(12) UK Patent Application (19) GB (11) 2 057 052 A

(21) Application No **7927960**
(22) Date of filing **10 Aug 1979**
(43) Application published **25 Mar 1981**
(51) INT CL³ **F02B 75/02//1/02 3/06**
(52) Domestic classification **F1B** 1G1P 1G3P 2A13B 2A13C 2A13E 2A15 2A1B 2A1C 2A1D 2A1E 2A4D 2Q3B 2Q3C 2Q3E
(56) Documents cited **GB 374561** **GB 234088**
(58) Field of search **F1B**
(71) Applicant
Arthur Andrew Larson, "Withywindle", Cook Lane, Northstoke, Oxon
(72) Inventor
Arthur Andrew Larson
(74) Agent
R. G. C. Jenkins & Co., Chancery House, 53/64 Chancery Lane, London, WC2A 1QU.

(54) Internal Combustion Engine Cycles

(57) In an internal combustion engine a charge chamber communicates with the combustion chamber via a valve which opens and closes at predetermined stages in the engine operating cycle. Between the conventional intake and compression stages of the cycle, there is an additional compression stage in which a portion of the fuel mixture in the combustion chamber is forced into the charge chamber and an additional intake stage in which the contents of the charge chamber are released into the combustion chamber while further fuel mixture enters the combustion chamber through the inlet valve or port. The normal compression, combustion and exhaust stages then take place, the compression ratio having been increased by the presence of the additional fuel mixture from the charge chamber.

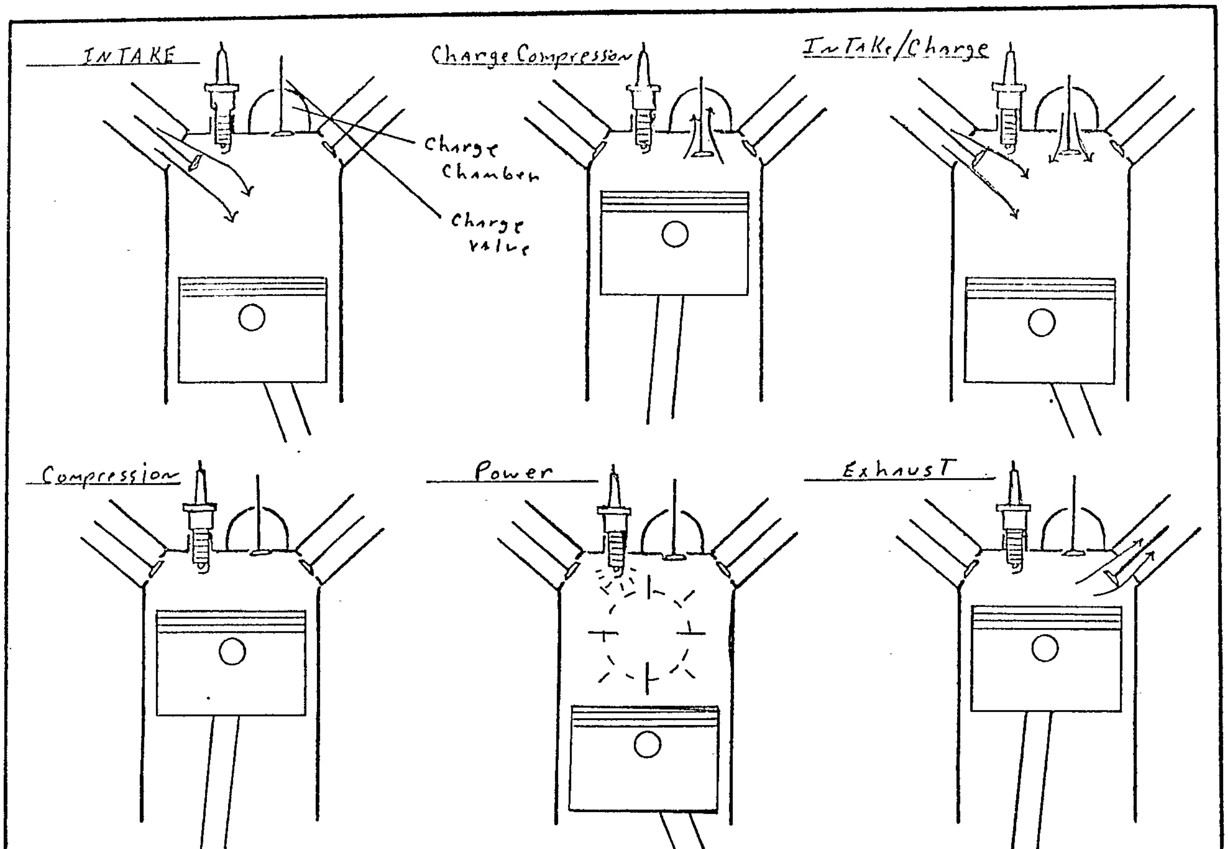
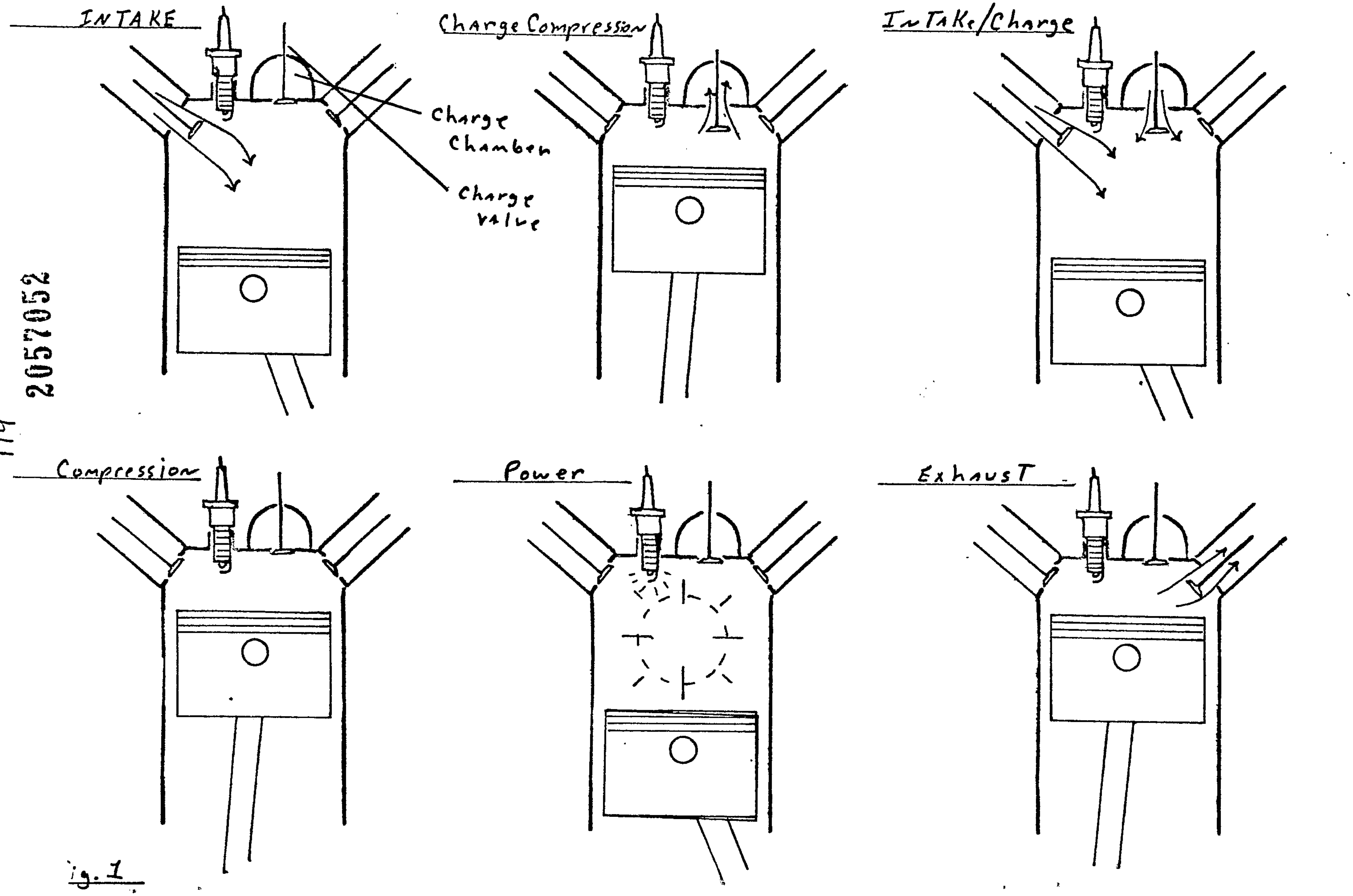


