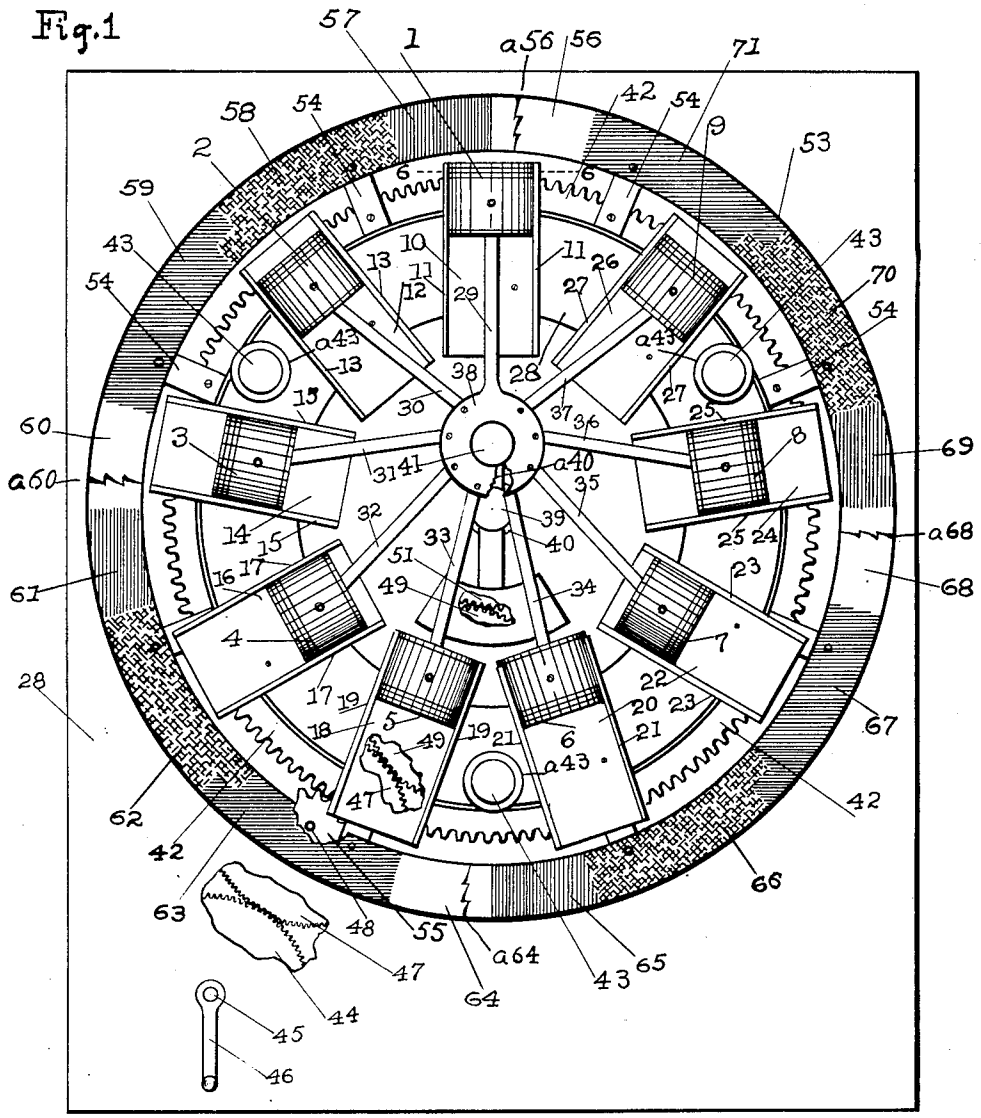
Aug. 29, 1933. R. C. LINDBERG 1,925,040

RADIAL GAS ENGINE DEMONSTRATOR

Filed May 10, 1932 2 Sheets-Sheet 1

Fig.1



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RADIAL GAS ENGINE DEMONSTRATOR

