined amount.

14. In combination with an air compressor of the type wherein the rotation of a driving cam communicates a rectilinear reciprocating movement to a block provided with a plurality of cylinders which are guided by fixed pistons, means for automatically holding said block against movement when the pressure created by the compressor reaches a predetermined amount and for releasing said block as soon as the pressure falls below this amount comprising a recess formed in the block, a latch adapted to enter said recess, means normally maintaining said latch out of engagement with the recess and always opposing such engagement, and pressure responsive means subject to the pressure created by the compressor for moving said latch into engagement with the recess.

15. In an air compressor, a rotatable driving cam, a reciprocable block containing a cylinder within which air is compressed, a fixed piston extending within said cylinder, means normally maintaining said block in contact with said cam whereby the rotary motion of the latter is converted into rectilinear reciprocating movement of the block, a recess formed in said block, a latch adapted to engage said recess when the block is at the end of the compression stroke, resilient means opposing engagement of said latch and recess, and pressure responsive means actuated by the pressure created by the compressor for urging said latch into engagement with the recess.

16. In an air compressor of the type wherein the rotation of a driving cam communicates a rectilinear reciprocating movement to a driven cam which is formed integrally with the block provided with a plurality of cylinders into which extend fixed pistons, means for lubricating said pistons with oil provided between the cams comprising a plurality of passages formed in the block and

extending from the face of the driven cam to the height of the open ends of the cylinders.

17. An air compressor comprising a rotary driving shaft, a driving cam carried by said shaft, a reciprocable block having a cam surface formed thereon the profile of which is a duplicate of that of the driving cam, resilient means surrounding the driving shaft and urging the cam surface of the block into contact with the driving cam whereby the rotary motion of the latter is converted into a rectilinear reciprocating movement of the block, a pair of compressor cylinders formed in the block, a pair of fixed pistons extending within said cylinders, one cylinder and piston being of larger bore than the other, and pressure actuated means for automatically stopping the reciprocating compressing action of the block when the pressure produced thereby reaches a predetermined amount, and for restoring said action when the pressure falls below said amount.

18. An air compressor comprising a rotatable driving cam, a cylinder block reciprocable along the axis of rotation of said driving cam, said cylinder block having a cylinder formed therein about an axis offset from said first named axis, a fixed piston extending with said cylinder, and means including a cam surface formed on said cylinder block for converting the rotary motion of the driving cam into rectilinear reciprocating movement of the cylinder block.

19. In an air compressor, a reciprocable cylinder block, high and low pressure cylinders formed in said block, actuating means for said block, and relatively stationary means within said cylinders cooperating with said actuating means to produce compression in said cylinders simultaneously.

20. In an air compressor, a reciprocable member having high and low pressure chambers therein, an intermediate chamber connecting said high and low pressure chambers, and relatively stationary means within said high and low pressure chambers and cooperating therewith to produce successive stages of compression in said chambers in response to movement of said reciprocable member.

In testimony whereof I have signed this specification.

NICOLAS HERZMARK.