Fig. 1

GB 2 057 052 A

2057052


INTAKE
Charge Chamber
Charge Valve
Charge Compression
InTAKe/Charge
Compression
Power
ExhausT

ig. 1

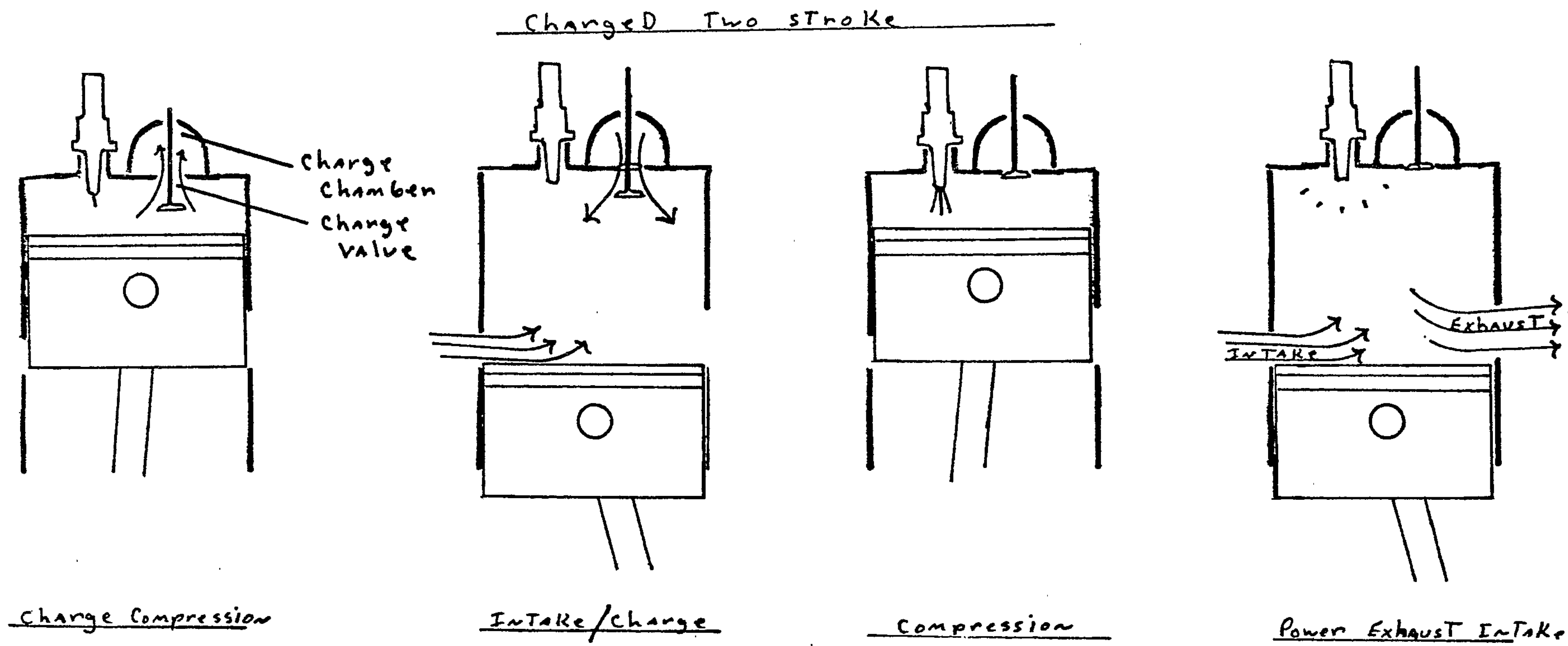

ChargeD Two sTroke
Charge Chamber
Charge Valve
Charge Compression
InTake/Charge
Compression
InTake
ExhausT
Power ExhausT InTake

