A MANUAL ON THE CARE
AND OPERATION OF THE

BESSEMER
GAS ENGINE

THE BESSEMER
GAS ENGINE CO.
Grove City, PA.

Awarded
Gold Medal
BESSEMER ENGINES
San Francisco
1915

THE BESSEMER GAS ENGINE CO.
GROVE CITY, PENNSYLVANIA, U.S.A.

INTRODUCTION

IT has been our object during the last twenty-eight years in which we have been manufacturing gas engines and compressors to make them as nearly perfect as expert mechanics, the most modern machinery and rigid inspection can make them, however, complete freedom from trouble can come only through a thorough understanding of the machine and the proper care of its various parts.

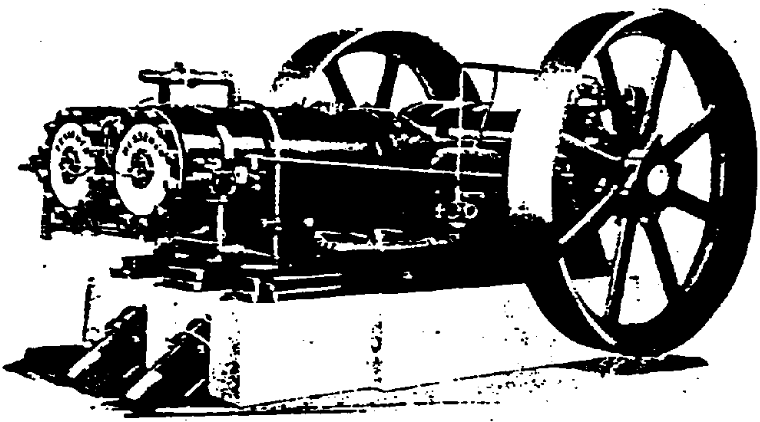
It must be remembered that a gas engine, like all machinery, will not work properly if misused, so it is important that the handling and care of same be understood if satisfaction is to be assured.

The object, then, of this MANUAL is to help Bessemer owners get the most satisfaction with the least trouble by giving them a proper understanding of the principles upon which the Bessemer gas engine operates, and as thorough a knowledge as possible of how to care for it. No effort has been made to tell how to take the engine apart, but should it become necessary, the knowledge gained from a careful study of this book will enable you to find the proper setting of all its parts. Should the engine not work just right, do not act hastily,—study out what may be wrong before you begin to dismantle the parts.

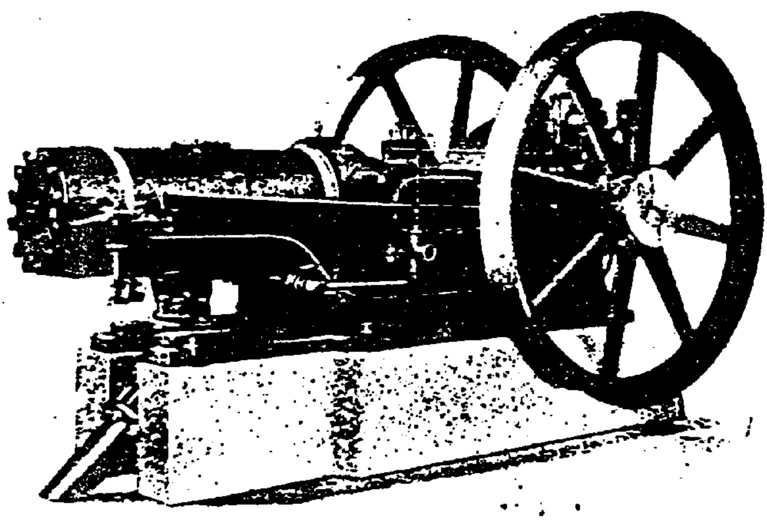
At all times the Bessemer Gas Engine Company stands ready to furnish you with information, advice and assistance, so please feel free to write, asking for any information on our machinery you may desire.

We maintain branch offices and warehouses in the principal cities of the United States and throughout the oil fields, where repair parts may be secured when necessary. This, alone, guarantees service to the man who is the owner of Bessemer machinery.

We wish to express, through this medium, our appreciation for the assistance our customers have given us in the up-building of a business such as we have today, and in return, our aim is to promote to an even greater degree the service and attention which we have given our customers in the past.



TWIN CYLINDER ENCLOSED CASE GAS ENGINE



SINGLE CYLINDER ENCLOSED CASE GAS ENGINE

Repairs and Correspondence

In the operation of Bessemer Engines and Compressors accidents will happen and are practically unavoidable where any moving machinery is installed. Not only accidents, but in time parts will wear out and need replacing. To take care of this branch of the business, we maintain at our plant in Grove City a complete supply of repair parts for all sizes of engines, also a large supply is carried at each of our field ware-houses for prompt shipment.

We wish to impress upon our readers that great care should be exercised in ordering parts either by mail or wire. First of all, ascertain from your chart of repair parts, which is furnished with the engine, the exact parts which you require and give us full information and data, being particular to give us the number of the engine, its horsepower, and the number of part. This information is valuable not only to us but also to yourselves, for when proper data is given us, your order is handled more promptly without having to refer back to records. Also, should you return any parts to be repaired, please be sure and mark same plainly so that they may be identified and thus save delay. When writing for information which is not contained herein, we would ask that you address same to The Bessemer Gas Engine Company, and not to individuals of the company. Correspondence addressed to the company is always directed into the right channel for prompt attention.

Directions for Location and Setting Engine

Of first importance is the choice of the location itself which should be carefully considered, taking into consideration the location of the lineshaft or the machine that the engine is to drive. When possible, the engine should be placed in a separate room, especially in foundries, wood working factories, in fact in any trade where flying dust is present. If this is impossible, a room should be partitioned off and provided with windows so that the engine will be kept free from dust.

In laying out the engine room, the future should be taken into consideration, and the engine room so arranged that additional power may be added with the least inconvenience.

The engine should be so located that there is at least three feet clearance between the flywheels and the wall, and the least distance permissable between the cylinder head and the wall for various size engines is shown on the foundation plans. This space is necessary in case the engine has to undergo repairs,—that there may be sufficent room to dismantle engine. Further, it is a good idea, in constructing your building, to have a suitable eye beam placed across your engine room on which could be hung a chain hoist. This is a very valuable feature in dismantling or assembling heavy machinery, and is particularly adapted where the engine is direct connected to a generator, for the handling of the generator as well as the engine parts.

Provision should be made for the proper guarding of flywheels with hand-railing to prevent any possible accidents.

