April 29, 1958 W. E. ARMSTRONG 2,832,855

IGNITION TIMING ADVANCE MECHANISM

Filed April 9, 1954 2 Sheets-Sheet 1

Fig. 1.

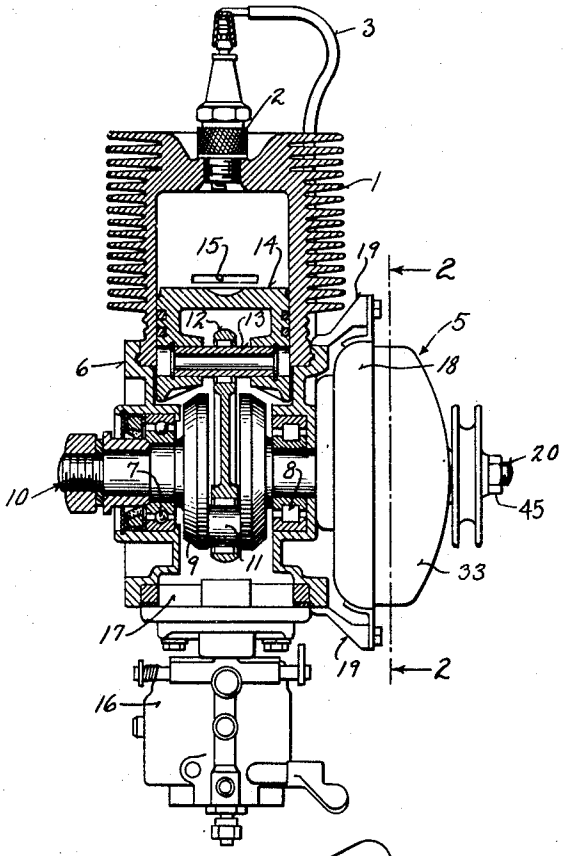
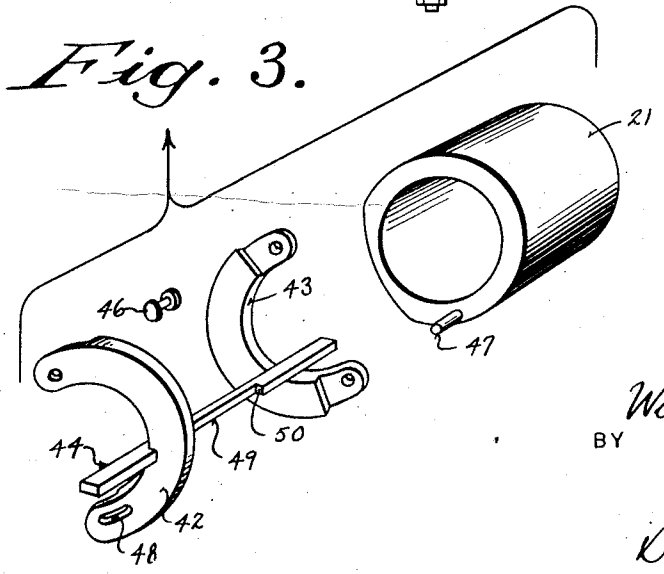


Fig. 3.



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Filed April 9, 1954 2 Sheets-Sheet 2

Fig. 2.

