May 5, 1942. M. KADENACY 2,281,585

SUPERCHARGING

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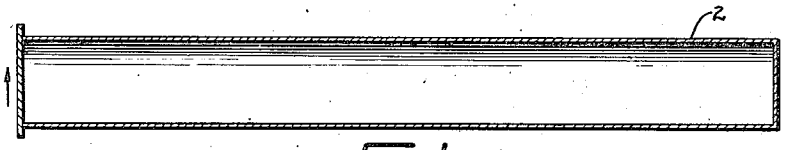



Fig 1

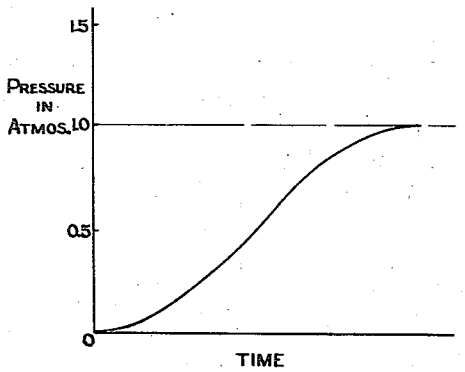



Fig 2

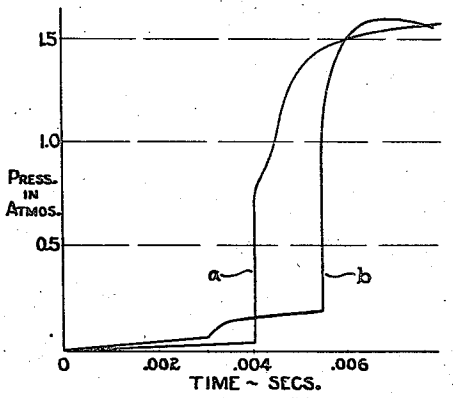



Fig 3

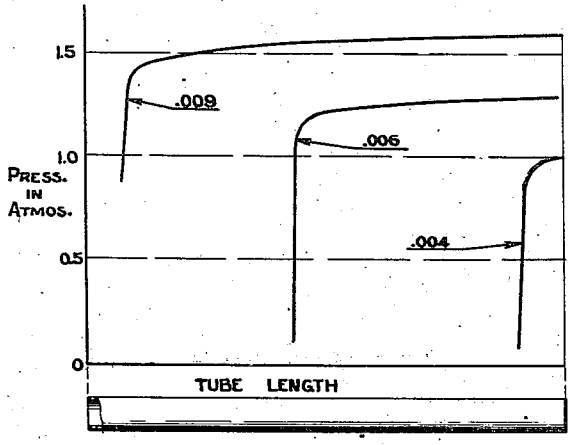



Fig 4

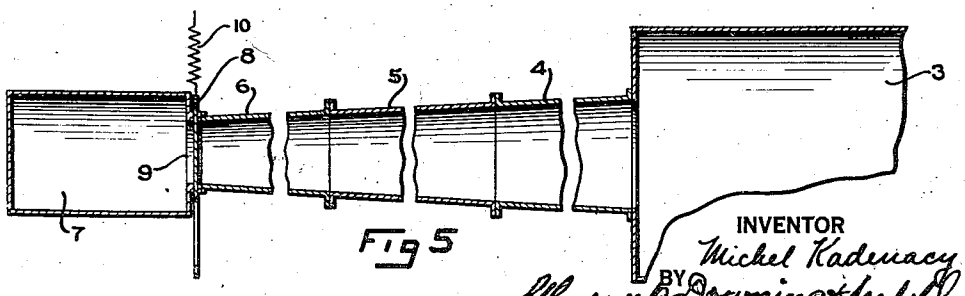



Fig 5

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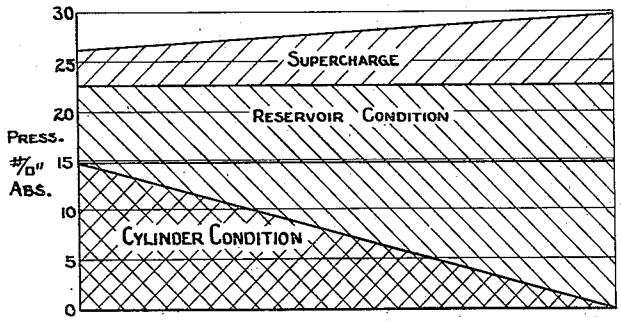