Foundations

The purchaser is furnished with plans and specifications upon receipt of order, the foundation can then be finished ready for the engine upon its arrival.

Official foundation plans, which have complete bill-of-material for the foundation and template as well as the detail of its construction are furnished as soon as possible after receiving order, and unless the plans are stamped official and bear the checkers signature, they should not be used. It is extremely important that the template be made exactly right, so before placing the template in position over the excavation, re-check the holes for the foundation bolts with the print. In some cases, it may be desirable to fasten a straight edge of suitable length parallel with the holes to aid in lining the template with either lineshaft or building. If so, it should be well braced to insure its accuracy.

Excavation varies considerably on account of the various soil conditions. Usually a good footing can be had at the depths specified on the plans, but if such is not the case, dig down to solid earth before starting foundations.

After excavation has been made, place the template in position, carefully lining same with either lineshaft or building, as the case may be. Before placing the foundation bolts in position, slip some short pieces of 2½ or 3-inch pipe over the same and wedge so that the bolt is in center of pipe. The space between the bolts and the pipe will allow for any deviation in the bolt holes in the engine frame. The portion of foundation ex-

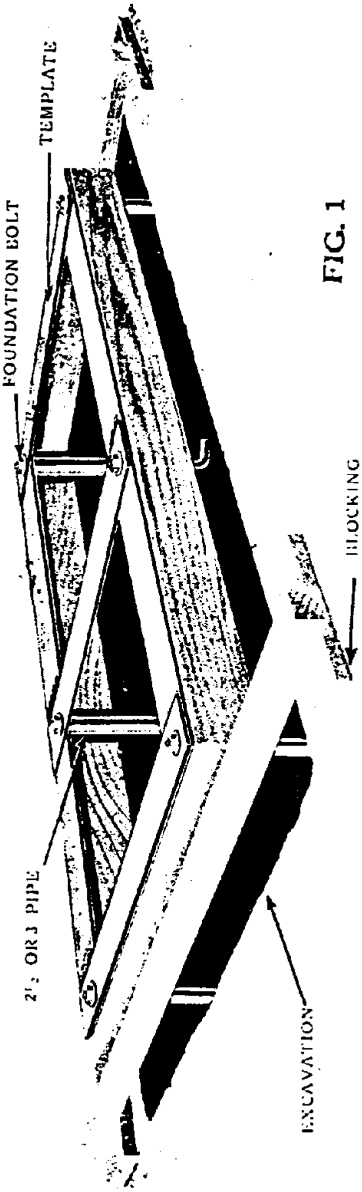


FIG. 1

tending above the floor line must be retained by a box, as illustrated in Fig. 1. This illustration also gives a general idea of the method of support. Great care, however, should be exercised in bracing so that the template cannot be moved while filling in concrete. After making sure that everything is all right, fill in concrete to within one-half to three-eighths of an inch from the finished height of the foundation and allow it to thoroughly set, then place the engine in position, wedging it to the proper height and at the same time perfectly level. Then pour in thin cement, allowing it to fill the short pieces of pipe around the bolts and at the same time run under the bed until it is slightly above the bottom edge. After it is thoroughly set, tighten the foundation bolts evenly at all points.

If concrete floor is to be laid in the engine room, do not allow it to be tied to the foundation, as there may be enough vibration transmitted to the building to be annoying. Cushion with sand properly protected with tar paper, so that the cement cannot reach the sand and harden it.

Exhaust

The exhaust pipe, the size of which is shown in the specifications furnished with the engine, should be as short and direct as possible, and should the length exceed thirty feet, it should be enlarged at least one size. The outlet pipe from the exhaust pit should be vertical, and from the highest point in the pit, so that any gas that might be carelessly pumped into the pit in starting the engine may readily escape. Otherwise, it is barely possible, should the engine for any reason not start with the gas turned on, that the gas may accumulate in the top of the pit and be ignited by a flame from the exhaust when the engine does start, causing an explosion that would injure the pit. In case it is necessary to run the exhaust pipe horizontally from the pit, there should be a vent pipe provided, leading from the highest point in the pit.

The silencing of the exhaust is a very important feature in some cases, especially when the engine is located in a city, and the object of the pit detailed on the foundation plans is to eliminate the objectionable sound. However, when the engine is not near any buildings the pit may be omitted. The specifications for the exhaust pit on the foundation plan are standard, and

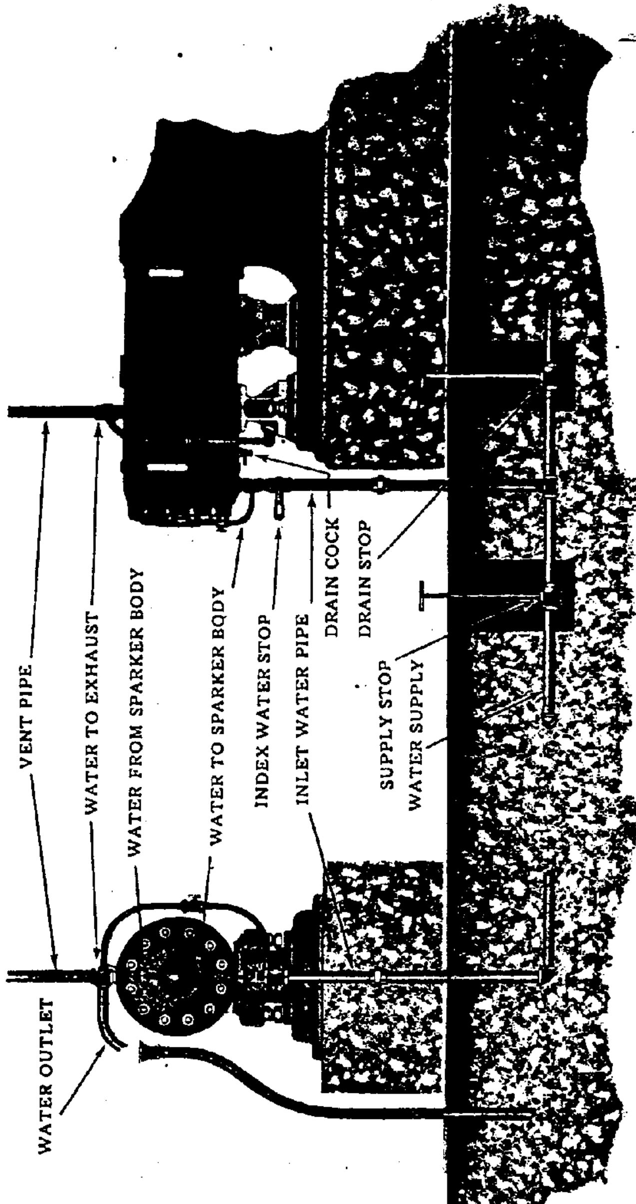

VENT PIPE
WATER TO EXHAUST
WATER FROM SPARKER BODY
WATER TO SPARKER BODY
INDEX WATER STOP
INLET WATER PIPE
DRAIN COCK
DRAIN STOP
SUPPLY STOP
WATER SUPPLY
WATER OUTLET

FIG. 2

they meet the usual requirements when a small quantity of water is allowed to enter the exhaust pipe through a water pipe leading from the overflow on the top of the cylinder to special connections on the side of the exhaust stool. See Fig. 2. As a precaution against explosion in the exhaust pipe when starting the engine up it would be best to turn the water into the exhaust before trying to start.