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Fig. 2

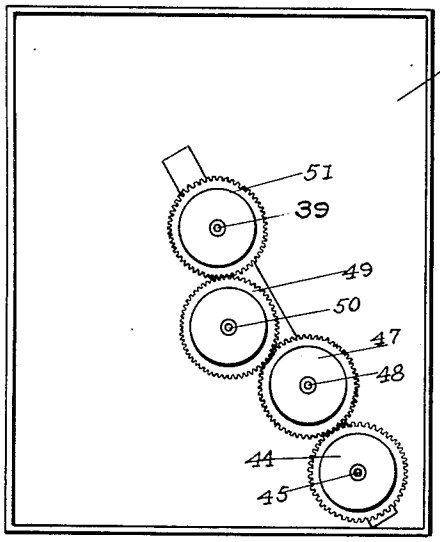


Fig. 3

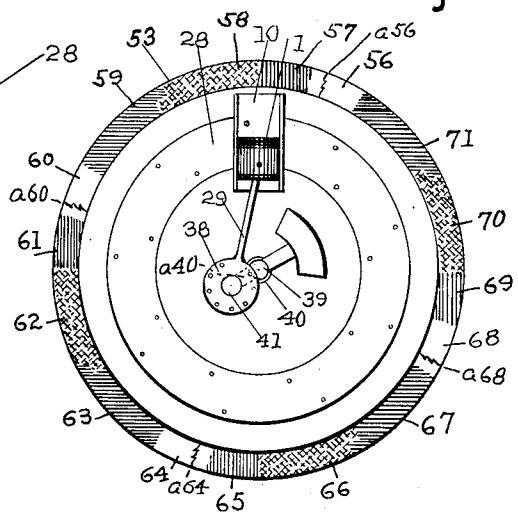


Fig. 4

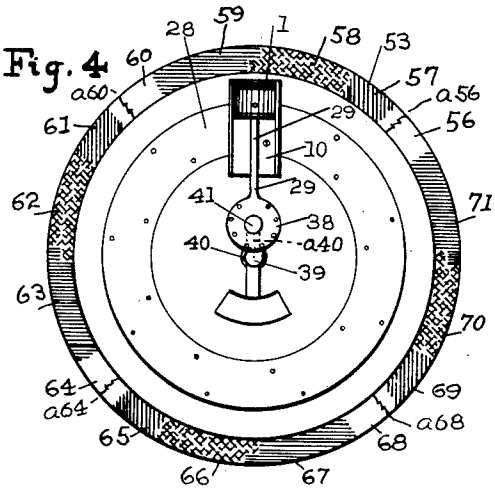
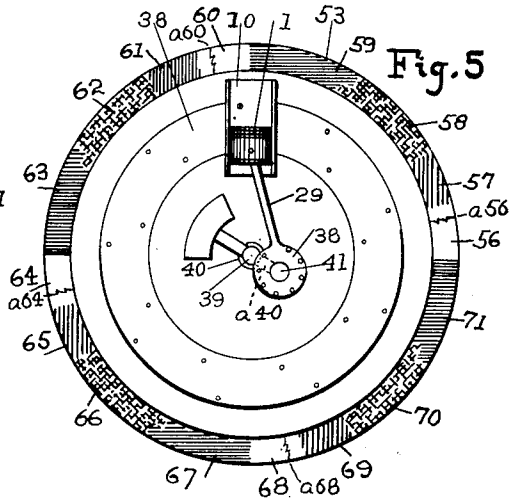


Fig. 5



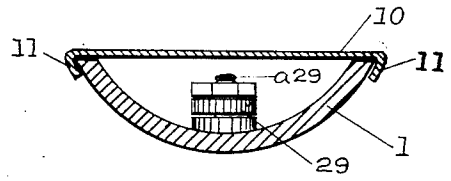


Fig. 6

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UNITED STATES PATENT OFFICE

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RADIAL GAS ENGINE DEMONSTRATOR

Raymond C. Lindberg, Bellingham, Wash.

Application May 10, 1932. Serial No. 610,518

1 Claim. (Cl. 35—16)

My invention relates to improvements in mechanical demonstrators of radial, internal-combustion engines and has for an object to show a moving cross-section of a multicylinder, radial, internal-combustion engine and the operative coordination of the connecting-rod hook-up, valve sequence and firing order.