Fig 2

2057052

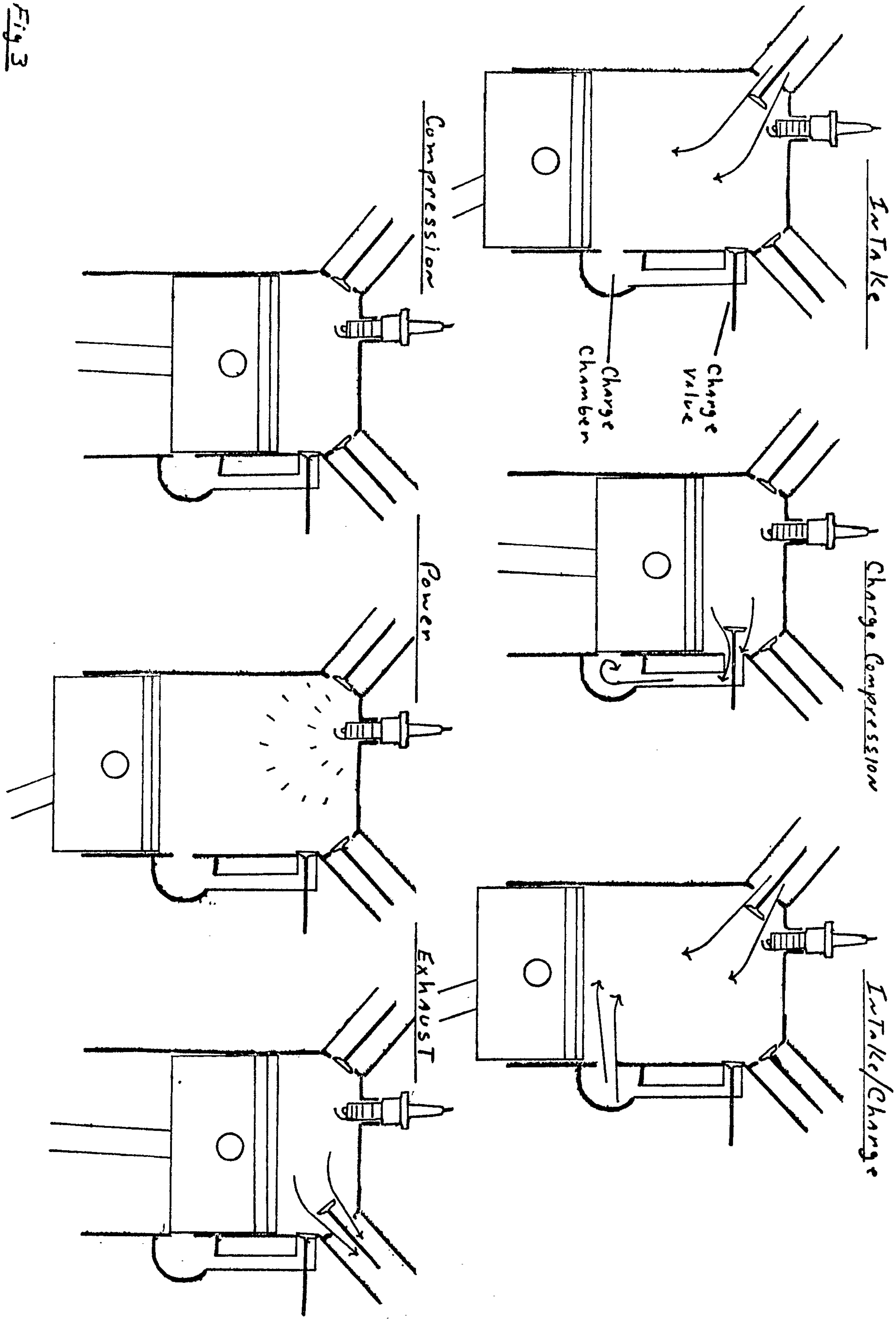


Fig 3

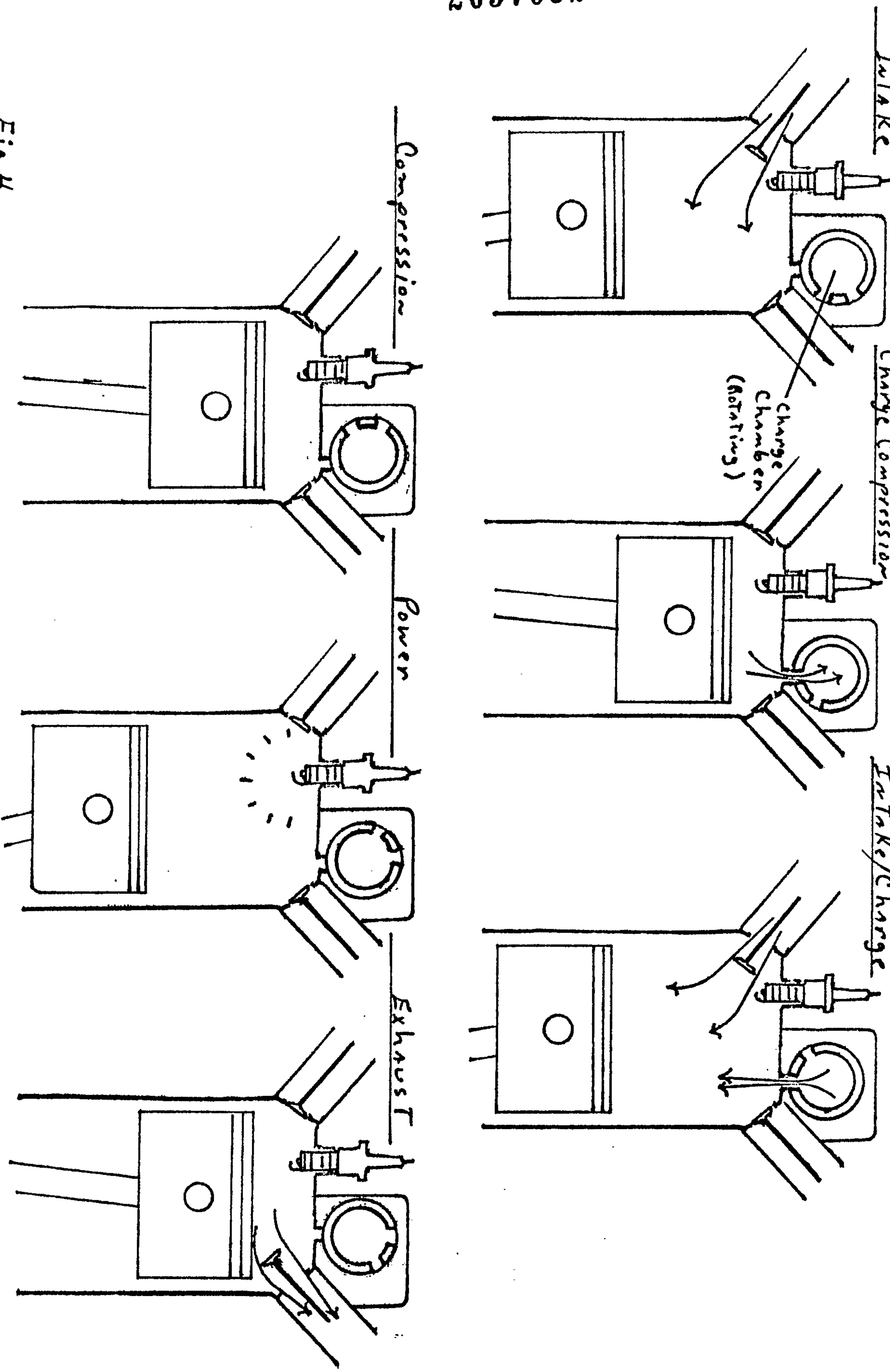

Intake
Charge Compression
Intake/Charge
Charge Chamber (Rotating)
Compression
Power
Exhaust