If more than one unit is installed, separate exhaust pits should be provided, otherwise, if one engine is shut down for any reason, the back pressure from the exhaust of the other engines will force the steam from the pit into the idle engine, which is very detrimental.

The exhaust pit should always be placed on the outside of the building. However, if this is impossible on account of room, we recommend using cast iron exhaust silencer, which can be located any convenient place in the room with absolutely no danger. The water which enters the exhaust pit, or silencer, does not all escape in the form of steam, but accumulates in the pit, so a drain must be provided to keep the pit free from the accumulation of water. The size of this drain should in no instance be less than three inches in diameter, and if the length of the drain pipe is over fifty feet, a four inch should be used.

If a home made muffler is used, care should be taken that the area of exhaust pipe is not reduced in any manner. If muffler with small perforations is used, the combined area of the holes should be not less than twice the area of the exhaust pipe. Otherwise, objectionable back pressure would be the result. In no case should exhaust pipe be dead ended unless end is properly perforated. Frequently the exhaust pipe is dead ended with perforations around the circumference of the pipe and without perforations in the end. This condition causes a rebound of the exhaust gases which obstructs the free flow through the holes in the side of the pipe, setting up a back pressure which is detrimental to the successful operation of the engine with a possibility of broken bridges in the exhaust ports caused by unequal expansion.

It would be best, when conditions are abnormal, to consult either the home office or one of its branches for additional information which will be cheerfully given.

Flywheels

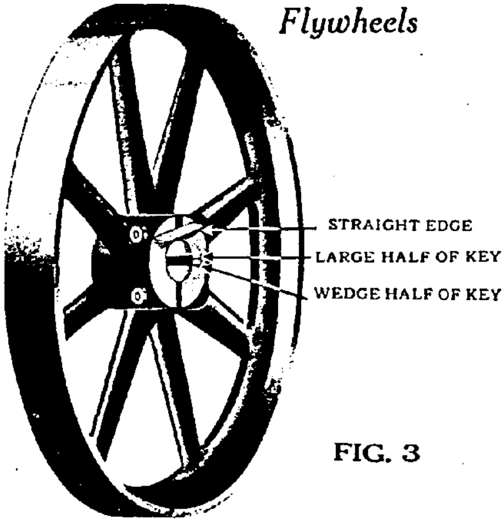


FIG. 3

Extreme care should be exercised in the handling of the flywheels, as carelessness may result in having a wheel that will not run true.

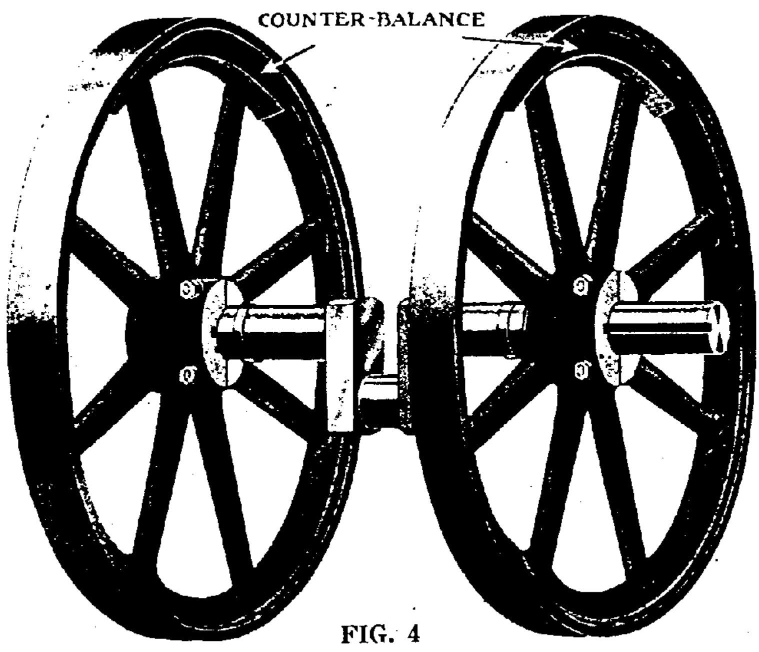


FIG. 4

The hubs and rims on all flywheels used on our engines are finished at one setting, thus insuring a true-running flywheel.

Before placing the wheels on the shaft, examine the hubs and shaft carefully to see that there are no dents. Examine also the bore, as a dent either in the bore or on the edge of the hub will throw the wheel out of line so that it will not run true.

All flywheels are of the split hub type and are held on the shaft by a special two-piece key and bolts. After placing wheels in position on shaft with the keyway on top, tighten the bolts slightly and drive the wedge half of the key in tight. Then after lining up the face of the hub with a straight edge,—see Fig. 3,—tighten the bolts securely with a long handled wrench. If the rim of the wheel should not run true, try the face of the hub again with a straight edge to be sure that no mistake has been made, as it takes very little to throw the rim out of perfect alignment. If the face of the hub is seemingly straight, try changing its position slightly, so that it favors the point on the rim that does not run true. Thus the wheel can be made to run perfectly true.