Another object of my improvement is to provide a multicolored ring, representing the cam ring of the engine being demonstrated, displaying the coordination of all of the pistons at any particular position in the stroke of one of them.

Another object of my improvement is to use a multicolored ring, representing the cam ring of the engine being demonstrated, disposed for revolution concentric and synchronously with the said cam ring and adjacent the outer limits of piston reciprocation displaying piston location as related to engine valve operation.

Another object of my improvement is to provide a multicolored ring divided into colored sectors corresponding with the cam surfaces of the cam ring of the engine being demonstrated and disposed for revolution adjacent the outer limits of piston travel for locating the position of piston travel at the beginning, during and at the end of each piston stroke as controlled by visually indicated valve action.

Another object of my improvement is to use a multicolored ring represenring the cam ring of the engine being demonstrated displaying piston location during any period of engine crank revolution.

Another object of my improvement is to provide a mechanical demonstrator to aid in visualizing the coordinating operations of the working parts of a radial, internal combustion engine and also their relative operative positions at any particular stage of engine operations.

Other objects of my improvement will appear as the description proceeds.

I attain these and other objects of my improvement with the mechanism illustrated in the two sheets of accompanying drawings, which form a part of this specification, in which Figure 1 is a plan view of my demonstrator; Fig. 2 is a bottom plan view of Fig. 1 drawn on a smaller scale; Fig. 3 is a view of my demonstrator similar to that of Fig. 1 in which the illustration is confined to the No. 1 piston, the other pistons being omitted from the drawing, shown at the conclusion of the work stroke, the exhaust valve having commenced to open, drawn on a smaller scale; Fig. 4 is of the same character as Fig. 3 and shows the No. 1 piston at the conclusion of the exhaust stroke, that is, at top dead center and indicates the simultaneous closing of the exhaust valve and opening of the intake valve; Fig. 5 is of the same character also as Fig. 3 and shows the No. 1 piston at the commencement of the compression stroke, and Fig. 6 is a cross section of a fragmentary part of Fig. 1 on the line 6—6 thereof drawn on a larger scale.

Similar characters designate similar parts throughout. Certain parts are broken away to show other parts hidden thereby.

With more particular reference to the designated parts: The plate 28 constitutes the principal frame structure on which my demonstrator mechanism is mounted. The nine pistons illustrated by the demonstrator are numbered 1, 2, 3, 4, 5, 6, 7, 8 and 9 as customary in the art. Each of the pistons is represented by a hollow cylindrical sector, shown best in Fig. 6 where the sector 1 represents the piston of that number mounted for reciprocation in a slideway consisting of a flat rectangular plate 10 having upturned edges 11, 11 which are disposed to engage the edges of the sector 1. The plate 10 of the demonstrator is used to be a semblance to the cylinder in which the piston No. 1 is assumed to be mounted, and it is fastened to the frame plate 28 to be stationary therewith.

One end of the master piston rod 29 is pivoted to piston No. 1 and the other end thereof is integral with bearing disc 38 which is mounted on the engine crank pin 41 to drive the same, by assumption, but actually, in the demonstrator, to be driven thereby. The crank pin 41 is in engine crank *a*40 having hub 40 fastened to the engine shaft 39 which is mounted in a bearing on frame plate 28 for revolution.

There are eight other cylinder-semblance plates 12, 14, 16, 18, 20, 22, 24, and 26 which also are fastened to frame plate 28 and, with plate 10, are disposed radially around shaft 39 equally spaced and equally distant therefrom. The cylinder-semblance plates 12, 14, 16, 18, 20, 22, 24 and 26 have upturned edges 13, 15, 17, 19, 21, 23, 25 and 29, respectively, to mount for reciprocation pistons Nos. 2, 3, 4, 5, 6, 7, 8 and 9 respectively. One end of each of auxiliary piston rods 30, 31, 32, 33, 34, 35, 36 and 37, respectively, is pivoted to one of said pistons, respectively, and the other ends thereof are pivoted to bearing disc 38 at points equidistant from the center of crank pin 41 and, with master rod 29, are equally spaced therearound.

A ring gear 42 is mounted for revolution on rollers, *a*43, *a*43 and *a*43, which in turn are mounted for revolution on pins 43, 43, and 43.