Fig 4

2057052

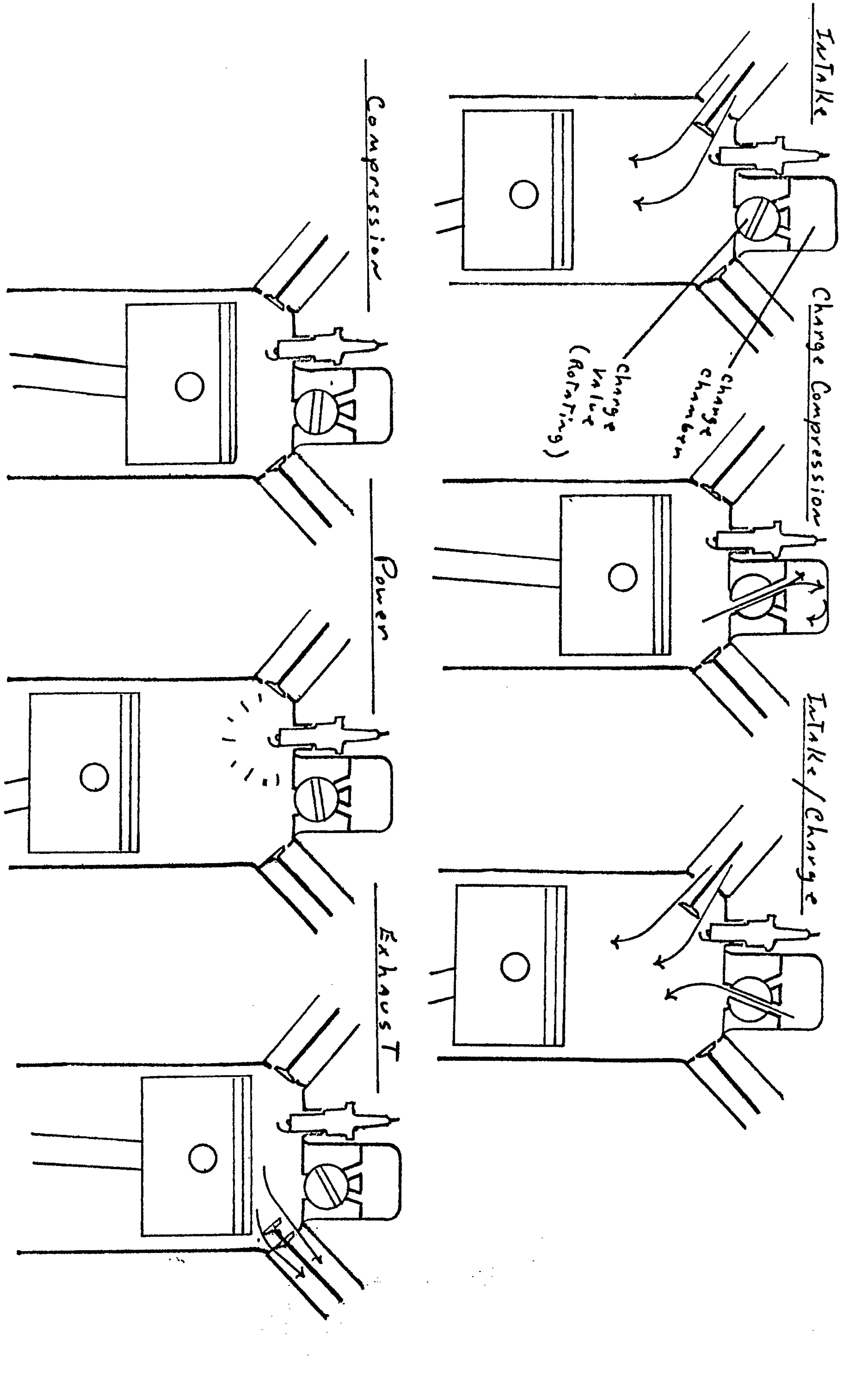


Fig 5

2057052

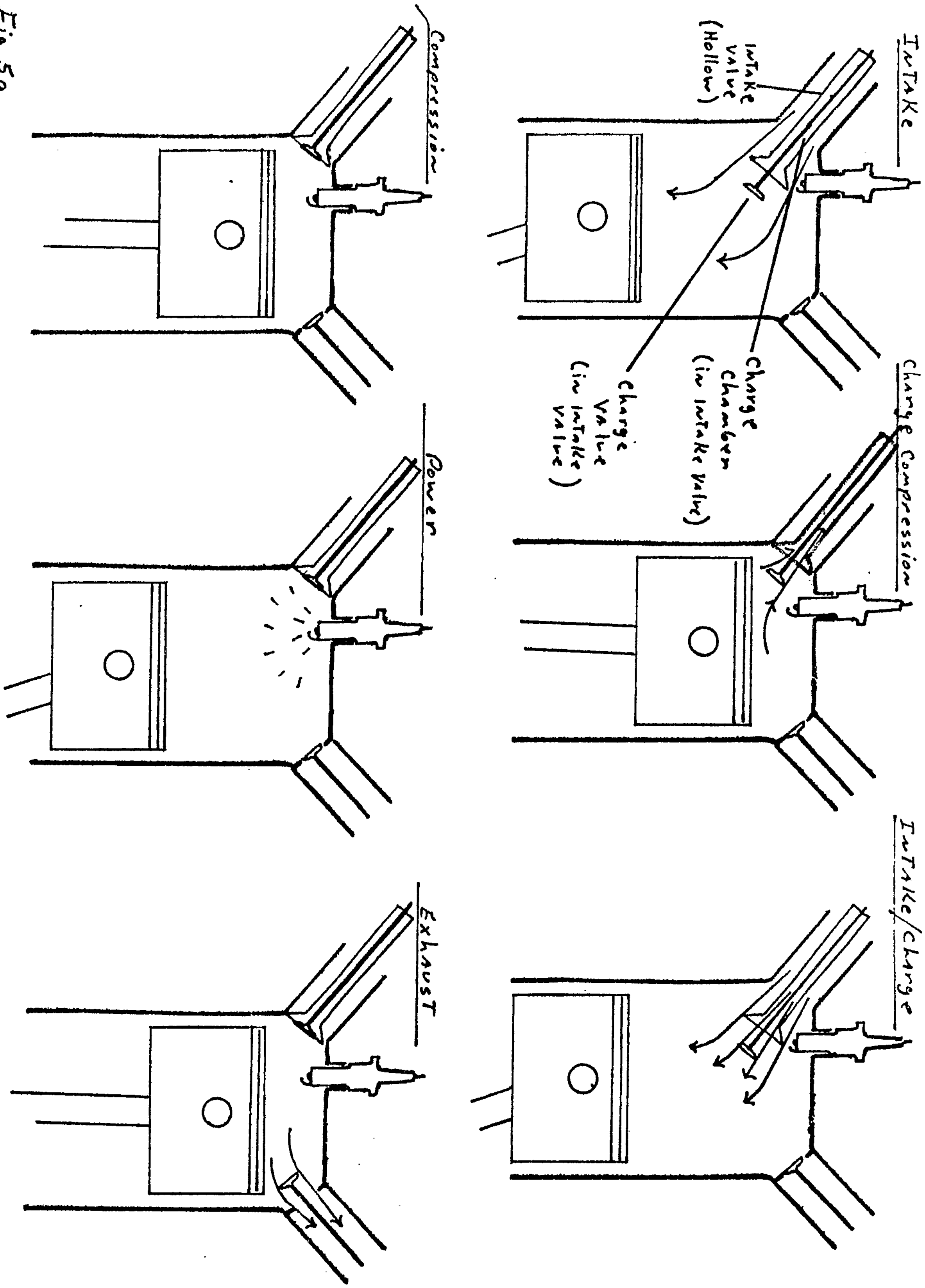
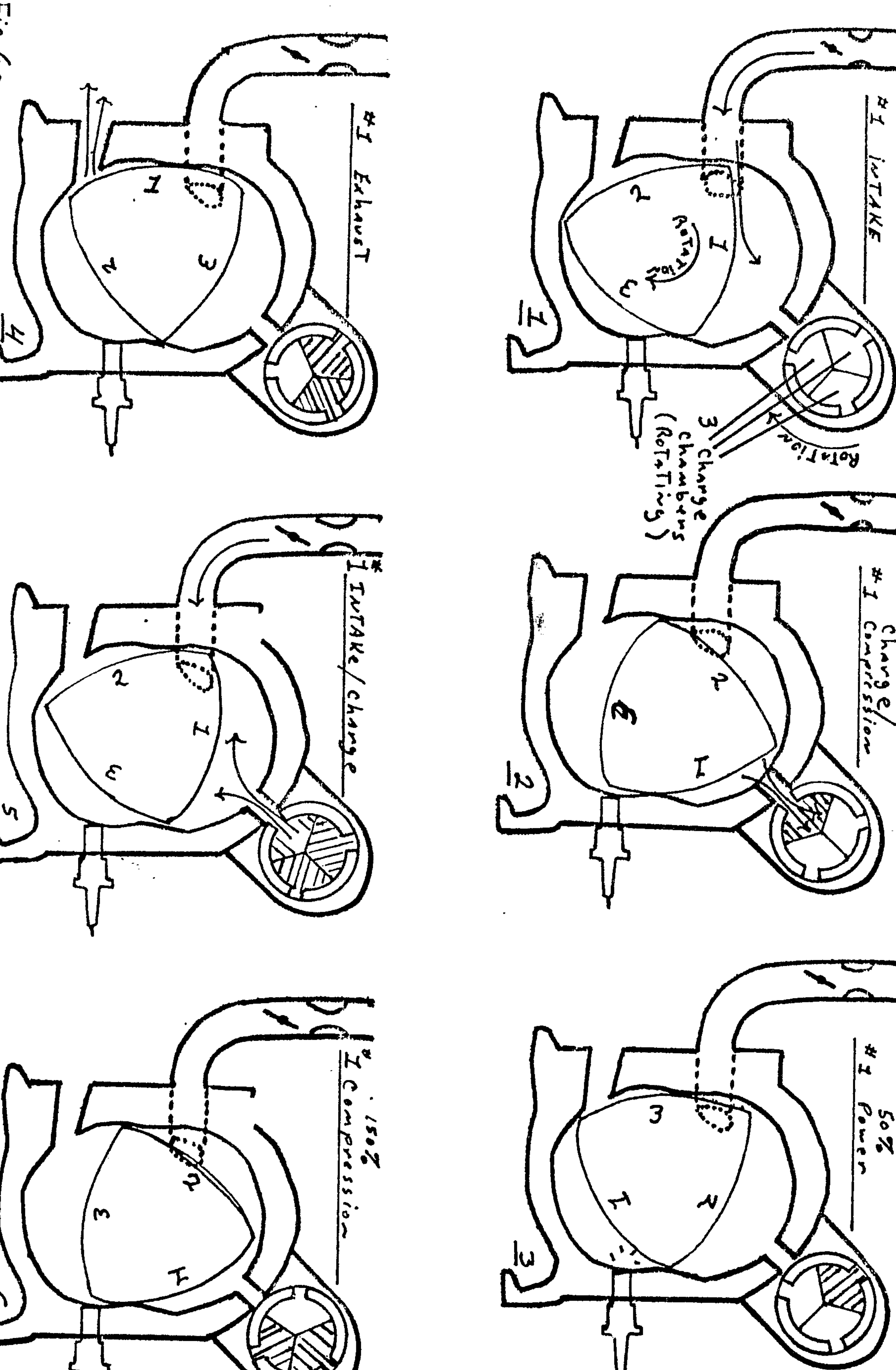


Fig 5a



#1 INTAKE
Rotation
3 Charge chambers (Rotating)
#1 Charge/Compression
#1 50% Power
#1 Exhaust
#1 INTAKE/charge
#1 150% Compression
1
2
3
4
5
6