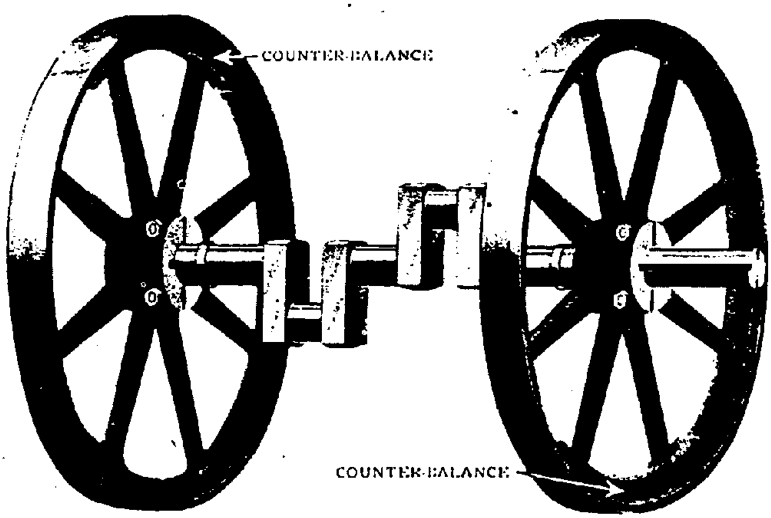


FIG. 5

All flywheels are provided with a counterbalance to compensate for the weight in the crank arm and the reciprocating mass. Each wheel is marked for its respective side, and the erector should be absolutely sure that they are put on right, as it is necessary that the counterbalance in the rim of the fly-wheels be placed opposite to the crank pin—see Fig. 4. It is not strictly essential that the counterbalance be used on twin cylinder engines with cranks 180 degrees apart at normal speed, as one side counterbalances the other. However, their use neutralizes alternately part of the force which otherwise would be carried through the center bearing and be absorbed by the opposite crank, causing a slight alternate twisting of the entire engine. To overcome this fault, we furnish balanced wheels with all twin cylinder engines, and it is just as important that the counterbal-

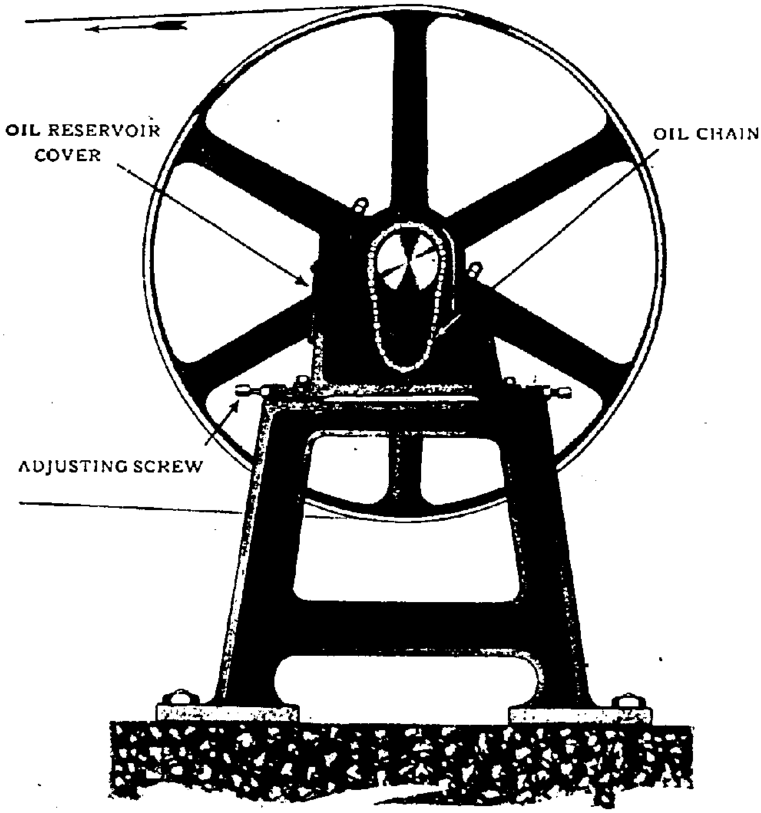


FIG. 6

ance be placed opposite the crank on the respective side on which wheel is placed on twin cylinder engines as it is for single cylinder engines. See Fig. 4 and 5, illustrating the relative positions.

Out-Board Bearing

An out-board bearing is furnished with twin cylinder engines when power is transmitted through a belt. While it is entirely safe to run our single cylinder engines without an out-board bearing, the twin cylinder engine has the same diameter crankshaft, so it is imperative, when the added power is transmitted through the belt, that the additional belt pull over that of a single cylinder engine should be carried by an auxiliary bearing.

Fig. 6 shows the out-board bearing and stand. The bearing itself is shown in section, and illustrates the oiling system, which consists of an oil reservoir and a chain over the shaft running in the oil, thus carrying it up to the bearing.

The bearing is adjusted horizontally only, and when once adjusted it is practically an impossibility for it to get out of alignment except through wear. The wear on the bottom of the bearing is about the same as that on the main bearings of the engine, so the shaft maintains its level position throughout the life of the bearings.

To locate the out-board bearing stand after the engine has been bolted down on the foundation, first place a level on the shaft before the clutch is put on and note the exact reading. Then with the clutch on the shaft and the bearing in place, remove the cap and again place the level on the shaft and wedge up the stand until the level shows the same reading as before the weight of the clutch was added. Then run the cement under the feet of the stand and allow it to thoroughly set before the foundation bolts are tightened. Replace the cap, being sure that it is not tightened up too tight. The pressure on the bearings is directly opposite the cap, so close adjustment is not necessary.

When it becomes necessary to adjust the engine bearings for horizontal wear, remove the belt and loosen the out-board bearing, so that when the engine bearings are adjusted, it can find its relative position. Before fastening, be sure that the belt side of the bearing is touching the shaft, as the bearing may be quite loose after long wear, and unless the cap is adjusted, the bearing might be set so that it touches the shaft on the opposite side to the belt, and whatever looseness there is between the shaft and the belt side of the bearing will cause the shaft to be deflected that amount before resisting the belt pull.

Gas System

General Principles

A gas engine receives its power through the burning of gas and air in proper proportion. For a given size engine a definite amount of gas is required, depending on the heating value, rated H. P. and the B. H. P. load. For satisfactory operation it is necessary to follow the layout shown on Fig. 7.

The gas system to the engine consists of a regulator, meter and gas reservoir. From the latter the gas is piped directly to the governor and thence to the mixing valve on the engine.

A low pressure regulator with suitable capacity should be placed in the gas line so that a uniform pressure will be maintained at from 6 to 10 oz. While it is possible to operate the engine on a much higher pressure, it is not recommended as the danger of choking while starting is increased. Both the regulator and meter are usually furnished by gas companies under contract.

On all type OC gas engines we furnish a Bessemer type R. G. low pressure regulator. Reference to Fig. 6-A shows the simplicity of construction and operation without sacrificing strength. While it is called a low pressure regulator it may be used with safety on pressures as high as 100 lbs. and still maintain the desired constant discharge pressure.