The pins are fastened in the frame plate equidistant from shaft 39 and equally spaced thereabout. The ring gear 42 is preferably disposed beneath the outer ends of the cylinder-semblance plates, and it is engaged by the spur gear 55 to be driven thereby. The spur gear 55 is fastened on the upper end of a short shaft which is mounted for revolution in a bearing on the frame plate 28 and has the spur gear 47 fastened on its lower end, disposed on the lower side of the frame plate. Also disposed on the lower side of the frame plate is the spur gear 44 which is engaged with the spur gear 47 and is fastened on the lower end of the short shaft 45 to revolve therewith. The shaft 45 is mounted for revolution in a bearing on the frame plate and is extended above the same having handle crank 46 fastened on its upper end by which it may be manually driven.

The spur gear 51 is fastened on the lower end of engine shaft 39 disposed on the lower side of the frame plate 28. The idler spur gear 49 is mounted for revolution on short stud shaft 50 which is fastened on the lower side of the frame plate disposed to cause the gear 49 to engage both of the gears 47 and 51. All of the gears 44, 47, 49 and 51 are of equal diameter and number of teeth, the construction providing for driving engine shaft 39 at the same rate as handle crank 46 and in the opposite direction. The construction also provides for driving ring gear 42 by hand crank 46 in the same direction thereof and at one-eighth the rate thereof.

The multicolored, annular, engine-cam-ring extension 53 has arms 54 by which it is fastened to the ring gear 42 to be revolved thereby and it is disposed adjacent the outer ends of the cylinder plates. The ring 53 is divided into four equal parts each of which is subdivided into four parts subtending the same angles being subtended by the cam sectors of the engine cam ring, which is not shown in the demonstrator.

Beginning with the sector 56, which is white in color and corresponds with a sector of the cam ring operable during a compression and firing period thus allowing both of the valves of a cylinder to remain closed; the next sector on the left is 57 which is red in color and corresponds with a cam sector which is operable during a power stroke of a piston and continues to allow both of said valves to remain closed; the next sector is at 58 which is orange in color and corresponds with a cam sector which operates to open an exhaust valve and maintain the same open till an intake valve is opened by the next cam sector with which a blue colored sector 59 corresponds. The overlapping adjacent ends of sectors 58 and 59 indicates that the cams operate to open an intake valve during the closing of an exhaust valve.

Thus is shown the four sectors of one quadrant of the ring 53. The remaining three quadrants of the ring 53 are exact replicas of the one explained and they correspond with the remaining three quadrants of the cam ring.

Continuing around ring 53 toward the left, the next sector 60 is white in color and is a compression and firing sector; the next is sector 61, a work sector, red in color; the next is sector 62, orange in color, an exhaust sector; the next is sector 63, blue in color, an intake or charging sector, which is the last of the second quadrant. The first sector 64 in the third quadrant is adjacent the said sector 63, is white in color, a compression and firing sector; the next is sector 65, red in color, a work sector; the next is sector 66, orange in color, an exhaust sector; the next is sector 67, blue in color, a charging sector, which completes the third quadrant. After sector 67 is white sector 68, a compression and firing sector; next is sector 69, red in color, a work sector; next is sector 70, orange in color, an exhaust sector, and the next and last is the sector 71, blue in color, a charging sector which is adjacent the said sector 56 and completes the fourth quadrant.

Thus constructed, colored and operated, the color ring consists of a single band of similar groups of different colored segments, each color segment thereof being revoluble synchronously with a particular cam surface, on the cam ring of the engine being demonstrated thereby, which impels in the said engine the particular engine action indicated by the said color.

The illustrated construction of piston-rod and crank-pin assembly hook-up, the radially-disposed cylinder slideways and their related operative movements closely resemble the movement of this type of gas engine and they are displayed in a way to clearly show their character. To these is added the multicolored ring 53 which by means of its carefully made colored sectors shows the operative conditions within the cylinders at any desired operative phase.

In order to better understand the useful character of this demonstrator some of its possibilities will be explained.