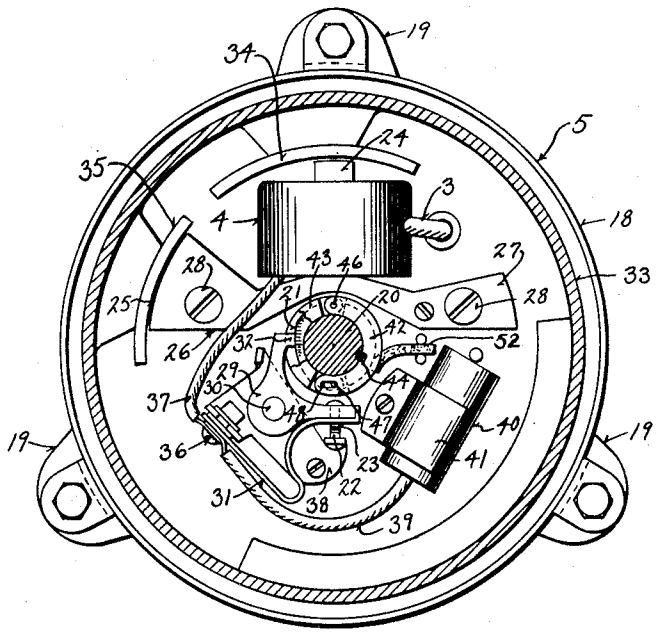


Fig. 4

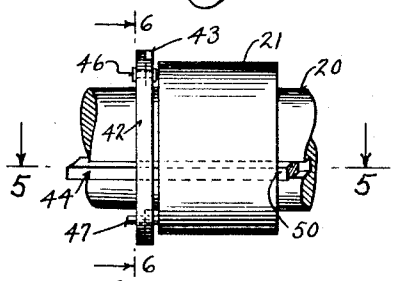


Fig. 5.

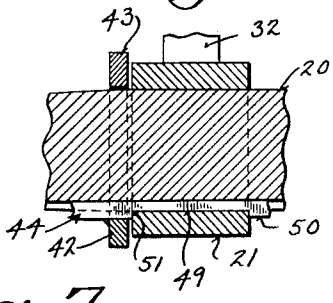


Fig. 6.

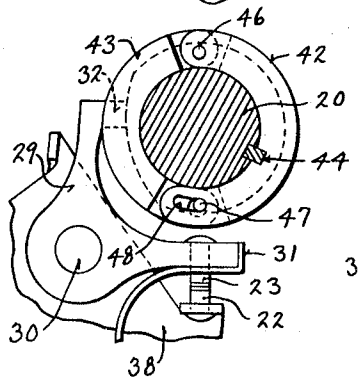
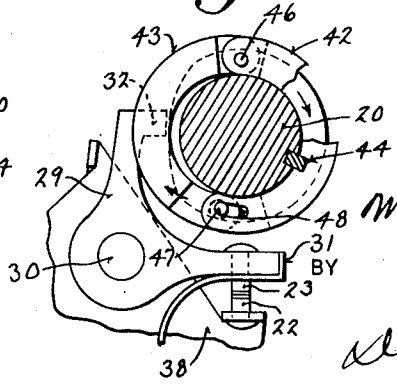


Fig. 7



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IGNITION TIMING ADVANCE MECHANISM

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9 Claims. (Cl. 200—31)

This invention relates to electrical jump-spark ignition apparatus for internal combustion engines in which the combustion charge is ignited electrically at a position of angular advance with respect to dead center and it resides in novel means by which the position of advance is rendered dependent upon engine speed through a crankshaft-driven cam frictionally engaged by a contact controlling follower or wiper the cam being capable of relative angular motion with respect to the crank and being urged toward an advanced relation with respect to the crank by centrifugal means, and being urged toward retarded relation with respect to the crankshaft mainly by the frictional engagement between the wiper and cam.

The improvement of this invention is adapted for use, generally, with jump spark ignition internal combustion engines, but its chief and important advantages of marked simplicity and economy and its unusual compactness render it especially useful in connection with small portable prime movers employed to power portable tools such as lawn mowers, portable chain saws, garden tractors, washing machines and similar tools and appliances. In all such equipment, ease of starting, freedom from backfiring, regular running at idling speeds and good power output at normal operating speeds are all important and desirable characteristics.

As is well-known, in jump-spark ignition engines, it is necessary at starting and during idling that a retarded ignition angle of advance, not greatly in advance of top dead center, be maintained, but as engine speed increases it is necessary that a greater ignition advance be provided if power output is to be sustained. Means for manually advancing and retarding the spark are not entirely suited to small high-speed engines; and accordingly large numbers of such engines are made and used, in spite of the disadvantages thereof, which operate with a fixed angle of ignition advance.