The general principles of operation are as follows:

Gas enters through the opening at "A," so designated on Fig. 6-A. From "A" the gas flows through the valve opening at "B." As the pressure increases on the discharge side "D" the same pressure is registered on the diaphragm "E." This is possible by the hollow valve shank "C," which causes a balanced condition. Regulation is obtained by moving the counterweight on the lever arm. Moving the weight out, that is away from the regulator, increases the pressure, and will give a range of between 1 and 10 oz. pressures.

Between the large and the small diaphragm "G and H," there is a vent connection at V which should be opened to the outside of building, to guard against opposing pressures; also to allow gas to escape outside in the event of a diaphragm proving defective.

BESSEMER TYPE "R G" LOW PRESSURE REGULATOR

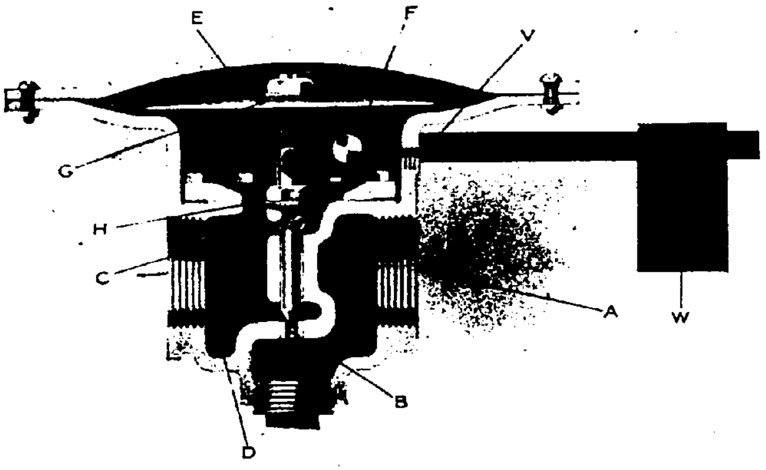
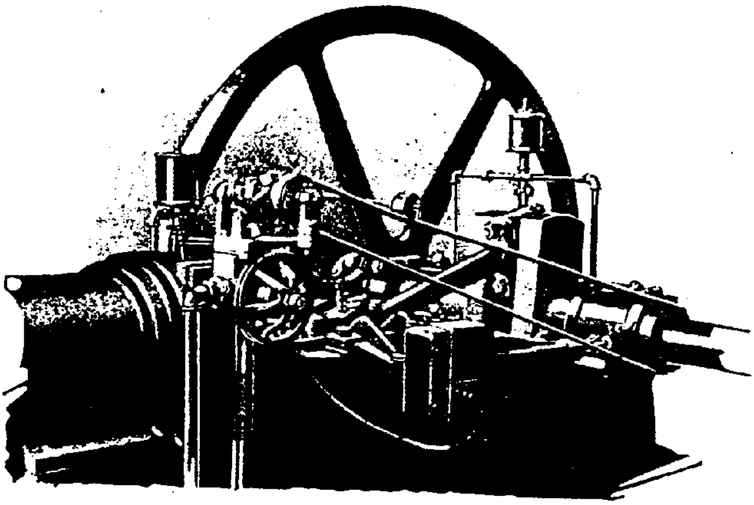


FIG. 6 A.

Gas Reservoir

The gas reservoir is simply a storage for gas, and should have a capacity of not less than six times the piston displacement. The reservoir may be made with a joint of large pipe, air receiver, or any low pressure container of suitable capacity. Its location should be as near the engine as possible, and if it cannot be located within eight or ten feet of the engine, use a larger gas line than corresponds to index stop, between gas reservoir and index stop, thus reducing the friction loss and maintaining nearly equal pressure between the engine and the reservoir.

BESSEMER OIL FIELD GAS ENGINE GOVERNOR



Following is a brief description of its operation:

The fuel control mechanism consists of the governor and fuel valve housing. The engine speed may either be under the control of the governor or under remote control. When the engine is under governor control the speed may be regulated while the engine is running by loosening the thumb screw holding the speed regulating bushing and turning the bushing to obtain the desired speed. By turning the bushing so as to draw it away from the bracket the speed will be reduced. If the engine is to be operated from a remote control the telegraph pulley is used. In this case remove the belt from the governor pulley. The engine should now be made to run idle, while at the same time the throttle valve is entirely closed. This is accomplished by unscrewing the bypass valve until the engine idles satisfactorily. The speed and power is then controlled by the telegraph arrangement.