In practice the following legend is painted on the frame plate of the demonstrator:

(Blue color) Intake opens 8° before top center.

(Blue color) Intake closes 60° after bottom center.

(White color) Compression continues for 180°.

(Red color) Power stroke continues for 120°.

(Orange color) Exhaust opens 60° before bottom center.

(Orange color) Exhaust closes 8° after top center.

Firing order: Pistons Nos. 1, 3, 5, 7, 9, 2, 4, 6, 8.

Spark occurs 30° before top center.

The degree measure referred to in the legend is that of the engine crank *a*40 in backward rotation referred to its initial position as shown in Fig. 1.

In Fig. 1, piston No. 1 has master piston rod 29 pivoted thereto, and for the purposes of the demonstrator, is a segment of a hollow cylinder and is mounted for reciprocation on cylinder plate 10 being engaged therewith by the overhanging edges 11, 11 thereof. The engine crank *a*40 is central to cylinder plate 10 causing piston No. 1 to be in what is known in the art as its top center position relative to cylinder plate 10.

The dividing line betwen white sector 56 and red sector 57 is central to cylinder plate 10. Note that the crank *a*40 revolves backward and that the color ring 53 revolves forward at one-eighth the rate of the crank revolutions. The legend states that the firing spark (*a*56) occurs 30° before top center. That is, in Fig. 1, spark *a*56 occurred when the crank *a*40 was within 30° of its illustrated position. Then the explosive mixture in the cylinder represented by plate 10 was fired before the piston No. 1 had quite reached its illustrated position at top center. Piston No. 1 begins its work stroke as soon as the crank *a*40 has moved to a position of, say, 10° beyond that shown in Fig. 1 and the red sector 57 has moved 1¼° farther over the piston; and the work stroke of the said piston closes when the crank *a*40 reaches

the position in its backward revolution 120° from its position in Fig. 1 as shown in Fig. 3, at which time the piston is near the bottom of its stroke, which fully occurs when the crank moves 60° farther to its bottom center position relative to the said cylinder represented at 10. The legend states that the exhaust valve opens 60° before bottom center which is the position of the crank *a*40 shown in Fig. 3. So that Fig. 3 shows the relative crank and colored ring positions when the exhaust valve is opened in the cylinder represented by plate 10 by the engine cam sector subtended by the orange color 58.

The legend states that the exhaust closes 8° after top center. In Fig. 4 the crank *a*40 is shown in its top central position relative to the cylinder represented at 10 and the overlapping ends of the orange color 58 and the blue color 59 are centrally over cylinder plate 10 indicating that the exhaust valve will close when the crank *a*40 has moved 8° from its position in Fig. 4. Also, the legend states that the intake opens 8° before top center. So that the intake valve in the cylinder represented by plate 10, when under control of the engine cam sector which subtends the same angle as does the blue colored sector 59 of the color ring 53, was opened thereby when the crank *a*40 passed the point in its rotation 8° before it reached its position shown in Fig. 4.

The legend states that the intake closes 60° after bottom center. In Fig. 5 the dividing line between the blue colored sector 59 and the white sector 60 is centrally over the cylinder plate 10; piston No. 1 is near the bottom of its stroke, and the crank *a*40 is in a position 60° after its bottom central position relative to plate 10. So that the relative positions of the cooperating parts in Fig. 5 are those pertaining when the intake valve of the cylinder represented by plate 10, when controlled by the engine cam sector which subtends the same angle as does the blue colored sector 59, is fully closed.

Thus, by means of the demonstrator illustrations, the operation of one of the nine piston and cylinder assemblies of a radial gas engine has been carried through one complete set of cylinder operations which included two revolutions of the engine crank and one quarter of a revolution of the cam ring as evidenced by the multicolored ring assumed to be revolved simultaneously therewith. If the same cylinder and piston were operated in connection with each of the other three quadrants of the colored ring 53, it would be found that the operations of the demonstrator mechanism are alike in each of the four quadrants of the said colored ring; so that no further particular explanation of the operation of this particular piston and cylinder appears to be needed. Furthermore, if each of the remaining eight cylinders and pistons were carried through examinations similar to those to which the operation of piston No. 1 and its cylinder have been subjected, the closest similarity of operations to those above explained would be found. So that, separate drawings like Figs. 3, 4 and 5, to explain the operations of each of the other piston and cylinder assemblies are not necessary. However, some of the other pistons may be referred to in connection with their location in Fig. 1 to more fully explain the assistance to an understanding of this gas engine provided by my demonstrator.