Fig 6

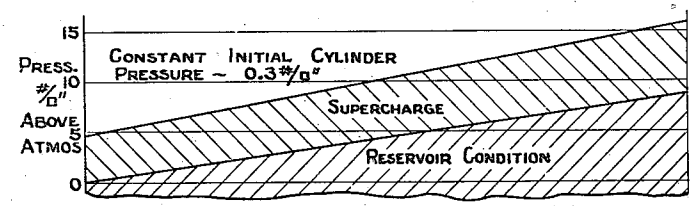



Fig 7

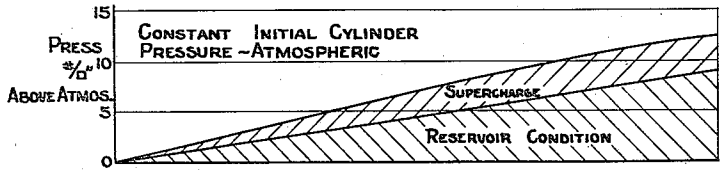



Fig 8

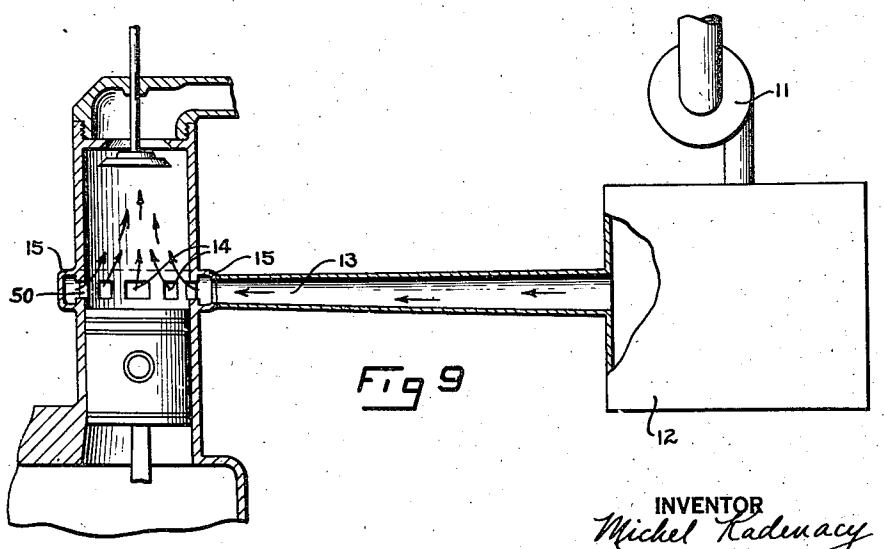



Fig 9

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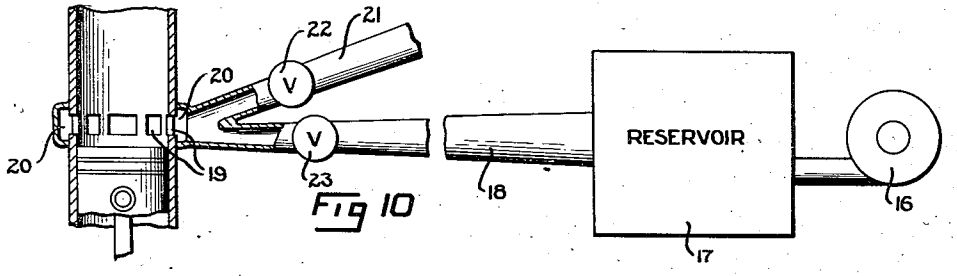



Fig 10

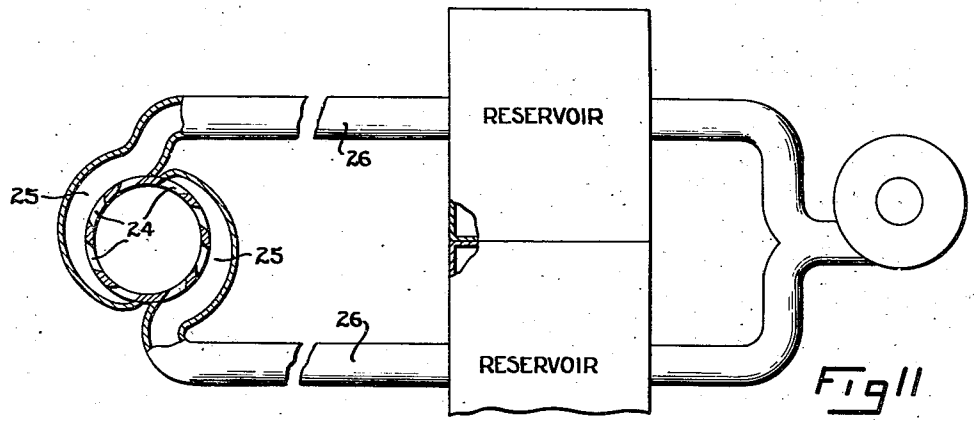



Fig 11

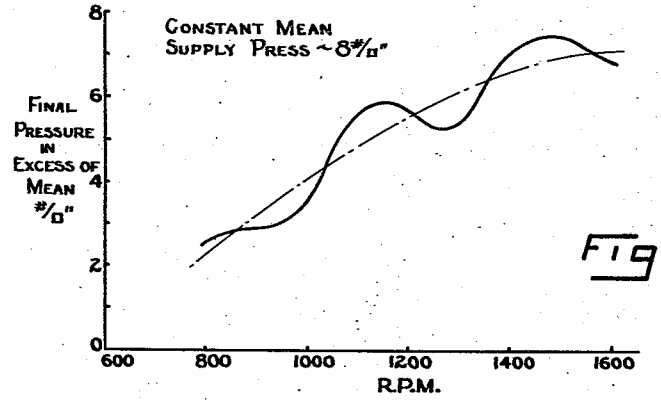



Fig 12

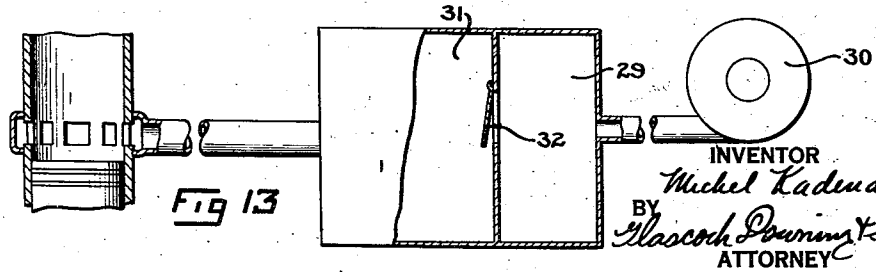



Fig 13

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Fig. 14.