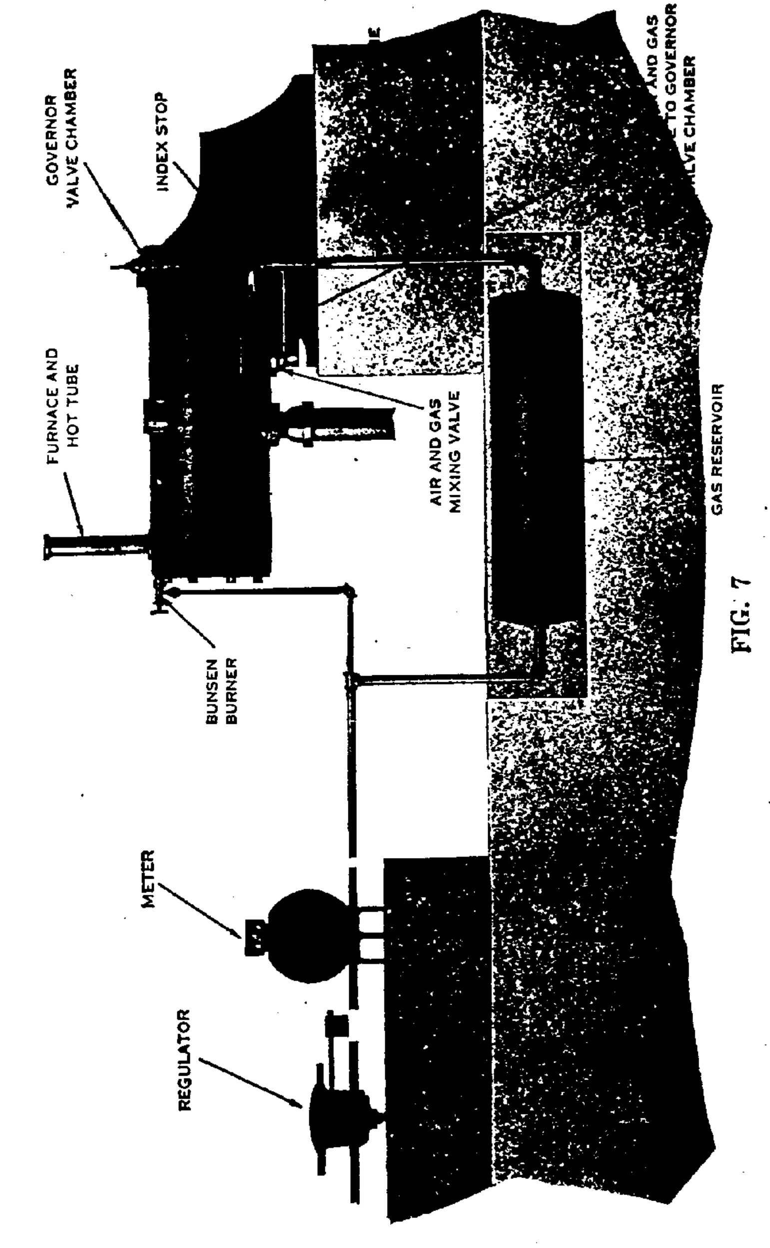


FIG. 7

Dimension Sheet for Bessemer Gas Engines.

NOTE—The diameter and face of fly wheels are made to suit the customers requirements. The shipping weight of engines as given is only approximate.

Gas Pipe

For general system of piping, refer to Fig. 7, which shows the relationship that the regulator, meter and reservoir bear to each other. The size pipe between the index stop and the reservoir should correspond to the size of the stop or the tap size in the governor body. (See instructions under gas reservoir for special conditions.)

If the distance between the regulator and the reservoir is greater than ten feet, a larger size pipe should be used than corresponds to the tap size in the regulator, and the size line leading to the regulator will depend upon its length, also the line required to reach the main. Table 8 gives the proper size line for various size engines when the gas pressure is from eight to ten ounces. Should the pressure be higher, of course a smaller size pipe could be used with entire satisfaction. However, taking into consideration the possible drop in pressure when there is a scarcity of gas, it would be safer to use the sizes specified.

When there is any question as to the proper size line to be used under special conditions, either take it up with some reliable gas man or write directly to us.

Mixing Valve

The mixing valve is a device through which the gas and air pass and are thoroughly mixed when entering the engine thereby guaranteeing complete combustion. Fig. 9 illustrates the main features of the valves used on all size engines. An annular space is provided around the body into which the gas enters and a number of holes are drilled from the face of the valve into this annular space, so when the valve is lifted from its seat, the gas, due to the vacuum in the cylinder during the charging stroke, leaves the annular space through these holes and meets a current of air entering the cylinder and forms the mixture.

Disk valves are used on all size engines, and springs of proper design are placed above these valves to oppose their lift. No spring adjustments are necessary and the valves having only about 3-16 inch lift guarantees reliable spring service.

DIAMETER OF GAS PIPE AT GIVEN LENGTHS REQUIRED FOR ENGINES, WITH MAIN LINE PRESSURE – 6 TO 8 OUNCES.

H.P. of ENG	LENGTH OF PIPE IN FEET											
	50	100	200	400	600	800	1000	1400	2000	3000	4000	5000
5	¾"	¾"	¾"	1"	1"	1"	1"	1¼"	1¼"	1¼"	1½"	1½"
10	¾"	1"	1"	1¼"	1¼"	1¼"	1½"	1½"	1½"	2"	2"	2"
15	1"	1"	1¼"	1¼"	1½"	1½"	1½"	2"	2"	2"	2"	2½"
20	1"	1¼"	1¼"	1½"	1½"	2"	2"	2"	2"	2½"	2½"	2½"
25	1¼"	1¼"	1½"	2"	2"	2"	2"	2"	2½"	2½"	2½"	2½"
30	1¼"	1¼"	1½"	2"	2"	2"	2"	2½"	2½"	2½"	3"	3"
35	1¼"	1½"	2"	2"	2"	2"	2½"	2½"	2½"	3"	3"	3"
40	1¼"	1½"	2"	2"	2"	2½"	2½"	2½"	3"	3"	3"	4"
50	1½"	2"	2"	2"	2½"	2½"	2½"	3"	3"	3"	4"	4"
60	1½"	2"	2"	2½"	2½"	2½"	3"	3"	3"	4"	4"	4"
70	1½"	2"	2½"	2½"	2½"	3"	3"	3"	4"	4"	4"	4"
80	2"	2"	2½"	2½"	3"	3"	3"	4"	4"	4"	4"	4"
110	2"	2½"	2½"	3"	3"	4"	4"	4"	4"	5	5	5
125	2"	2½"	2½"	3"	4"	4"	4"	4"	4"	5	5	5
150	2½"	2½"	3"	4"	4"	4"	4"	4"	5	5	5	6
165	2½"	2½"	3"	4"	4"	4"	4"	5"	5"	5"	6	6

TABLE. 8.

Mixing Valve Adjustment

There is but one adjustment on the mixing valve and that is the butterfly valve in the air passage. This valve controls the amount of air in proportion to the amount of gas. There is one particular setting of this valve which gives best results for a certain pressure of gas, and usually it can be found very readily by experience.

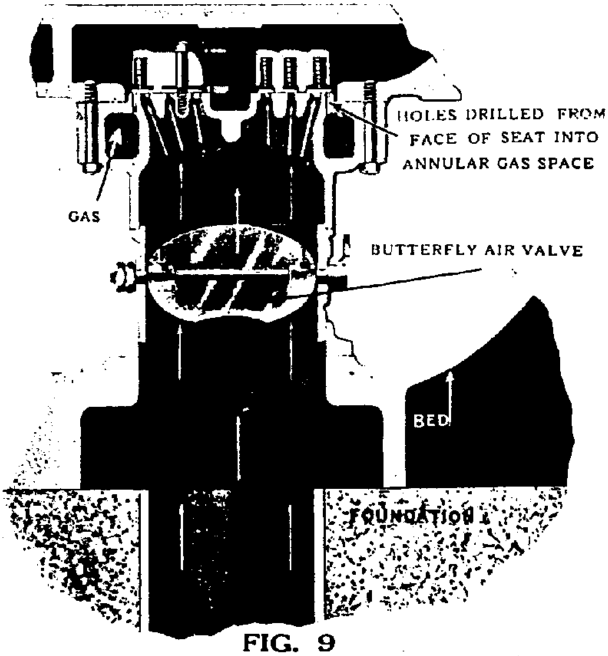


FIG. 9

When pulling a full load with a gas pressure of from 6 to 8 ounces, this valve should be wide open, and while the performance of the engine on light loads will be equally as satisfactory with the same setting, it is advisable to partly close the valve for continuous light load on account of the slight saving of gas thereby effected. The saving is due to the lowering of the mean effective pressure in the charging end of the cylinder caused by lowering its volumetric efficiency, and at the same time lowering the transfer pressure.