Take, for instance, piston No. 3 and cylinder plate 14 of Fig. 1. By turning crank *a*40 through 50° in backward rotation it will be within 30° of its top central position relative to cylinder plate 14 and meanwhile the colored ring has revolved forward through 6¼° which places the piston No. 3 in its firing position, according to the legend, and the spark indicated at *a*60 occurs to ignite the nearly fully-compressed charge in the cylinder.

Next consider piston no. 5 and its cylinder plate 18 as shown in the demonstrator illustration in Fig. 1. A movement of 130° in backward rotation of the crank *a*40 from its position in Fig. 1 will bring it within 30° of its top central position relative to cylinder plate 18, and meanwhile color ring 53 has moved forward through 16¼°, which places white sector 64 adjacent the cylinder plate 18 in the position indicated by the legend for the occurrence of the spark at *a*64 while the position of the piston No. 5 is that of nearly full compression.

Next consider piston No. 7 and its cylinder plate 22. A backward rotation of 210° in crank *a*40 from its position in Fig. 1 will bring it within 30° of its top central position relative to cylinder plate 22. Meanwhile color ring 53 has moved forward through an angle of 26¼°, relative to its position in Fig. 1, which brings the white sector 68 adjacent to the end of the cylinder plate 22 and in the position when, according to the legend, the spark at *a*68 should occur, while the piston No. 7 is nearly in the position of full compression.

Next consider piston No. 2 and its cylinder plate 12. A movement in backward rotation of 48° of crank *a*48 from its position shown in Fig. 1 will somewhat withdraw piston No. 2 from its top position and meanwhile the color ring 53 has moved forward through 6° relative to its position in Fig. 1 which places the assumed engine cam ring and the illustrated color ring in the position where, according to the legend, the exhaust valve of the cylinder represented by cylinder plate 12 will be fully closed. Also, according to the said legend, the intake valve of the said cylinder opened as soon as the crank *a*40 had moved through an angle of 32° from its position shown in Fig. 1. The overlapping adjacent ends of the orange colored segment 58 and the blue colored segment 59 is to indicate that the intake valve opens prior to the closing of the exhaust valve a space during which the engine cam ring moves 2° and the engine crank moves 16°.

In this way, if it were needed to a clear understanding by those skilled in the art, each of the particular and related movements and operations of the cooperative parts of the demonstrator, and the engine which it typifies, could be taken up and explained. In fact, that is what is done by the instructor using this demonstrator before a class of novices in the art.

It may be added that in a nine cylinder engine, as represented by the demonstrator illustrated, the engine cam disc and the colored ring 53 of the demonstrator revolve forward through one revolution while the crank revolves backward eight revolutions during the time while all of the nine cylinders and the pistons therein complete a period of operation.

My demonstrator also could include a spark timer demonstrator operating in conjunction therewith. But its operations are easily explained without a demonstrator and its inclusion is not necessary.

Having thus disclosed my invention, what I claim as new therein and desire to secure by Letters Patents is,—

A radial internal combustion engine de-

monstrator including, a plurality of radial guides, slides mounted for reciprocation in the said guides, an assembly of a crank shaft and connecting rods to reciprocate the said slides synchronously with the pistons of the engine being demonstrated, a ring mounted for revolution concentric with the said crank shaft revoluble thereby synchronously with the cam ring of the engine being demonstrated, disposed adjacent the outer ends of the said guides having thereon a single band of similar groups of different colored segments, each color segment thereof indicating a particular engine operation impelled by a particular cam surface of the said cam ring of the engine being demonstrated, a demonstrator frame for supporting the said guides and for mounting the said crank shaft and color ring for revolution, and means for revolving the said crank shaft and color ring in opposite directions at the same relative speeds as the relative speeds of the crank shaft and cam ring of the engine being demonstrated.

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