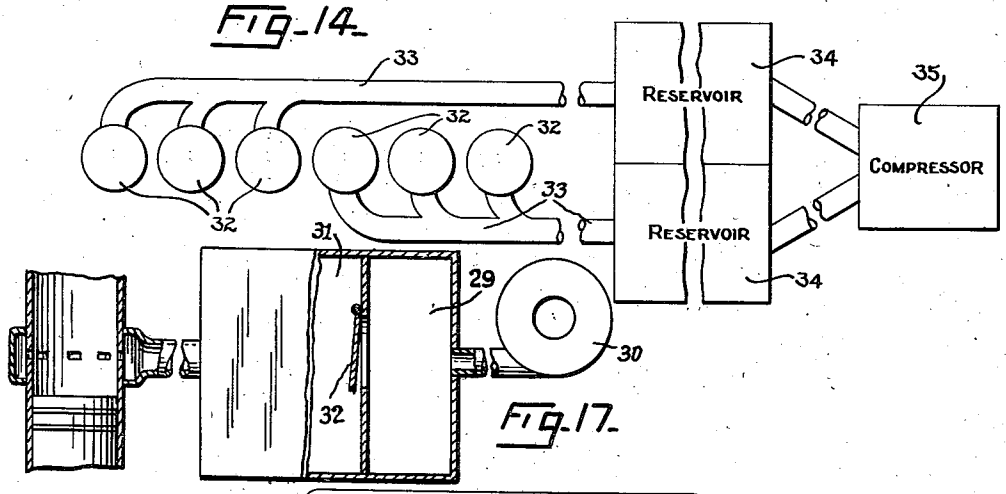



Fig. 17.

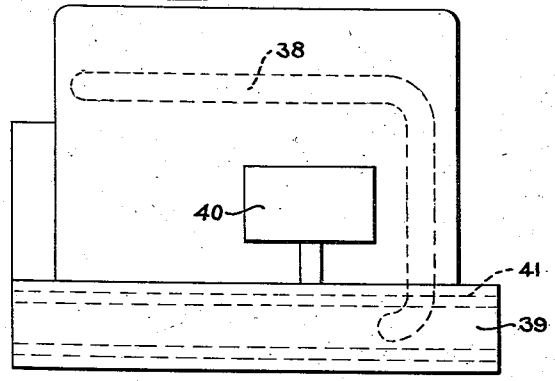



Fig 15

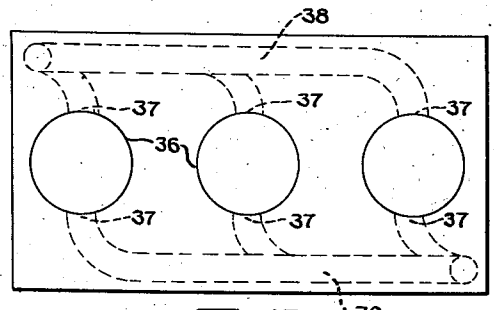



Fig 16

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Patented May 5, 1942

2,281,585

# UNITED STATES PATENT OFFICE

2,281,585

## SUPERCHARGING

Michel Kadenacy, Furzeney, Fulmer, England

Application November 13, 1940, Serial No. 365,532
In Great Britain November 14, 1939

14 Claims. (Cl. 123—65)

This invention relates to a novel method and means of charging a vessel which may be the cylinder of an internal combustion engine.

The object of the invention is to utilize the particular properties of gases consequent upon the sudden or ballistic discharge of gases from a region of high pressure to a region of lower pressure, in order to create in the region of lower pressure a pressure substantially greater than that originally existing in the region of high pressure.

Another object of the invention is to provide a novel method and apparatus for obtaining the maximum mass of air in the cylinder of an internal combustion engine for any given supply pressure and in particular a mass of air in the cylinder, at the closure of the ports, which is at a pressure considerably in excess of the supply pressure, whereby very high outputs may be obtained from such engines.

The invention is particularly applicable to two cycle internal combustion engines, of the kind set forth in my Patent No. 2,102,559, wherein by a suitable opening in time and area of the exhaust orifice the burnt gases are discharged as a mass through an exhaust system suitably formed to maintain their outward motion and wherein the charge is introduced into the cylinder when the burnt gases are in full outward motion as a consequence of their mass exit from the cylinder and cause a suction effect to be exerted at the inlet to the cylinder.

The invention consists in utilizing the explosion or ballistic discharge of a gas from a source of supply into a receiver in order to create and trap in this receiver a mass of the said gas at a pressure substantially higher than that of the source of supply.

The invention further consists in apparatus for supplying and trapping in a receiver a mass of gas at a pressure in excess of that of a source of supply of this gas, comprising a reservoir, a receiver, and a tubular connection between the reservoir and the receiver having an open communication at one end with the reservoir and a controlled communication at the other end with the receiver, means for establishing a pressure in the reservoir and tubular connection which is higher than the pressure in the receiver, and means for so controlling the communication between the tube and the receiver that a large aperture is opened in a short period of time whereby the contents of the reservoir and tube will discharge ballistically as a dense mass into the receiver and create therein a pressure which is greater than the previously existing pressure in the reservoir and tube.

The invention still further consists in apparatus as described above and further comprising means for so controlling the subsequent closure of the communication between the tube and receiver, that this communication is closed before the said ballistic discharge has expended its whole effort, that is to say, while a dense mass is still in high speed motion in the tube towards the receiver and the total contents of the receiver are in condition of super-compression above the previously existing pressure of the reservoir and receiver.