Consequently the amount that the M. E. P. is lowered decreases the negative work and adds just that much to the effective power of the engine. The approximate closing of the valve is inversely proportional to the load of the engine, i. e., for three-quarters load close the valve one-quarter, for one-half load close the valve one-half and for one-quarter load close the valve three-quarters. It must be remembered, however, that when the load is variable the setting must be for the maximum load, or there will be danger of stalling the engine.

Low Gas Pressure

A decided advantage is effected through the proper adjustment of this valve when the pressure is low. Closing this valve induces a greater suction in the gas passage, causing a greater amount of gas to flow through the same size opening than when the valve is open. It must be remembered, however, that under such conditions the full rated H. P. of the engine cannot be developed, but a greater percentage of the rated H. P. of the engine can be had through the proper adjustment of this valve under such conditions.

Cooling System

It frequently happens that the purchaser of a gas engine overlooks the importance connected with having a good water cooling system for it. Possibly the system may be right, but the water very impure, or the wrong system for the quantity of water at command, and when such errors are made, dissatisfaction is sure to follow. Therefore, to be insured against such blunders, the following paragraphs should be carefully read:

The Quality of Water

In the first place the purity of the cooling water is no less important than the purity of feed water for boilers. Although the formation of scale occurs only in certain places in the jacket space, which is highly heated, the precipitating of earthly impurities in the water forms mud or slush and other incrustations which seriously interferes with the cooling action of the water.

When the quality of the water is questionable, it should never be directly supplied to the engine, but first should be allowed to settle out all the impurities possible in a settling tank, and if the water contains any great amount of lime or alkali, it would be best to have it chemically treated. Otherwise, it will form hard incrustations that will seriously interfere with the cooling action of the water and be difficult to remove.

Cooling Water Required

Experience has shown that approximately one-third of the total heat supplied per B. H. P. is lost in the external cooling medium and with an assumption that the average H. P. engine requires 13,500 B. T. U. per H. P. hour, it will be seen that the cooling medium must be able to carry off approximately 4,500 B. T. U. per B. H. P. hour, and if the temperature range is 75°, (from 50° to 125°) the consumption of cooling water will be 60 pounds (7.2 gal.) per B. H. P. hour when the water is wasted. In some cases, however, the characteristics of the gas are such that the temperature of the jacket water must not be above 110° or premature ignition will occur, and in such cases the amount of water required may reach 8 gal. per B. H. P. hour, especially for large size engines. To be on the safe side when designing the water system, figure 9 gal. per B. H. P. hour, which will take care of the possible small temperature range and the loss due to leakage.

Circulating System

If, for any reason, it is not possible to obtain sufficient cooling water so that it can waste after leaving the cylinder jacket, it will be necessary to cool the water by some artificial means so it may be effectively used over and over. In cooling the water, some of it will escape in the form of vapor, and it must be replaced. The maximum amount thus lost will amount to about one gallon per B. H. P. hour.

The arrangement for small engines usually consists of a tank, the capacity of which is about 100 gallons per B. H. P., and if the tank capacity exceeds 200 bbl. we recommend using two or more tanks, or a cooling tower placed above tank to aid in cooling the water.

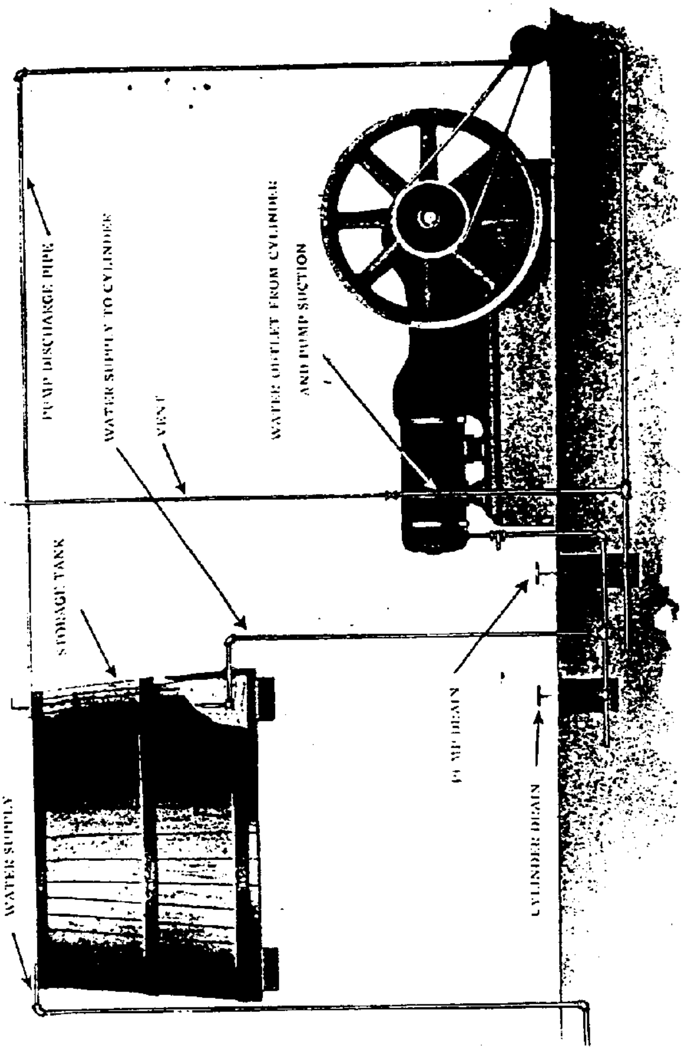

PUMP DISCHARGE PIPE
WATER SUPPLY TO CYLINDER
VENT
WATER OUTLET FROM CYLINDER AND PUMP SUCTION
STORAGE TANK
WATER SUPPLY
PUMP DRAIN
CYLINDER DRAIN

FIG. 10

Fig. 2 shows the general arrangement of a cooling method when water is allowed to waste, and Fig. 10 shows the closed system, suitable for small engines only, or for intermittent running of large sizes. When the tank capacity is not sufficient for cooling in the closed system, there should be a reservoir of suitable size into which the hot jacket water when discharged from the cylinder, may run, this water after being cooled is then pumped into the tank again, thus using it over and over. If it is impossible to have a reservoir for cooling, a cooling tower of wooden partitions, iron wire or any kind of baffle plates may be built above the tank. The water to be cooled is discharged at the top of these baffle plates and guided in such a way that a large surface of the water is exposed to the atmosphere. The water is cooled in this way partly by evaporation of part of its volume and partly by the conduction of some of the heat to the air.