Means for automatically advancing the spark with increasing engine speed have long been available for use in larger engines. A common structure of this type has included a breaker cam which is movable angularly with respect to the crankshaft, the motion being controlled by centrifugal fly weights acting against a spring. The governor power required to move and maintain the cam reliably against the friction imposed by the breaker arm in such devices is considerable and for this reason fly weights of considerable mass, working against a spring of considerable tension, have been required. The minimum practical dimensions and the cost of such equipment are such as to render the use thereof, on small engines, undesirable. In the case of small engines, advance of the spark in strict proportion to engine speed has, in accordance with this invention, been found to be of minor importance, since a single retarded spark position will give good starting and steady idling characteristics, free of backfiring, and a single advanced spark position, brought about at speeds in the lower ranges of normal operating speed, is adequate. This is particularly true in the many instances where the engine is used essentially as a constant speed prime mover.

It is an object of this invention to provide spark ignition means sufficiently compact to be suitable for use in small spark ignition internal combustion engines, which means deliver an advanced spark at speeds above starting and idling speeds, and a retarded spark at starting and idling speeds.

Another object of this invention is to provide a speed-responsive ignition-advance for internal combustion engines, through means low enough in cost to render the use thereof economical in prime movers of small size.

It is a further object of this invention to provide centrifugally responsive spark advancing and retarding means for the ignition system of an internal combustion engine which is free of dependence upon means interposing a continually acting force in opposition to the centrifugally created force of the fly weight means so that the entire available force of the fly weight means is available to cause spark advance to occur, thus reducing the mass and dimensions of fly weight means required to produce the advancing action.

Another object is to provide a spark advance means, wherein the force acting to cause retarding motion, at lower speeds, is provided by friction rather than by a spring or other biasing force which is continuous in its action.

These and other objects and advantages will appear from the description following in which reference is made to the accompanying drawings which form a part hereof, and in which there is shown, by way of illustration and not of limitation, a specific form in which the invention may be embodied.

In the drawings:

Fig. 1 is a side view in elevation and in section of a conventionalized single cylinder two cycle gasoline engine including an improved magneto constructed in accordance with this invention,

Fig. 2 is a view in section of the magneto assembly of the engine shown in Fig. 1 viewed through the plane 2—2.

Fig. 3 is an exploded view in perspective of the improved advancing mechanism controlling the breaker cam of the magneto shown,

Fig. 4 is a fragmentary view of a portion of the engine crankshaft showing the breaker cam and timing advance elements appearing in Fig. 3 mounted thereon,

Fig. 5 is a fragmentary view of the crankshaft of the engine shown, viewed through the plane 5—5, shown in Fig. 4,

Fig. 6 is a view in cross section of the engine crankshaft showing the breaker cam mounted thereon in retarded position together with the breaker arm, and

Fig. 7 is another view in cross section of the engine crankshaft with the breaker cam advanced from the position shown in Fig. 6.

The form of the invention appearing in the drawings is shown applied to a magneto ignition system for an otherwise conventional, single-cylinder, air-cooled, two-cycle internal combustion engine, being typical of engines wherein the invention demonstrates its greatest utility. It is to be understood, however, that the invention may be found useful in single or multiple cylinder engines of both the two-cycle and the four-cycle type, with either magneto or battery ignition systems.

The engine, as shown, includes a finned cylinder 1 with a central spark plug 2 connected by a lead 3 with the high tension terminal of a magneto coil 4 housed within the magneto assembly 5. The cylinder 1 is secured to a crankcase 6, having bearings 7 and 8 straddling the throw 9 of a crankshaft 10 rotatably mounted on the bearings. A connecting rod 12 makes journaled connection at its lower end with crank pin 11, of throw 9, and pivotally engages wrist pin 13 in piston 14 all in conventional manner. A transfer passage joining the crankcase 6 with space above the piston, but not shown, provides an inlet for fuel and air while exhaust is through exhaust port 15. A carburetor 16, connected through an

induction valve 17 with the crankcase 6, supplies the fuel-air mixture which is transferred from the crankcase 6 to the cylinder 1 by crankcase compression.