Fig 6a

2057052

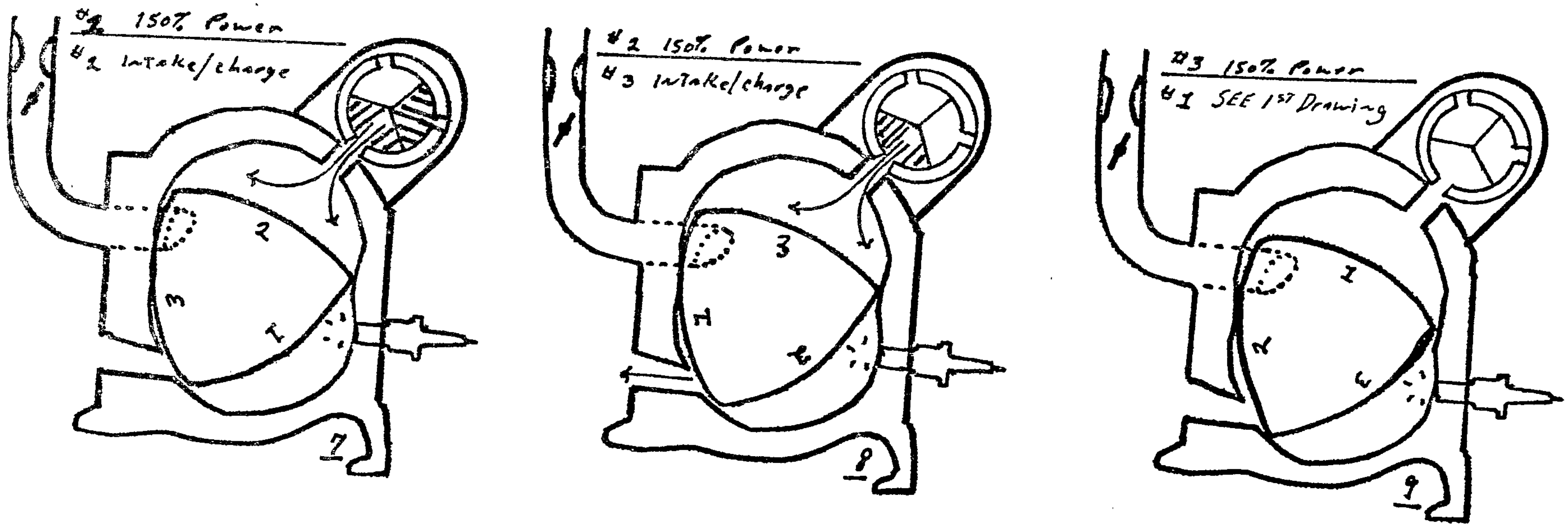


Fig 6B

2057052

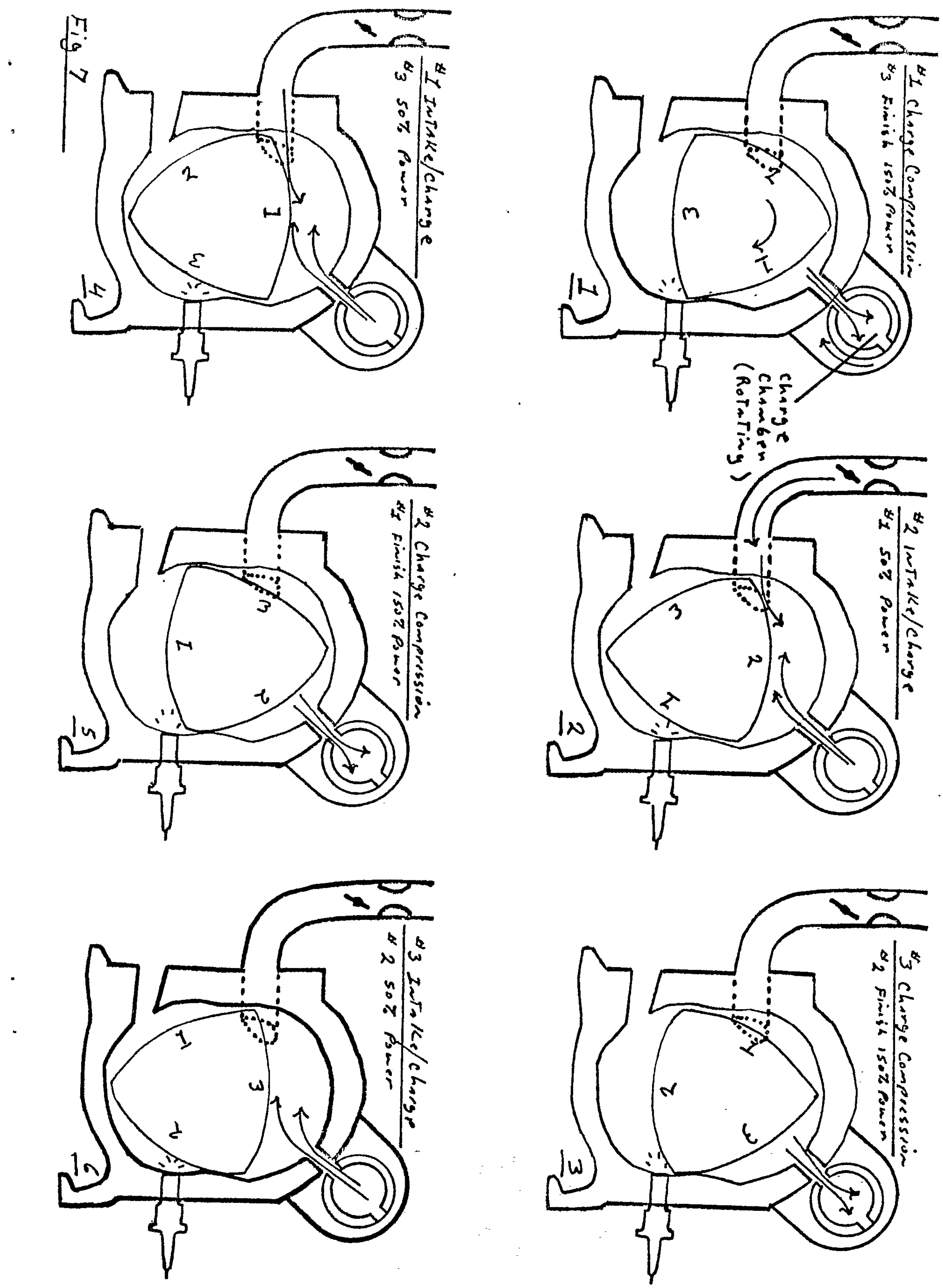


Fig 7
#1 Charge Compression
#3 Finish 150% Power
Charge Chamber (Rotating)
#2 Intake/Charge
#1 50% Power
#3 Charge Compression
#2 Finish 150% Power
#1 Intake/Charge
#3 50% Power
#2 Charge Compression
#1 Finish 150% Power
#3 Intake/Charge
#2 50% Power
1
2
3
4
5
6

SPECIFICATION

The Charge Chamber for Internal Combustion Engines

Technical Field to Which Invention Relates

The directly related field is that of the design of internal combustion four stroke, rotary, or two stroke, petrol, diesel or other fuel engines.

Background Art Useful for Understanding the Invention

The two and four stroke engine, their design, combustion characteristics, head design, super charging and turbo charging characteristics, air flow, intake and carburation or injection, design and operation. All of the aforementioned areas of knowledge for petrol, diesel, producer gas, or other fuel-using internal combustion engines, including the rotary (Wankel) engine.

Description or Disclosure of Invention, the Problems it Resolves, and the Solutions; With Advantages Over Present State-of-the-art Internal Combustion Engines

The problems to be resolved are: how to obtain more power and more economy at less cost than is now obtained with a normal four stroke, two stroke or rotary internal combustion engines.

The invention or concept requested to be patented basically consists of adding a hollow chamber, hereinafter designated as "charge chambers", and valving to the combustion chamber or chambers on an internal combustion engine, with associated changes to various timing components.

The charge chambers allow a normal four stroke, two stroke, or rotary engine to be effectively turbo-charged without having actually to be turbo-charged. For diesel engines it gives the same power and economy as obtained by turbo-charging. For petrol engines, it gives better economy and power than on a normally turbo-charged, petrol engine. It does not require the costs of, or maintenance of a super-charger or turbo-charger.

The easiest way to add a charge chamber and valve is to include it in the engine's head assembly. It could be included elsewhere in the block assembly but at a higher cost for retooling and manufacture. Plus, to add the chamber to each cylinder via the engine block would require an engine swapout to convert an existing car, truck, or tractor to this concept.

Putting the charge chambers in the head assembly allows an existing engine to be converted simply by changing the head assembly (which now includes the charge chambers, valves and rockers, or rotating valves), changing the cam shaft and gearing and changing the distributor timing gearing. These would run slower.

How the Invention Works

A normal, state-of-the-art four stroke engine has four strokes (two strokes per one crankshaft revolution). Taking one cylinder's operation we find the four strokes operate as follows:—

Stroke 1, Intake—The piston moves down causing a suction and the intake valve opens to admit a (theoretical) 100% fill of air-fuel mixture into the cylinder. At Bottom-Dead Centre, BDC, the piston is at its lowest point, the crankshaft is at 180° of the 1st revolution and the intake valve closes shortly thereafter.

Stroke 2, Compression—The piston moves upwards compressing the mixture (since the valves are both closed) into the space left between the top of the piston and the engine head cumulating at Top-Dead Centre, TDC. Assuming we had a 1000 cc (cubic centimetre) engine at a 10:1 (ten to one) compression ratio, each cylinder would have a total volume of 250 cc and the volume of the compression space would be 25 cc at TDC. The pressure would be 10 atmospheres or 147 lb/sq in. The crankshaft would have now completed 360°, or one revolution.

Stroke 3, Power—At TDC, or just shortly before, the ignition system delivers a high tension spark to the spark plug. This spark jumps the gap at the plug tip and ignites the air-fuel mixture. The resulting explosion drives the piston down with sufficient force to drive the other cylinders in their respective paths. The piston now reaches BDC and the crankshaft has reached 180° of the 2nd revolution. The piston continues to move past BCD. (For a diesel engine the power stroke is the same except the injector injects fuel into the cylinder at TDC, or slightly before.)

Stroke 4, Exhaust—The piston now moves up again and the exhaust valve opens allowing the piston to force the new expended, burnt, air-fuel mixture out into the exhaust system. The piston reaches TDC, the crankshaft finishes its 2nd full revolution and the exhaust valve closes. Just before the exhaust valve closes, the intake valve opens ready for the next intake stroke and begins another four stroke cycle.

This is the normal four stroke engine cycle.

The addition of the charge chamber invention to a four stroke engine works slightly differently. First, a four stroke engine is converted into a six stroke engine. The six strokes operate as follows:—

Explanation of the Charged 6 Stroke Operation

See enclosed diagram, Fig. 1.

There are 6 strokes:

1. Intake
2. Charge compression
3. Intake and charge
4. Compression
5. Power
6. Exhaust

There are three valves per cylinder. The middle valve in Fig. 1 is the charge chamber valve.

Basic Operation

1. Intake

This stroke is identical in every respect to a normal 4 stroke for the given engine. As the piston moves down, the intake valve opens and a normal 100% intake of air-fuel mixture is drawn into the cylinder at BDC. At BDC the crankshaft is at 180° of the 1st revolution.

2. Charge Compression

This stroke is identical to a normal compression stroke except that long before Top-Dead Centre, TDC, the charge valve opens, allowing the compressed mixture to be compressed into the charge chamber. Very shortly after TDC the charge valve is completely closed, holding the compressed mixture. The crankshaft completes the 1st full revolution.

3. Intake and Charge

The piston passes TDC on the second stroke and starts to move down. The intake valve opens after TDC and the piston draws in additional air-fuel mixture to fill the cylinder again with a 100% intake of air-fuel mixture.

Before the piston comes to Bottom-Dead Centre, BDC, the charge valve opens and just afterwards the intake valve closes. At the time of the piston achieving BDC, the pressure (or suction) is still at some negative, value allowing the maximum discharge of the charge chamber mixture into the cylinder, thereby increasing the total volume of air-fuel mixture in the cylinder to some value approaching 150% of normal intake volume. The crankshaft is at 180° of the 2nd revolution.

4. Compression

The piston starts to move upwards compressing the 150% mixture just as is done in a normal compression stroke, only now to a higher compression pressure approaching 150% of the normal compression at TDC. The crankshaft is at 360°, or finish, of the 2nd full revolution.

5. Power

The power stroke is identical to a normal power stroke with the ignition (injection or spark) occuring some time before TDC. Since the air-fuel mixture ratio is the same, only 150% more volume and compression, an increase of power is obtained. The crankshaft at the end of the power stroke is at 180° of the 3rd revolution.