The invention also consists in the provision, in an engine of the kind above referred to, of a pipe on the inlet orifices communicating at its other end with a reservoir arranged to be fed by a compressor for the supply of charging air to the cylinder of the engine, and means for so controlling the said inlet orifices that a large area of orifice is opened in a short interval of time, the said means being arranged for opening the said orifices at such an interval before the closure of the exhaust orifices and of the inlet orifices that, on the opening of the said inlet orifices, there will be a ballistic discharge of air from the reservoir and pipe into the cylinder, and into the exhaust system when the said orifices are still open, and upon the closure of the exhaust orifices, the stoppage of the high speed motion of the said mass of air will cause a super-pressure in the cylinder above the pressure of supply and upon the closure of the inlet orifices there will still be a mass of air in high speed motion in the pipe towards the said inlet orifices whereby the said super-pressure will be maintained and trapped in the cylinder.

Other objects and novel features of this invention will more fully appear from the following detailed description when the same is read in connection with the accompanying drawings. It is to be expressly understood, however, that the drawings are for purposes of illustration only and are not intended as a definition of the limits of the invention, reference being had for this purpose to the appended claims.

In the drawings wherein like reference characters refer to like parts throughout the several views:

Fig. 1 is a sectional view through the apparatus for illustrating one of the principles of air flow on which the present invention is based;

Fig. 2 is a pressure-time curve depicting con-

ditions in the tube of Fig. 1 when air is admitted therein slowly;

Fig. 3 is a pressure-time curve of conditions in said tube when air is admitted according to the method of the present invention;

Fig. 4 is a pressure-tube length curve under conditions of an entry into said tube corresponding to those represented in Fig. 3;

Fig. 5 is a somewhat diagrammatic view, with parts broken away, of an apparatus for carrying out the steps of the present invention;

Figs. 6, 7 and 8 are pressure curves showing the degree of additional supercharge attained by the method of the present invention under varying conditions;

Fig. 9 is a diagrammatic view, partly in section and partly in elevation of apparatus embodying the present invention;

Fig. 10 is a view similar to Fig. 9 of an alternate embodiment of this apparatus;

Fig. 11 is a diagrammatic plan view, partly in section, illustrating still another form of the invention;

Fig. 12 is a pressure R. P. M. curve, illustrating the excess supercharge attained in a given engine;

Fig. 13 is a diagrammatic view, partly in elevation and partly in section, of an embodiment of apparatus having novel reservoir means for reducing pressure oscillation effects;

Fig. 14 is a diagrammatic plan view of an embodiment of the present invention as applied to multi-cylinder engines;

Fig. 15 is a diagrammatic view in elevation of another embodiment of the present invention as applied to multi-cylinder engines;

Fig. 16 is a plan view of the apparatus of Fig. 15; and

Fig. 17 is a diagrammatic view showing the cross sectional area of the inlet ports less than that of the inlet pipe.

As shown in Fig. 1, if a tube 1, closed at both ends is exhausted of air and an opening is then made at one end 2, air will enter the tube and destroy the vacuum.

If the orifice is very small, or if the orifice is large, and is equal to the cross-section of the tube, but is opened slowly, air expands into the tube and gradually fills it until the final pressure in the tube is atmospheric pressure. If the tube is reclosed too soon the pressure will be below atmospheric but however long a time is allowed for filling, the pressure will never become more than atmospheric pressure. This condition appears to conform to the well-known expansion of gases from a region of high pressure to a region of low pressure leading to an equalization of pressure in both regions.

Fig. 2 shows the form of pressure/time curves corresponding to this condition of entry, taken at the closed end of the tube and midway along the tube.

During this entry of air into the tube, the velocity of the initial portions will be high and the velocity of the later portions, when the orifice is fully open, will be small.

The inventor has found that if the opening is made large, for example, equal to the cross-section of the tube, and is opened with increasing rapidity, a speed of opening is reached when the character of the entry changes. Instead of the pressure rising gradually in the tube until it approaches or reaches the external atmospheric pressure, it is seen that there is an abrupt rise in pressure which appears first at the closed end of the tube and before any substantial pressure is recorded in any other part of the tube nearer the orifice. At the closed end of the tube, the pressure rises vertically, not only up to atmospheric pressure, but to a pressure considerably in excess of this, and the zone in which the super-pressure exists increases towards the orifice so that it occupies an increasing volume of the tube.

Fig. 3 shows the form of pressure curves corresponding to this condition of entry of air into the tube. The curve *a* represents pressure variations on a time base at the closed end of the tube, and the curve *b* pressure variations at a point midway along the tube. It will be seen that at the time point when the pressure rises abruptly at the closed end of the tube to a pressure considerably in excess of atmospheric pressure (curve *a*) there is as yet no substantial indication of pressure midway along the tube (curve *b*). But throughout the tube there is a mass of air in motion at high speed toward the closed end, and this mass enters without substantial loss in density, as is shown by the abrupt rise in pressure when it is stopped by the closed end of the tube. The super-pressure is sustained over a period of time since any reaction from the closed end of the tube is counteracted by the continually arriving mass of air, so that the impact front which is at the first moment the closed end of the tube travels back towards the open end. Consequently, an increasing section of the tube becomes filled with a dense mass of air under a super-pressure and eventually, if it is allowed to do so, will explode out of the tube when the force and mass of the ballistic entry has expanded itself.