The magneto assembly 5 is provided with an inner housing 18, joined to the crankcase 6 by brackets 19, which rigidly maintain the housing 18 in concentric relation with the crankshaft 10. An extension 20 on the crankshaft 10 enters the housing 18 to drive a cam 21 which acts to separate contacts 22 and 23 joined in short circuit relationship with a low tension winding in coil 4 in accordance with customary magneto practice.

Coil 4 surrounds a central pole 24 of a yoke 26 provided with flanking poles 25 and 27. Yoke 26 is secured by screws 28—28 to the inner housing 18 with the faces of poles 24, 25 and 27 concentric with crankshaft 10.

Separation of the contacts 22 and 23 by the cam 21 is effected through an insulating breaker arm 29, pivotally mounted on post 30, carrying the contact 23 and spring urged by spring 31 toward a position in which the contacts are engaged. The end of the breaker arm 29, opposite that carrying the contact 23, extends radially inwardly with respect to the extension 20 of shaft 10 to engage the surface of cam 21 as a wiper or cam follower 32.

Cam 21 is circularly cylindrical over approximately two-thirds of its circumference while the remainder is cut below the circular contour to provide a gradual drop, into which the wiper 32 descends, to permit contacts 22 and 23 to engage, whenever the cam 21 reaches the position shown in Figs. 2, 6 and 7. After a short dwell in engagement, further rotation of cam 21 thereafter brings the gradually increasing radius of its contour again into contact with wiper 32 producing separation of contacts 22 and 23. The moment of this separation creates an impulse causing firing to occur in accordance with well-known principles of magneto construction.

Secured to the extension 20 of the crankshaft 10 is a bell-shaped flywheel 33 drawn to the shape shown, serving not only as a flywheel but also to complete the enclosure of the remaining magneto parts. The flywheel 33 is formed of magnetic material and carries strongly, permanently, magnetized rotor shoes 34 and 35, located to pass close to the pole tips of poles 25, 24 and 27. As shoe 34 leaves and shoe 35 approaches a position adjacent pole 24 a rapidly changing magnetizing force is applied to pole 24 tending to induce a rapid change in flux threading coil 4. For an interval just preceding, the primary circuit of coil 4 remains closed by engagement of contacts 22 and 23, which reopens at or near a condition of maximum rate of change of magnetizing force.

The fixed end of spring 31 is carried in an insulated binding post 36 and joined through lead 37 with the primary winding of coil 4. The opposite end of the primary winding is electrically joined or grounded to the inner housing 18 which through bracket 38 is in electrical engagement with contact 22 supported thereon. Closure of the primary circuit, heretofore mentioned, is thus effected upon engagement of contacts 22 and 23. Connected also to post 36 by lead 39, is a capacitor 40 the opposite terminal of which is grounded through its mounting 41 to the inner housing 18. Upon separation of contacts 22 and 23 the usual oscillating discharge is caused to occur in the primary circuit of which capacitor 40 forms a part in accordance with well-known ignition circuit practices.

Cam 21, as appears more clearly in Fig. 3, has a smooth central bore within which the crankshaft extension 20 is received with a close but free turning fit. Because of this freedom of motion between the cam 21 and the shaft extension 20 means are provided for driving the cam. For this purpose, a split collar having a fixed portion 42 and a centrifugally responsive or fly weight portion 43 are assembled about the extension 20 adjacent the cam 21. A key 44 received in a key slot

in the extension 20 and there rigidly held by the hub of the fly-wheel 33 and nut 45 is secured rigidly to the fixed portion 42 of the split collar thus causing the latter to rotate with and in rigidly fixed relation to the shaft extension 20. In this manner there is provided a mounting, fixed in relation to shaft extension 20, for a pivot pin 46 which in turn provides a pivotal connection between the fixed portion and the fly weight portion of the split collar.