6. Exhaust

The exhaust stroke is identical to a normal exhaust stroke, at the end of which the crankshaft is at TDC of the piston, at 360°, the finish of the 3rd full revolution.

Detailed Operation

Ref. also Fig. 1.

1. Intake

Identical to a normal intake stroke in every way; the cylinder draws in 100% of a full air-fuel mixture.

2. Charge Compression

Assuming the capacity of the charge chamber (25 cc) is the same as the cylinder capacity at TDC, the mixture compressed into the charge chamber will be 50% of the total mixture at one half the normal compression, i.e., if the normal compression was 10:1 or 147 lb/sq in. at TDC, the 50% volume mixture compressed into the charge chamber would be 5:1, or 73 lb/sq in. The 50% of mixture left in the cylinder would also be at 5:1 and 73 lb/sq in.

The charge chamber valve would be timed to fully open at least 80% to 90% before TDC. The charge chamber valve would be timed to be fully closed by 5° to 6° after TDC to ensure that the maximum amount of mixture would be compressed into the charge chamber.

3. Intake and Charge

As the piston starts to move downwards, the 73 lb/sq in. left in the cylinder would assist the engine in the piston's movement. Assuming there was 50% of the total mixture still left in the cylinder at TDC, the assistance would be felt on the piston at 73 lb/sq in., decreasing to zero pressure at the halfway mark of the piston's travel towards BDC, thereby replacing more than 50% of the power expended to compress the charge in the previous stroke. Shortly before the piston arrives at this point, the normal intake valve opens to allow the piston to suck in the additional 50% of intake mixture to refill the cylinder with the appropriate 100% intake volume.

In a normal intake stroke of a four stroke engine, the intake valve remains open until approximately 40° after BDC to gain the small benefit of the induction air column ram effect. In the 6 stroke intake and charge stroke, the intake valve closes just after or slightly before BDC and the charge valve opens just prior to the intake valves closing. The charge chamber being at 73 lb/sq in., discharges into the cylinder just before and during BDC when the pressure (or suction) is still at some negative value.

Since the cylinder pressure is at a negative value, the 50% mixture in the charge chamber will be able to discharge approximately 9/10 of its total mixture into the cylinder before the pressure equalises, giving a total final air-fuel volume of close to 150% of normal in the cylinder.

It must be borne in mind that the cc of the cylinder in our example is ten times the cc of the charge chamber, thereby ensuring the atmost complete discharge of the charge chamber.

The charge valve closes approximately 15°—20° after BDC.

4. Compression

The compression stroke is identical to a normal compression stroke except that the end compression value is now raised to 15:1 or 220 lb/sq in.

5. Power

The power stroke is identical to a normal power stroke in operation but with vastly more power produced due to the increased volume and compression. The higher compression of a 150% volume of air-fuel mixture results in a vastly increased power output (since most of the power expended in the charge compression stroke was returned, this increased power output is almost all pure gain).

6. Exhaust

The exhaust is identical to normal exhaust.

Detail of Advantages

Better Economy

There are a lower number of explosions for the same number of engine revolutions. Since each cylinder now makes 3 revolutions or cycles for each complete 6 stroke cycle, there is only 1 explosion per 3 complete crankshaft revolutions for each cylinder/piston. Therefore, to attain the same number of wheel revolutions per engine revolutions, the total explosions are that much reduced.

The lower number of explosions per engine/wheel revolutions will have the advantage of letting the valves run cooler as there is more time between explosions. Less explosions per unit number of revolutions mean less wear and tear on the engine parts and less ring blow-by, etc. In a normal uncharged 4 stroke, 4 cylinder engine there are 2000 explosions per each 1000 revolutions. In a charged 6 stroke engine with 4 cylinders there are only 1333 explosions per each 1000 engine revolutions.

More Power and Economy

The effect of the charged 6 stroke engine is similar in power output to a similar 4 stroke engine that is turbo-charged. However, in a charged 6 stroke petrol engine greater economy is also gained, unlike a turbo-charged petrol engine that uses more fuel. A charged 6 stroke diesel engine would attain both better economy and power, equivalent to a turbo-charged diesel.

The higher power level achieved by the 1333 explosions per 1000 engine revolutions allows the engine to be run slower to achieve the same number of output or wheel revolutions, i.e., instead of needing the engine to run at 1000 rpm to achieve the 1000 wheel revolutions, now, by utilising a higher gear ratio, the engine needs to run at only 700—800 rpm for the equivalent power output required per 1000 wheel revolutions. 800 revolutions of the engine new mean only 1064 explosions per 1000 wheel revolutions. This is compared with 2000 explosions per 1000 wheel revolutions in the original 4 stroke example, for the same power output.

This is where economy in fuel is obtained, not to mention reduction in engine wear and tear and running costs. A smaller, therefore less expensive engine may thus be able to replace and produce the same output power as a larger engine.

A smaller physically-sized engine means less material cost to build, lower costs to repair, due to smaller components such as pistons. A smaller engine means lower transportation and storage manufacturing costs.

A smaller engine means a smaller engine compartment. A smaller engine means a lighter engine. A smaller engine compartment and lighter weight mean less dead weight and less air resistance for the same power of automobile, therefore also less fuel costs.

Lower Manufacturing Cost

The charge chamber, being strictly a void in the head block or block assembly, costs nothing.

The charge valve and associated rocker arms and push rods would cost extra, but not much. The cam shaft and gearing would cost no more than an equivalent normal cam shaft and gearing. A rotary charge valve would cost even less.

The distributor timing gearing again would cost no more than the original gearing.

The only extra cost above and beyond a normal 4 stroke engine would be the extra valve and rocker/push rods.

To produce the same power output, the engine and components would be smaller, thereby reducing material costs overall.

Quieter Operation

Since the number of explosions per thousand engine revolutions is less, the operation of the engine would be quieter.

Added Power

Since the added two strokes of a charged 6 stroke engine are almost without power loss because the charge compression stroke compresses to half the normal compression, and since the piston is helped in its downward stroke in the next intake stroke by the pressure left in the cylinder, most of the power expended to compress the charge is returned in the charge/intake stroke, so the added two strokes take very little power and the 50% or more power gained in the resultant power stroke is almost pure gain.

By making the charge chamber two times the cylinder volume at TDC, more than a 50% extra charge will be released into the charge/intake stroke, resulting in even more power output during the power stroke. This would require even less total power loss for the charge compression and charge/intake strokes, and result in an even higher final compression and resultant power output.

Better Mixture and Economy

The original charge mixture is mixed normally and heated during the intake and charge compression strokes, then when the charge is released into the cylinder during the charge/intake stroke, it aids in the mixing and heating of the new mixture.

The residual mixture left in the charge chamber after the original start up revolutions will effectively result in a higher compression and charge volume being compressed and utilised in the succeeding strokes.

Other Engines that can be Charged

A two stroke engine can use the same charging principle by adding two strokes which utilise the charging principle described herein and making a charged 4 stroke engine out of a normal two stroke engine. (See Fig. 2) A Wankel engine can also utilise the charge chamber concept to obtain increased power and better economy.

Other Methods of Charging

As described herein, the changes to a 4 stroke engine are all made in the head assembly with the exception of the cam components and timing gearing.

1. With an overhead cam engine, all changes can be made in the head assembly resulting only in a head change and change in distributor timing (for petrol engines), or injector timing for an overhead cam diesel engine, to convert an existing engine.

2. With a six cylinder or twelve cylinder engine the charge could be fed via a pipe directly from the cylinder in the charge compression stroke to the cylinder that is at the same time in the charge/intake stroke. A charge valve and cam would still be necessary for each cylinder.

3. Assuming it could be machined, the charge chamber could be in the block assembly near the bottom of the cylinder wall with appropriate valving. (See Fig. 3). As shown, the charge chamber is situated with its port uncovered when the piston is at BDC. The piston itself acts as a valve.

The intake stroke pulls in a full charge and in the next stroke, the charge compression stroke, the charge valve opens, allowing the mixture to be compressed into the charge chamber. The exhaust post of the charge chamber is covered by the piston skirt, effectively sealing the port. The charge valve closes shortly after TDC of the charge compression stroke.

The piston then moves down in the intake charge stroke, the intake valve opens, a full mixture is drawn in and at the bottom of the stroke, the piston uncovers the charge chamber exhaust port and the charge mixture is discharged into the cylinder. The intake valve closes at the time the piston uncovers the charge port. By making the port more narrow and horizontal, the discharge of the charge mixture can be delayed longer, allowing the piston to approach closer to BDC before the intake valve needs to be closed.

The piston now enters the compression stroke and as it moves up it covers the charge chamber port, sealing it off. The 150% mixture is compressed, ignited, and the power stroke is done. At the bottom of the power stroke the charge chamber port is uncovered but should not affect operation one way or the other. The exhaust stroke is now done and the burnt mixture is exhausted. The cycle now repeats.

The advantage of this method of placement of the charge chamber allows the charge valve to only be actuated once during the full 6 stroke cycle.