Fig. 4 shows the type of pressure distribution curves obtained in the tube during the entry of the air under these conditions, at varying intervals of time after the commencement of opening of the orifice. The base of the diagram represents the tube, 0 being the open end, and the vertical ordinates represent pressure in the tube in fractions of an atmosphere absolute pressure. The curves are marked with time intervals of the order which are found in practice and these represent time intervals after the opening of the orifice. From this figure it will be seen that if the orifice were to be closed at a suitable moment, air would be trapped in the tube at a density and pressure much greater than that of the external atmosphere. If the orifice is opened still more rapidly, the super-pressure is increased, but eventually a speed of opening is reached beyond which, in practice, the super-pressure no longer increases. Experimental evidence suggests, however, that the maximum super-pressure obtainable under the conditions of this experiment, would be of the order of two atmospheres absolute and in practice 1.5 atmospheres absolute is readily obtainable.

From this it will be seen that in order to obtain this result, the speed of opening the orifice determines the character of the entry of air into the tube. This speed must be high and is linked with the area opened which must be large since it determines the mass of air set in motion. The condition must be such that the discharge of air into the tube is explosive or ballistic in nature, and that the mass of air concerned in the discharge will be sufficiently great and also such that this mass of air is abruptly stopped by an obstacle, in the case in point, the closed end of the tube.

Fig. 5 shows an arrangement comprising a reservoir 3 connected by conical pipe sections 4, 5,

6 to a receiver 7, with a slide valve 8 closing the orifice 9 of the receiver and adapted to be opened by suitable means represented diagrammatically by a spring 10.

In this apparatus, the receiver 7, by its form and proportions, may be likened to the cylinder of an internal combustion engine having an inlet orifice represented by 9 in the figure. The slide valve is arranged to be operated at such a speed and the orifice of the receiver is so large that the effects of super-pressure in the receiver can be obtained consequent upon the ballistic discharge of air from the pipe and reservoir into the receiver. By way of example, suitable dimensions for the apparatus of Fig. 5 in order to attain the results hereinafter set out, are as follows:

Reservoir 3 is 36 cm. long and 20.5 cm. in diameter;

Receiver 7 is 14 cm. long and 9.5 cm. in diameter;

Orifice 9 is 5 cm. in diameter;

Pipe 6 is 30 cm. long and 5.2 to 5.8 cm. in diameter;

Pipe 5 is 30 cm. by 5.8 to 6.6 cm. in diameter;

Pipe 4 is 30 cm. long by 7.0 to 8.5 cm. in diameter.

With this apparatus it was found that speeds of opening of the slide valve of 11 to 15 meters per second gave good results approaching a maximum.

With this apparatus, if the pipes and reservoir are removed, so that the opening of the valve puts the aperture of the receiver in direct communication with the external atmosphere, and the receiver is evacuated before the orifice is opened, the shock of the entering air mass fills the receiver up to a pressure 0.67 lb. per square inch above atmospheric pressure. With the pipe 6 added, the super-pressure becomes 4.2 lbs. per square inch; with sections 6 and 5, it becomes 5.3 lbs. per square inch, and with sections 6, 5 and 4, 5.75 lbs. per square inch, showing the great influence of the addition of the first section of pipe and the further but decreasing influence of the additional sections.

If the reservoir is added, then the supercharge becomes 4.6 lbs. per square inch above atmospheric presure, showing the restrictive influence of the reservoir as compared with the open atmosphere.

Results obtained with varying initial pressures in the space formed by the reservoir and pipes and in that formed by the receiver, shows that even with only slight initial pressure difference a super-pressure is recorded in the receiver following the ballistic discharge of the contents of the pipes and reservoir into the receiver and the stoppage of the high speed motion of this dense mass by the end wall of the receiver. Such results are illustrated in Figs. 6 to 8.

In Fig. 6 the initial pressure in the reservoir and pipe is maintained constant, at 8 lbs. per square inch above atmospheric pressure and the initial pressure in the receiver is varied from 0.3 lb. per square inch absolute up to atmospheric pressure. The supercharge obtained in the receiver varies from 3.5 lbs. per square inch, (11.5 lbs. above atmospheric pressure) when the initial pressure in the receiver is atmospheric, up to almost 8 lbs. per square inch (16 lbs. above atmospheric pressure) when the pressure in the receiver is 0.3 lb. per square inch absolute.

In Fig. 7 the initial pressure in the receiver is kept constant at 0.3 lb. per square inch absolute, and the initial reservoir and pipe pressure is varied from atmospheric pressure up to 9 lbs. per square inch, the supercharge correspondingly varying from 4.5 lbs. per square inch to 7 lbs. per square inch.

In Fig. 8 the initial receiver pressure is kept constant at atmospheric pressure and the initial reservoir and pipe pressure is varied from atmospheric pressure up to 9 lbs. above atmospheric pressure. It will be seen that a supercharge is produced in the receiver even for very minor differences in the initial pressures. For example, when the initial pressure in the reservoir and pipe is 1 lb. above atmospheric pressure, and the initial pressure in the receiver is atmospheric pressure, the final pressure in the receiver following the ballistic discharge of air into the receiver is 1½ lbs. above atmospheric pressure adjacent the inlet orifice of the cylinder.

With this apparatus, the duration of the super-pressure is from .003 to .004 second and commences some .006 second after the commencement of opening of the slide valve.