An actuating pin 47 extending axially from the end surface of cam 21 enters, with a loose fit, a hole in the free end of the fly weight member 43 and continuing beyond passes through a guiding and retaining slot 48 in the adjacent end of the fixed portion 42 of the split collar. By reason of this construction, the cam 21, the shaft extension 20 and the fly weight 43 are free to occupy and move between the two positions shown in Figs. 6 and 7 in response to the dominating component of the resolved forces acting thereon.

As a convenient means for retaining the cam 21 against endwise movement the key 44 is notched as at 49 to conform with or to fall below the circumference of the shaft extension 20 thus leaving shoulders 50 and 51 acting with a free sliding fit upon the end surfaces of the cam 21. As appears in Fig. 2, a lubricator felt is mounted to bear upon the cam surface of cam 21 with very little friction to maintain lubrication at the sliding engagement between the cam 21 and the wiper 32.

It will be observed that the fly weight 43 acts against no governor spring, nor any other biasing force, acting continuously thereon, and, as a result, whenever the rate of rotation of the shaft extension 20 exceeds that at which centrifugal force exceeds the retarding effect of the friction of wiper 32 and lubricator felt 52, cam 21 will be advanced to the position shown in Fig. 7, and will remain in said advanced position until speed again drops below the said determining speed. The determining speed of advancing and retarding motion, herein called determining speed of advance, is established by the mass of fly weight 43, the mechanical advantage of the connection of the same with the cam 21, and the torque imposed by parts in frictional engagement with the cam 21. Since the latter forces are comparatively constant while the centrifugal force increases exponentially with speed, the determining speed of advance will occur reliably within a relatively narrow range in spite of alterations due to normal wear.

The scope of advance provided in the apparatus, shown in the drawings, is approximately fifteen degrees which has been found useful for engines driving rotary sickle type lawn mowers, washing machines, chain saws, lighting plants and all loads where the engine operates at governed speed. In such cases, the advanced position of firing is chosen to fall where power output will be greatest at rated operating speed. In the retarded position the engine will then have easy starting free of backfiring and will idle more smoothly. It is to be understood that whenever an engine equipped with the apparatus of this invention is slowed or brought to a stop, deceleration cannot possibly be instantaneous, due to the inertia of the moving engine parts and the inertia of the load. As a result, the cam 21 with its very small inertia will be retarded in exery case of stopping or even of slowing down below the determined speed of advance. Therefore the engine will always be prepared for starting or will immediately assume retarded position for idling or improved "lugging" as soon as the engine is sufficiently slowed.

All of the above is accomplished by means which are extremely compact and, therefore, easily accommodated within a small engine magneto or breaker with no significant change of dimension. The cost is, furthermore, but a small fraction of the value of the gain in engine rating which it permits, or of the saving in wear and tear upon pull starters if the engine is prone to backfire on starting.

It is to be fully understood that the improvement of this invention operates to control the ignition primary circuit and is, therefore, equally adapted for use in connection with so-called battery systems. In such cases, the only modification required is that the cam and advancing means, herein shown and described, be substituted for the cam otherwise employed therein to drive the breaker contacts.

Where the apparatus of this invention is employed, in connection with magneto ignition, it is preferred that the magneto employed exhibit wide or flat peak voltage characteristics, with the peak embracing the zone of advance as nearly as possible. Where such is not possible, for ease of starting, it is preferred that the retarded position of firing should be located favorably with respect to the peak of the magneto output. After full speed running is attained, the advanced position of firing need not coincide with the maximum of the voltage peak since voltage will be adequate on account of increased magneto speed.

The apparatus of this invention has been herein shown in use in connection with a single cylinder engine but it will be obvious that it is adaptable for use with multiple cylinded engines as well.

The omission of a governor spring or other continuously acting biasing force permits the use, in accordance with this invention, of a very small fly weight as compared with counterloaded governors in which the actuating force must be a small fraction only of the total centrifugal force developed. This is particularly true in small high speed engines, because the high frequency vibrations prevailing which prevent the occurrence of erratic friction between the cam **21** and the shaft extension **20**.