The placement of the chamber near the bottom of the cylinder also allows the intake valve to be left upon a fraction longer than when the chamber is right next to the intake valve.

The head assembly in this method of charging is unchanged. The charge valve, interconnection channel, and charge chamber can all be within the engine block assembly.

4. Another method of charging is to replace the charge chamber as shown in Fig. 4 with rotating, valve-less charge chamber. (See Fig. 4.)

This rotating charge chamber has its ports situated so as to allow the charge compression stroke to compress the charge mixture into the rotating charge chamber. The chamber rotates as to cover the port right after TDC of the charge compression stroke. At the bottom of the intake stroke, the second port rotates in line with the cylinder or head opening and allows the charge mixture to discharge into the cylinder giving the 150% increase of air-fuel mixture in the cylinder.

The piston enters the compression stroke and the rotating charge chamber rotates the 2nd port past the opening. During the compression stroke and the succeeding power, exhaust and intake strokes, the rotating charge chamber seals the opening and the first port is again rotated in line with the opening during the next charge compression stroke.

The advantage of using a rotating charge chamber is that no extra cam lobes or push rods or valves are needed. The existing intake lobes on the cam shaft need to be changed as in the original example plus, of course, the cam shaft timing and the distributor timing. The rotating charge cylinders can be housed in a single shaft with the appropriate voids and ports drilled. The rotation of the chamber shaft would be timed at 1 revolution to each 3 crankshaft revolutions.

Since no push rods or valves are used, no holes for the push rods need be drilled in the engine block only the engine head assembly need be entirely changed.

5. Another way, perhaps even better than the rotating charge chamber, is to have a charge chamber as normal but to have a rotating valve to allow charge and discharge of the charge chamber in place of the charge chamber valve. (See Fig. 5.)

The rotating valve would have a hole drilled through it to line up with the charge chamber and the cylinder at the correct times to capture the compressed charge and to allow its discharge in the correct time frames, i.e., long before and during the TDC of the charge compression stroke and shortly before and during BDC of the intake charge stroke.

The rotating charge chamber or rotating valve concepts can also be used for the 2 stroke or the rotary Wankel engines.

Advantage

The advantage of using rotating valves or rotary charge chambers is that they are entirely quiet, trouble-free, and no push rod holes need be drilled into the engine block, as the rotating component can be driven directly from the existing cam timing chains or gears.

As shown in the figure for the rotating charge valve, a straight orifice needs a valve rotation of 30° displacement for each stroke of the 6 strokes. It would be a better design to have the orifice shaped like a "V" with an internal angle of 120°. This allows a 60° rotation of the valve for each of the 6 strokes, giving a faster orifice open and close, to the charge chamber, allowing the rotating charge valve to rotate a full rotation for the entire 6 stroke cycle, and only lining up with the associated charge chamber and cylinder openings only once for each opening per valve rotation.

6. Another way to have the charge chamber would be to have it incorporated into the intake valve itself. The intake valve would be hollow and the charge valve would be mounted directly in the intake valve. (See Fig. 5A.) Both valves would be actuated by the same cam shaft lobe. The intake valve cam lobe would have three distinct levels. One would be the lowest position, i.e., that of no lift and both valves would be closed. The highest point on the cam lobe would open both valves fully. The intermediate point would actuate the charge valve open but would not open the intake valve. Operation would be as follows:—

First Stroke, Intake—the intake valve must open. Since our lobe must be at the high point to open the intake valve the charge valve would also open. However, in this stroke, this will not affect the engine's operation. So the intake valve opens and the downward stroke of the piston draws in a 100% charge of air-fuel mixture. Basic operation is exactly the same as any normal intake stroke.

2nd Stroke, Charge Compression—the cam lobe turns to an intermediate height (lift) and the intake valve closes leaving the charge valve open. The piston moves up and compresses the mixture into the hollow intake valve body (which is now the charge chamber, and the charge valve closes at TDC).

3rd Stroke, Intake Charge—the piston goes down aided by the 50% compressed mixture still in the cylinder. Near the bottom of the stroke the cam lobe with a very quick lift opens the charge valve and the intake valve almost simultaneously. It would seem that the charge mixture discharging into the cylinder would tend to stop the intake from intaking the mixtures.

However, this is not the case. The amount of back pressure that the charge might develop to hinder the normal intake will be off-set by the jet suction effect of the charge mixture which will draw into the cylinder more normal intake mixture through the normal intake valve opening, thus again attaining a near 150% mixture into the cylinder.

The piston now reaches BDC and the intake valve closes slightly thereafter and so does the charge valve.

4th Stroke, Compression—compression is just as for a normal compression of 150% mixtures.

5th Stroke, Power—power should be the same as an engine charged with a charge chamber.

6th Stroke, Exhaust—exhaust is normal.

For the 4th, 5th and 6th strokes, the intake and charge valves are closed.

The advantage of having the charge chamber incorporated into the intake valve is the ease of conversion to a charged engine. The intake lobes are charged but no new lobes are needed for the charge valves. No extra push rod holes are needed, no extra push rods or rockers are needed.

The existing cam must have its intake lobe changed, its gearing or timing changed and the distributor timing changed. The engine block needs no changes. Only the intake valve assembly needs modifications in the engine head itself.

Other Methods of Charging

There are as many ways of charging as there are men to think of them.

Other ways could be to have the charge chamber in the spark plug itself and the charge valve actuated electrically or to have a normal charge chamber with electrically actuated charge valves.

An electrically operated charge valve could be an asset when the engine is used with lower octane fuels. In that case the electric valves could be switched off by a manual switch to instantly reduce the compression ratio of the engine by one third.

An engine using mechanical popett type valves or rotary valves could also, with a minimum of effort, have the charge valves disabled, allowing the engine to be switched from one type of fuel to another, if desired. If this were done and nothing else, i.e., the camshaft or timing not changed, the engine would still have six strokes, but the intake and charge compression strokes would be just extra strokes. The power used would be very small for the two strokes as the effort to compress the charge on the 2nd stroke would be returned almost 100% on the 3rd stroke. Since the air-fuel mixture was already 100% and the intake valve would open midway in the 3rd stroke, we would be assisted in the first half of the stroke by the compressed mixture.

Of course, any charged engine with six strokes can easily be reconverted back into the lower compressioned four stroke engine by disabling the charge valves, and changing back the camshaft and timing to the original. Also, the distributor/injector timing would be changed back and we have our normal four stroke engine.

Engines using the rotary charge chamber or rotating valves need only to disable the rotating component and change the timing cam shaft to reobtain the original engine. The charge chambers would still be incorporated within the engine head or block assy but would not have any effect upon the engine operation.

The Wankel Engine: How to Charge

Example 1

The Wankel engine, due to its unique construction, poses a different challenge for the method of incorporating charge chambers.

Since the Wankel engine uses a rotary three-sided piston, we have the situation, for example, where at one point in time (see Fig. 6A, Drawings 1—4) side one of the triangular piston is finishing intaking, side three is finishing the power stroke and side two is exhausting.

In the next point in time side one is compressing, side three is starting to exhaust and side two is starting to intake. In the next time slice, side one is on the power stroke, side three is finishing exhausting and side two in intaking. In the fourth time slice, side one is exhausting, side three is finishing its intake and side two is finishing the power stroke.

For a complete 360° revolution of the rotating piston, all sides of the triangular piston have gone through one complete 4 stroke cycle (for each side) making three intakes, three compressions, three powers and three exhausts per one 360° revolution.

One way to incorporate the charge chamber concept in a Wankel engine requires that during one 360° revolution of the rotary 3 sided piston, three charge chambers must be charged, one after the other, during three consecutive compressions. The three charge chamber inlets or single inlet to a triple rotating charge chamber (shown) would open into the compression area at the correct time to charge the chambers during the 3 consecutive compressions. (See Figs. 6A, 6B and Table of Events on page 20.)

Since the intake area overlaps the compression area, the charge valve or valves (rotary or poppett) would now be timed to discharge their respective compressed charges to the last stages of the next successive three intakes.

The three intakes that receive the additional charges would now be the intake/charge cycles and the resulting three succeeding compression and power cycles would now have 150% more air-fuel mixtures.

Both power and economy would be improved. The piston would make one 360° revolution for three power cycles of 50% power, and in the next 360° revolution there would be three 150% power strokes.

Example 2

Another method of charging the Wankel engine is to (see Fig. 7):—

Have the piston's leading side, No. 1, do charge compression for the next following side, No. 2. The following side No. 2, would then have 150% more air-fuel volume for more power. The leading side No. 1 would have also ignited during its power stroke but at 50% power.

Meanwhile, the 3rd side would go through its intake cycle then charge compresses it for the next side, No. 1, for No. 1's intake/charge. No. 3 would now go through a 50% power stroke and No. 1 would go through a compression and 150% power stroke.

Now side No. 2 does its intake cycle and a charge/compression which is discharged into No. 3's intake/charge stroke and No. 2 goes then through a 50% power and No. 3 goes through a 150% compression and power stroke.