The inventor has also found that for any given installation of reservoir, (atmosphere or closed chamber) pipe and receiver, there is a limiting time of useful ballistic discharge into the receiver and a limiting useful time in which it can be utilized and trapped for creating a supercharge in the cylinder. A definite quantity of air will take part in the ballistic discharge and this has to supply the receiver and also ensure that upon the closure of the receiver there is still a mass of air moving at high speed toward the receiver in the pipe.

Further, in an engine, the exhaust system will add to the capacity of the receiver as long as the exhaust orifice remains open.

In the application of the invention to an internal combustion engine the conditions in the cylinder of the engine may vary. The cylinder may already be full of air at approximately atmospheric pressure at the moment the supercharging admission commences, or it may be under a virtual or potential depression.

In an engine of the kind set forth in Patent No. 2,102,559, above referred to, inlet is opened when the burnt gases are in full outward motion from the cylinder and cause a suction effect to be exerted at inlet. In such engines, running at effective speeds of 500 R. P. M. or more, the time interval between inlet opening and exhaust and inlet closure is sufficiently short to be comprised within the limiting interval of a ballistic discharge of air into the cylinder for the purpose of producing a dynamic supercharge in the latter upon the closure of the ports. In such a case the main admission of air will be the supercharging admission. If the return of the burnt gases occurs early during the admission period, it will reduce the supercharge obtained; if it occurs towards the end of the charging period it may contribute in the result; if it occurs after the closure of the ports it will be without influence.

With engines running at very low speeds, say below 500 R. P. M., the interval between inlet opening and exhaust and inlet closure may become too long and in this case, a first charge will be introduced when inlet opens and the supercharging admission will be made later in the admission period and at such a point that the interval between the commencement of this admission and the closure of exhaust and inlet

will be shorter than the limiting duration of a ballistic discharge into the cylinder.

Fig. 9 shows an arrangement suitable for carrying out the invention in the case when the main admission is the supercharging admission, and Fig. 10 in the case when it forms a second admission. In Fig. 9, a compressor 11 delivers into a chamber or reservoir 12 which is connected to the inlet orifices 14 of an engine cylinder by a pipe or duct 13 which directs the air towards the inlet orifices, a collarette 15 around the inlet ports forming a continuation of the cross-section of the duct. This duct 13 may be parallel or preferably be of decreasing section towards the inlet orifices and should contain no interposed capacity chambers. The length and volume of the pipe should be such as to contain sufficient air to ensure that when the inlet ports close there is still motion of a mass of air in the pipe towards the inlet ports. The crosss-section of the pipe should be slightly larger than that of the air ports and the collarette round the air ports should continue the section of the pipe and direct the air to the ports and not form a capacity chamber; and in general, the cross-section of the pipe should be made greater for high engine speeds so as not to restrict and retard the motion of the air during the ballistic discharge. The reservoir should be of sufficient volume so that the mass set in motion by the ballistic discharge into and through the cylinder will be sufficiently great.

The exhaust ports should preferably close before the inlet ports since it is the stoppage of the motion of the air charge by this closure that creates the super-pressure. The exhaust port closure extends over a crank angle and commences to be effective before the ports are actually closed.

The area of inlet orifice should preferably predominate over the exhaust area during the exhaust port closure and should preferably be still large when the exhaust ports close, since it is during this time that the entering mass of air packs into the cylinder to extend the zone of super-pressure as the pressure front stopping the motion moves backwards. In the case where, by mechanical limitations or due to other requirements, the exhaust and inlet ports close substantially at the same time, the supercharge can still be obtained satisfactorily if the return of the burnt gases in the exhaust system is arranged to occur at or about the closure of the ports.

In Fig. 10 the compressor 16 feeds the reservoir 17 connected by the pipe 18 to the ports 19 through the collarette 20, and in addition a separate duct 21 is branched on the pipe 18 close to the cylinder. Valve means 22 are provided in the duct 21 and valve means 23 in the pipe 18, and will be arranged for operation so that the cylinder is first charged through the duct 21 and that the supercharging admission is later made by the ballistic discharge through the pipe 18 into the cylinder caused by the large and rapid opening of valve means 23.

Fig. 11 shows an arrangement suitable for engines in which the air is introduced through a ring of ports 24 encircling the cylinder and the inlet passages 25 are divided into two groups, each fed by a separate pipe 26 and reservoir 27, the two reservoirs being fed by a common blower 28.

By way of example of suitable proportions for an installation such as that shown in Fig. 11, the reservoirs may each be from 10–20 cylinder volumes, the pipes 1 meter long and having a cross-section 10 to 20 per cent greater than the area of the air ports at cylinder. The cross-sectional area of the collarette being similarly proportioned to suit the port area fed at each point of the collarette. Generally the pipes may each contain 2 to 3 cylinder volumes of air. The inlet orifices may be proportioned by assuming that one cylinder volume of air has to be supplied to the cylinder during the admission period at a mean speed of 100 meters per second through the mean area of inlet port opened during this period, which will be approximately the total area divided by two. Additionally, it is recommended that the total area of the inlet ports should not be less than ¼ the cross-sectional area of the cylinder. Where one pipe and one reservoir are used, the volume of the single reservoir will be 20 to 40 cylinder volumes, and the pipe volume 4 to 6 cylinder volumes. The pipe length of 1 meter is suitable for speeds from 800 to 1600 R. P. M. but in general, will require to be longer at lower engine speeds and may be shorter at higher speeds.