I claim:

1. In an ignition-timing advance mechanism for an internal combustion engine, having a breaker arm carrying breaker contacts, the combination comprising: a shaft adapted to be driven by said engine; a cam for actuating said breaker arm, said cam being mounted on said shaft for rotation therewith and for limited rotational displacement with respect thereto; friction means, including said breaker arm, engaging said cam and thereby subjecting said cam to the frictional drag of said friction means; a pivot, secured to said shaft in driven relation thereto adjacent one end of the cam; a fly weight pivotally secured to said pivot and having a free end circumferentially spaced therefrom; and a connection between the free end of said fly weight and said cam for driving said cam and imparting an advancing torque thereto sufficient to overcome merely the frictional drag imposed on said cam by said friction means when said shaft is driven at speeds in excess of idling speed.

2. Mechanism according to claim 1, wherein a split ring surrounds the shaft adjacent the cam, one part of the split ring being secured to the shaft to provide a mounting for the said pivot and the remaining portion of the said split ring being pivotally secured to said pivot to act as the fly weight.

3. Mechanism according to claim 2, wherein the first part of the split ring provides stop means limiting the advancement of the cam by the fly weight.

4. Mechanism according to claim 1, wherein the pivot is mounted close to the outer circumference of the shaft, and the fly weight extends approximately one-half the circumference of said shaft to its point of connection with said cam.

5. Mechanism according to claim 1, wherein an axially extending pivot extending between the free end of said fly weight and said cam forms the connection therebetween.

6. In an ignition-timing advance mechanism for an internal combustion engine, having a moveable contact support for an electrical contact active when moved to initiate the igniting spark for said engine, the combination comprising: a shaft adapted to be driven by said engine in timed relation thereto; a cam for moving said contact support, said cam being mounted on said shaft for rotation therewith and for limited rotational displacement with respect thereto; friction means, including said contact support, engaging said cam and thereby subjecting said cam to the frictional drag of said friction means; centrifugal means, driven by said shaft, and interposed between said shaft and said cam to impose on the latter a centrifugally developed advancing torque, sufficient at speeds above idling speeds, to overcome merely the frictional drag of said friction means, and thereby to advance said cam, but limited in its centrifugally developed advancing torque, at idling speeds to a value less than said frictional drag.

7. Mechanism according to claim 6, wherein there is stop means carried by the shaft, to limit the advancement of the cam.

8. In an ignition-timing advance mechanism for an internal combustion engine, the combination comprising: a rotatable member adapted to be rotated by said engine; contact means for opening and closing the ignition circuit; means for actuating said contact means, said actuating means being mounted for rotating with the rotatable member in either retarded or advanced fixed relation thereto; stop means delimiting said two fixed relations; friction means applied to the actuating means, for biasing the latter to assume its retarded relation; and centrifugal means, carried by the rotatable member for biasing the actuating means to assume its advanced relation, the biasing torque of the centrifugal means increasing with the angular velocity of the rotatable member, so that this torque is less than the biasing torque of the friction means at idle engine speeds, and is more than said biasing torque of the friction means at working engine speeds; said two torques constituting the only imposed torques determinative of the angular relation of the actuating means to the rotatable member.

9. In an ignition-timing advance mechanism for an internal combustion engine, the combination comprising: a fixed support; a shaft rotatable with respect to the support and adapted to be rotated by said engine; contact means for opening and closing the ignition circuit; means for actuating the contact means, said actuating means being mounted for rotation with the shaft, and movable with respect to the shaft within limits defining an advanced and a retarded position; friction means mounted on the support, and engaging the actuating means to apply thereto a torque biasing the actuating means to move toward retarded position when the actuating means is rotating; and centrifugal means, mounted on the shaft and engaging the actuating means, to apply thereto a torque biasing the actuating means to move toward advanced position when the shaft is rotating; the biasing torque of the centrifugal means increasing with the angular velocity of the shaft so that this torque is less than the biasing torque of the friction means at idle engine speeds, and is more than the biasing torque of the friction means at working engine speeds; the centrifugal means constituting the only means, mounted on the shaft and engaging the actuating means, to apply a biasing torque to said actuating means.

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