Therefore, in the two full 360° piston revolutions each side of the piston goes through alternate 50%—150%—50%—150% compression and power strokes or, uncharged—charged—uncharged—charged strokes in alternate cycles. Therefore, in two 360° revolutions of the piston, there are (3) 50% power strokes and (3) 150% power strokes, in alternate successions, etc.

The only changes to a normal Wankel engine would be the addition of:—

1. Either 3 rotary charge chambers and valves, as in the first example.

2. One charge chamber with appropriately timed rotary or poppett valve to capture the charge and release it during alternate compressions and intakes as in Eample 2. (See Fig. 7 and Table of Events on page 21.)

Table of Events for Figs. 6A and 6B

Drawing No.		
1	No. 1	Side Intake
	No. 2	Finishing Exhaust
	No. 3	Starting 150% Power
2	No. 1	Charge/Compression (into charge chamber No. 1)
	No. 2	Starting Intake
	No. 3	Starting Exahust
3	No. 1	50% Power
	No. 2	Starting charge/compression (into charge chamber No. 2)
	No. 3	Finishing Exhaust/starting intake
4	No. 1	Finishing exhaust/starting intake
	No. 2	50% Power
	No. 3	Starting charge/compression (into charge chamber No. 3)
5	No. 1	Intake/charge
	No. 2	Finishing exhaust
	No. 3	50% Power
6	No. 1	Compression (150% mixture)
	No. 2	Starting intake/charge
	No. 3	Exhaust
7	No. 1	Power (150%)
	No. 2	Intake/charge
	No. 3	Starting intake/charge
8	No. 1	Starting intake/charge
	No. 2	Power (150%)
	No. 3	Intake/charge
9	No. 1	Intake/charge (go back to 1st drawing)
	No. 2	Finishing exhaust (go back to 1st drawing)
	No. 3	Power (150%) (go back to 1st drawing)

Table of Main Events for Figure 7

Drawing No.	
1	Side No. 1—compresses the mixture into the charge chamber (charge compression)
	Side No. 2—is in its intake cycle
	Side No. 3—is finishing a 150% power cycle
2	Side No. 2—does intake/charge
	Side No. 1—does 50% power stroke
	Side No. 3—finish exhaust
3	Side No. 3—charge compression
	Side No. 1—intake
	Side No. 2—150% power
4	Side No. 1—intake/charge
	Side No. 3—50% power
	Side No. 2—finish exhaust
5	Side No. 2—charge compression
	Side No. 1—150% power
	Side No. 3—intake
6	Side No. 3—intake/charge
	Side No. 2—50% power
	Side No. 1—finish exhaust

Go to drawing No. 1 to continue.

Summary of the Different Ways of Using a Charge Chamber for a Wankel Engine

The way described in Example No. 1 compresses the mixture into the charge chamber on 3 consecutive compression strokes. The 3 following power strokes are at 50% normal power because of the 50% mixture left in the compression area.

In the next revolution, the charge chambers are discharged into three consecutive intake cycles resulting in three consecutive 150% power strokes.

The power strokes then would be as in Example 1:

No. 1 50% power
No. 2 50% power
No. 3 50% power
No. 1 150% power
No. 2 150% power
No. 3 150% power and so on

If desired, an exhaust valve could be fitted to block the exhaust port and not ignite the 50% strokes. This would result in:

No. 1 no power
No. 2 no power
No. 3 no power
No. 1 150% power
No. 2 150% power
No. 3 150% power and so on

Example No. 2, because of the different method of charging, gives the power cycles alternately as follows:

No. 1 50% power
No. 2 150% power
No. 3 50% power
No. 1 150% power
No. 2 50% power
No. 3 150% power and so on

Again, if desired, an exhaust valve could be fitted and the 50% power cycles not ignited to give the power strokes as follows:

No. 1 no power
No. 2 150% power
No. 3 no power
No. 1 150% power
No. 2 no power
No. 3 150% power and so on

This concludes my basic description (specification) of my invention of the charge chamber for internal combustion engines.

Claims

1. An internal combustion engine of the type wherein a fuel-air mixture is compressed within a combustion chamber prior to ignition thereof, the engine also having a charge chamber communicating with the portion of the combustion chamber in which the mixture is compressed, valve means being provided to open and close the communication between the charge chamber and the combustion chamber and said valve means being arranged to operate in a cycle whereby the valve opens to admit to the charge chamber a portion of a first charge of mixture being compressed and subsequently opens to release the said mixture into the combustion chamber to augment a second charge of mixture therein prior to further compression and ignition thereof.

2. An engine according to Claim 1 which is a piston engine, the or each combustion chamber being located in a cylinder with a reciprocating piston therein.

3. An engine according to Claim 2 which is of the two stroke type but modified to operate in a four stroke cycle, an additional compression stroke and an additional inlet stroke, both with the charge chamber valve open, being interspersed between the convention 2-stroke cycles of compressions and intake/stroke exhaust, during which said normal cycle the charge chamber valve is closed.

4. An engine according to Claim 2 which is of the four-stroke type but modified to operate in a six-stroke cycle an additional compression stroke and an additional intake stroke being interspersed between the normal intake and compression strokes of the four stroke cycle, the charge chamber communicating with the combustion chamber during the said additional strokes and the charge chamber valve being closed during the remaining strokes of the cycle.

5. An engine according to Claim 4 wherein the charge chamber communicates additionally with the cylinder through a port in the cylinder wall at a position such that it is uncovered by the piston when the piston is at the bottom of its stroke but is closed off by the piston when the latter moves towards its top position.

6. An engine according to any preceding claim wherein the charge chamber valve is a poppet valve.

7. An engine according to Claim 6 wherein the charge chamber and the charge chamber valve are located within a reciprocating member valve serving as the inlet valve to the combustion chamber.

8. An engine according to any one of Claims 1 to 4 wherein the charge chamber is formed within a cylindrical valve member having at least one peripheral opening therein and arranged to rotate between positions in which the charge chamber communicates with the combustion chamber through the said peripheral opening and a position in which the said opening is closed.

9. An engine according to any one of Claims 1 to 4 wherein the charge chamber valve comprises a rotating member having an opening therethrough transverse to its axis of rotation and positioned between the combustion chamber and the charge chamber, the said member being arranged to rotate between a position in which respective ports in the combustion and charge chambers communicate with one another through the said opening and a position in which the said ports are closed off by the rotating member.

10. An engine according to any preceding claim wherein the charge chamber is formed in a spark or injector plug arranged to ignite the mixture in the combustion chamber.

11. An engine according to Claim 1 which is of the rotary piston type, the charge chamber communicating with the combustion chamber at a position between the intake port and the spark plug or fuel injector of the engine.

12. An engine according to Claim 11 wherein three said charge chambers are provided within a rotating valve member, the valve member having a peripheral opening for each charge chamber positioned so that as the valve member rotates each said opening in turn is aligned with a port leading into the combustion chamber whereby each charge chamber in turn communicates with the combustion chamber.

13. An engine according to Claim 11 wherein the charge chamber is formed within a rotating valve member having at least two peripheral openings therein positioned such that as the valve member rotates they are aligned in turn with a port communicating with the combustion chamber, so that the valve admits to the charge chamber a portion of a fuel mixture being compressed by a first side of the rotary piston and subsequently releases the said portion to augment a subsequent charge of fuel mixture about to be compressed by a second side of the rotary piston.

14. An engine according to any one of Claims 1 to 5, Claim 10 or Claim 11 wherein the charge chamber valve is electrically operated.

15. An engine according to any one of Claims 1, 2 and 4 that has six cylinders and has a channel linking a combustion chamber at the end of its charge/compression stroke, to the associated compression chamber which is at the end of its intake/charge stroke. No charge chamber being necessary in this instance as the compressed first charge from one cylinder, acting as the charge chamber, is valved directly to the compression chamber of the cylinder presently in its intake/charge stroke. Each cylinder has therefore a channel with mechanical or electrical valve, leading to another cylinder for which it supplies the first charge. Each cylinder also has another channel from which it receives its additional charge from another cylinder.

16. An internal combustion engine substantially as herein described with reference to any one of Figures 1 to 7 of the accompanying drawings.

New Claims or Amendments to Claims filed on 31/1/80.
Superseded Claim 1.

New or Amended Claim:—

1. An internal combustion engine of the type wherein a fuel/air mixture is compressed within one or more combustion chambers prior to ignition thereof, the engine also having a charge chamber communicating with the portion of the or each combustion chamber in which the mixture is compressed, valve means being provided to open and close the communication between the charge chamber and the combustion chamber and said valve means being arranged to operate in a cycle whereby the valve opens to admit to the charge chamber a portion of a first charge of mixture being compressed during a first compression state and subsequently opens to release the said mixture into the combustion chamber to augment a second charge of mixture being drawn into the combustion chamber prior to compression of the augmented charge in a second compression stage and subsequent ignition thereof.

Printed for Her Majesty's Stationery Office by the Courier Press, Leamington Spa, 1981. Published by the Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.