The following is an example of the application of the invention to a 2-cycle internal combustion engine of the kind set forth in my Patent No. 2,102,559 in which by a suitable opening in time and area of the exhaust orifice the burnt gases are discharged as a mass through an exhaust system suitably formed to maintain their outward motion and the charge is introduced into the cylinder when the burnt gases are in full outward motion as a consequence of their mass exit from the cylinder and cause a suction effect to be exerted at the inlet to the cylinder.

This engine was a single cylinder opposed piston engine of sixty-five mm. bore and 210 mm. combined stroke giving a cylinder volume of 700 cc. capacity and was fitted with an arrangement such as that illustrated in Fig. 11. The air admission ports divided into two groups, had a total area of 20 cm.$^2$ and the admission period was 96° of crank angle. The pipes were of parallel section and the pipes used varied from 3.8 to 5 cm. diameter. The length of the pipes was 92 cm. The reservoirs were from 8.64 to 17.5 meters capacity each. With this arrangement the typical results shown in Fig. 12 were obtained. From this figure it will be seen that at all speeds above 800 R. P. M. a substantial super-pressure is recorded in the cylinder, the constant mean supply pressure being 6 lbs. per square inch gauge in each case. At the higher engine's speed the super-pressure becomes almost 16 lbs. per square inch, i. e., 8 lbs. above the supply pressure. The output of the engine is increased in proportion to this increased density of the air charge and reaches 220 to 260 lbs. per square inch BMEP. These results show that the supercharge, according to the invention, can be applied to variable speed engines as well as engines running at constant speed.

In another example an arrangement as such illustrated in Fig. 11, was applied to a 2-cycle engine of the kind referred to above of 1.7 liters cylinder volume, having a valve control exhaust orifice in the cylinder head and a ring of inlet ports on the cylinder walls. The engine ran at a costant speed of 1000 R. P. M. In this case the pipes were of parallel section 106 cm. long, and 5.7 cms. diameter. The reservoirs were approximately 20 liters capacity each. With mean air supply pressures of 4 lbs., 6 lbs., and 8 lbs. per

square inch, the final pressure recorded in the cylinder at port closure was 7.9, 10 to 12 and 13 to 16 lbs. per square inch respectively, the super-pressure in each case being considerable. The maximum net output obtainable with 8 lbs. blower pressure being 156 lbs. per square inch BMEP.

With the same engine fitted with a normal large capacity chamber round the inlet ports, and with air fed directly to this chamber by a blower at mean pressures of 4 and 6 lbs. per square inch, the pressures in the cylinder at port closure were 2.7 lbs. per square inch and 4.6 lbs. per square inch, respectively. These figures show clearly how the arrangement converts the usual loss between source of supply and cylinder into a positive gain, which represents a considerable increase in the quantity of oxygen introduced and retained in the cylinder, thus enabling very high outputs to be obtained for substantially the same power absorbed by the blower.

Referring again to the curve shown in Fig. 12 it will be seen that the super-pressure fluctuates with engine speed above and below a mean line which is shown dotted. These fluctuations indicate the influence of pipe length on the results obtained and show that this influence is of a secondary order.

When the inlet ports open, an explosion of air from the reservoir and pipes follows, and a dense mass of air in high speed motion passes along the pipe and through the cylinder and the exhaust system. The closure of the exhaust orifice stops this column of air and the closure of inlet traps a super-compressed charge in the cylinder and at the same time stops the motion of air in this end of the pipe, so that a super-pressure is registered at this point and travels backwards until the air in the pipe discharges into the reservoir. Thereafter, the mass of air will swing backwards and forwards between the closed air ports and the reservoir causing a periodic fluctuation in pressure. During this time also, the compressor continues to feed air into the reservoir.

As a consequence of these fluctuations, when the inlet ports open on the next cycle, the air in the pipes may be stationary if the oscillations have died away, or it may be in process of oscillation towards or away from the ports, and this will determine the starting condition for the following charging period.

But whatever be the condition of rest or motion of the air in the air pipe, on the opening of the inlet the ballistic discharge of air into the cylinder occurs and restarts the process of charging, and the oscillations determine only whether this supercharge will be above or below the value it would have if the air were stationary at the commencement of the discharge.

In order to relieve the compressor from the influence of these oscillations of pressure a chamber 29 may be interposed between the compressor 30 and the reservoir 31, with a non-return valve 32 between the chamber and reservoir opening towards the reservoir as shown in Fig. 13.

In applying the invention to engines having a plurality of cylinders 32, the latter are preferably connected in groups of two or three cylinders to common pipes 33 and reservoirs 34, as shown diagrammatically by way of example, in Fig. 14 in which the compressor 35 supplies reservoirs 34.

The pipes and reservoir may form an integral part of the engine structure and may be built into the cylinder block. The reservoir may be located beneath the engine or in any other suitable position. The reservoir may be cooled, for example, by water circulation pipes passing through it.

Figs. 15 and 16 show such an arrangement of an engine comprising three cylinders 36. The inlet ports 37 in the cylinders are divided into two groups connected to pipes 38 running along each side of the engine and terminating at their other ends in a reservoir 39 situated below the engine block and fed with air by a compressor 40 mounted on the side of the engine. Tubes 41 pass through the reservoir for suitable connection in a water circulation system for cooling the air in the reservoir.

What I claim is:

1. Apparatus for supplying and trapping in a receiver a mass of gas at a pressure in excess of that of a source of supply of this gas, comprising a reservoir, a receiver, and a tubular connection between the reservoir and the receiver having an open communication at one end with the reservoir and a controlled communication at the other end with the receiver, means for establishing a pressure in the reservoir and tubular connection which is higher than the pressure in the receiver, and means for so controlling the communication between the tube and the receiver that a large aperture is opened in a short period of time whereby the contents of the reservoir and tube will discharge ballistically as a dense mass into the receiver and create therein a pressure which is greater than the previously existing pressure in the reservoir and tube.

2. Apparatus claimed in claim 1 and further comprising means for so controlling the subsequent closure of the communication between the tube and receiver, that this communication is closed before the said ballistic discharge has expended its whole effort, that is to say, while a dense mass is still in high speed motion in the tube towards the receiver and the total contents of the receiver are in condition of super compression above the previously existing pressure of the reservoir and receiver.

3. In an explosive engine wherein the charge is introduced into the cylinder when the burnt gases are in full outward motion as a consequence of their mass exit from the cylinder and cause a suction effect to be exerted at the inlet to the cylinder, a pipe on the inlet orifices communicating at its other end with a reservoir arranged to be fed by a compressor for the supply of charging air to the cylinder of the engine, and means for so controlling the said inlet orifices that a large area of orifice is opened in a short interval of time, the said means being arranged for opening the said orifices at such an interval before the closure of the exhaust orifices and of the inlet orifices that, on the opening of the said inlet orifices, there will be a ballistic discharge of air from the reservoir and pipe into the cylinder, and into the exhaust system when the said orifices are still open, and upon the closure of the exhaust orifices, the stoppage of the high speed motion of the said mass of air will cause a super-pressure in the cylinder above the pressure of supply and upon the closure of the inlet orifices there will still be a mass of air in high speed motion in the pipe towards the said inlet orifices whereby the said super-pressure will be maintained and trapped in the cylinder.

4. An engine as claimed in claim 3 wherein the reservoir is several times as large as the cylinder.

5. An engine as claimed in claim 3 wherein the pipe has a length sufficient to contain a plurality of volumes of the receiver.

6. An engine as claimed in claim 3 wherein the tube has a cross-section slightly larger than the full opening of the inlet orifice of the cylinder.

7. An engine as claimed in claim 3 wherein a second receiver is provided which is separated from the first by a non-return valve to damp out the pressure variations on the blower.

8. The method of supercharging an engine cylinder having inlet and exhaust ports, from a reservoir having a pressure therein greater than atmospheric, which consists in ballistically discharging air from the reservoir through said inlet port into said cylinder at substantially the instant the pressure in said cylinder is at its lowest sub-atmospheric pressure, suddenly stopping the movement of the air in the cylinder by closing said exhaust port, whereby a pressure is obtained in said cylinder higher than that in the reservoir, and closing the inlet port before the super-pressure in the cylinder produces a discharge therefrom toward said reservoir.

9. A method of transferring a compressible fluid medium from a region of high pressure to a region of lower pressure in order to create in the region of lower pressure a final pressure greater than that initially existing in the region of high pressure which consist in discharging fluid from the region of high pressure ballistically with directed motion into the region of low pressure, stopping the motion of said directed fluid within the region of low pressure, whereby a fluid pressure front is created at a pressure higher than the initial pressure of the high pressure region, which fluid front will thereupon travel back towards the direction of supply, and interrupting the communication between the two regions when the said front has travelled past the communication between the two regions but before the said super-pressure can produce a discharge back towards the source region.

10. The method of filling a receiver with a gas at a higher pressure than the source of supply of said gas where said receiver is provided with a passage communication with said source, which consists in creating a pressure differential between said source and receiver, opening said passage to create an explosion or ballistic discharge of said gas from said source into said receiver, and thereafter closing said passage to trap substantially the entire mass of gas which initially surges into said receiver.

11. The method of charging an engine cylinder having inlet ports with expansible fluid at a higher pressure than the source of said fluid, said source comprising a reservoir connected by a passage to said inlet ports, which consists in creating a partial vacuum in said cylinder, filling said passage with fluid from said source, opening said inlet ports to said passage, ballistically discharging a mass of fluid into said cylinder and closing said inlet ports at substantially the instant when fluid ceases to surge into said cylinder, thereby trapping in said cylinder the mass of fluid initially discharged therein.

12. The method of charging an engine cylinder having inlet ports and outlet ports with air at a higher pressure than the source of said air from a reservoir of air which is connected by a passage to said inlet ports, which consists in creating a partial vacuum in said cylinder by the ballistic discharge of combusion gases through said outlet ports, increasing the pressure in said air reservoir to thereby create a pressure differential between said cylinder and said reservoir, filling said passage with air from said reservoir, opening said inlet ports to said passage, ballistically discharging a mass of air into said cylinder, and closing said inlet ports at substantially the instant when air ceases to surge into said cylinder, thereby trapping in said cylinder the mass of air initially discharged therein.

13. The method of charging a receiver with an expansible fluid to a pressure in excess of the pressure of the source of said fluid which consists in creating a pressure differential between said source and said receiver, directing a mass of fluid from said source to said receiver, ballistically discharging said mass of fluid into said receiver, and trapping in the cylinder substantially the entire mass of fluid initially discharged into the cylinder.

14. The method of charging a receiver from a source of expansible fluid to a pressure higher than the pressure of said source of fluid which consists in providing a fluid directing passage communicating with said source and said receiver, creating a pressure difference between said source and said receiver, directing a mass of said fluid through said passage, explosively discharging said fluid mass from said passage into said receiver, and trapping in said receiver substantially the entire mass of fluid initially discharged into said receiver.

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