Ignition System

General Principles

The purpose of the ignition system is to furnish means whereby the mixture of air and gas in the combustion chamber may be ignited at just the right instant. In the case of the Bessemer Gas Engine, we use two well known systems. In one, electric current is furnished by a high tension magneto which provides an unusually hot and regular spark (see Fig. 11.) The other system is the hot tube. This furnishes a hot zone, into which a small quantity of mixture is compressed and ignited by the high temperature of the tube, a flame emanating and igniting the mixture in the combustion chamber.

High Tension Magneto

All high tension magnetos must be positively driven, as the spark occurs only when the armature is at a certain position. The magneto must be timed so that the sparking position has the proper relative position to the crank.

A low tension current is produced in the armature winding when it is rotated, and by interrupting the primary circuit a high tension current of several thousand volts is induced in the secondary winding, and is sufficient to start an arc between the points on a spark plug.

A condenser of small capacity is connected across the breaker points to prevent burning them and assist in the rapid collapse of the magnetic lines. A safety gap is provided to guard against burning out the magneto should the high tension cable leading to the spark plug become disconnected while the engine is running. If it were not for this path of escape for the high tension current, it would puncture the insulation on the secondary winding and put the magneto out of commission.

Circuit Breaker

To remove circuit breaker, release spring by pushing it aside by knob on end, pull out complete breaker box and remove cover nut. This allows removal of the cover and gives access to the breaker point.

When breaker points fail to separate or when they are too far apart, adjust lock nut attached to lower circuit breaker arm with small screw driver inserted through a hole in the housing for that purpose. The proper distance apart is 1/64 of an inch. A gauge is furnished with each magneto to aid in making this adjustment.

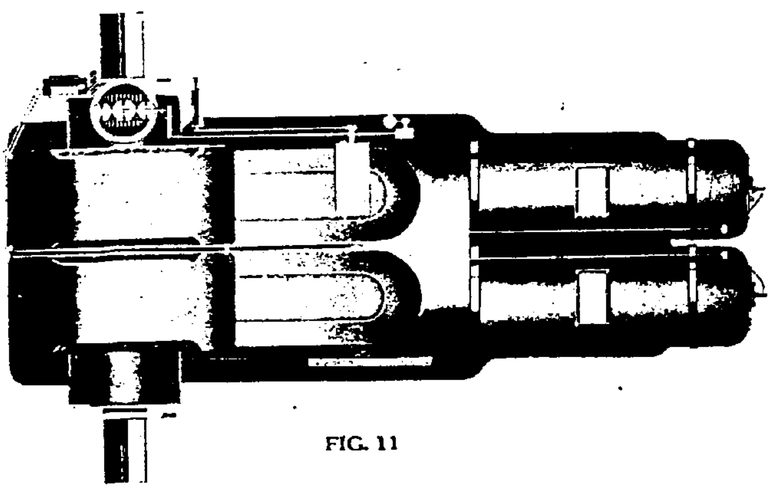


FIG. 11

Distributor

To open distributor, remove the high tension lead by turning it to the right, unfastening it at the bottom, unscrew brass knurled nut and remove the three point bridge or spider, thus releasing cap on distributor block and giving a view of the distributor and brush.

Care of Magneto

Once every two months clean out the distributor with a soft cloth, removing any carbon dust that may have worn off the carbon brush, and clean out any surplus oil there may be in the circuit breaker, then oil the wick in the roller on the upper contact arm with two or three drops of good oil. Make sure that the contact points are clean and that no oil has lodged on them. Oil on the breaker point is an insulator and will cause missing. Replace the circuit breaker box, being sure that the contact spring has been properly replaced and that the nut holding box in place is tight.

Once a month place a few drops of oil on each of the three bearings. One bearing is located on each side of the rotor shaft and one on the distributor shaft.

Setting Magneto

To replace the magneto, should it become necessary for any reason to remove it from the engine, proceed as follows: If the engine is a twin, turn the flywheels around until one of them reaches the firing position, and turn the spark advance arm about half way between mid-position and full advance, which is about the point where the induced current in the primary winding is the strongest. Remove the breaker box cover, also the distributor cover, and turn the armature in the direction that it runs until the contact points just begin to separate, then in this position bring the gears in mesh, and after tightening the magneto to the bracket, test the setting by advancing and retarding the interrupter arm, noting carefully the position when the interrupter points begin to open, as that is the time ignition occurs. To get the exact setting, it may be necessary to change the magneto a tooth or two either in advance or retard in order to have the interrupter arm come in the position where the current is the strongest. Then turn the wheels in the direction that the engine runs so that all lost motion in the gears will be taken up and when the proper setting is found, lock the interrupter arm with the small thumb screw, then note the segment with which the distributor is in contact and connect the high tension wire leading from this segment to the spark plug of the cylinder which is to be fired. The other wire, of course, connects to the plug on the opposite cylinder.

The magneto used on the single cylinder engine has no distributor, but instead, the interrupter is placed on the distributor shaft which runs one-half as fast as the armature (or crank shaft speed). Thus only one interruption in the current is had for each revolution of the engine, and at the same time, the speed and the current strength is the same as that of the twin cylinder engine.

To set this magneto, follow the setting instruction for the twin cylinder engine, except the distributor.

Timing the Spark

The time when the spark should occur in the cylinder depends on the speed the engine is running, the load the engine is pulling, the temperature of the cylinder and the character of the gas used.

There is a certain point in the travel of the piston at which ignition must occur in order to get miximum efficiency, and with a little experience this point can be located.

Ordinarily the spark should occur when the crank is about 15 degrees below the dead center position. However, in some cases it may be necessary to be as late as 5 degrees below dead center or as early as 25 degrees below. If the spark is too late the maximum effort of the combustion is exerted so long after the piston has passed the dead center position that some of the useful energy is wasted and not being converted into mechanical work, is lost through the exhaust and water jacket. Late ignition also causes backfire, i. e., the mixture in the front end of the cylinder being ignited by the burning gases in the combustion chamber coming in contact with the fresh mixture in the transfer ports causes an explosion which greatly reduces the speed of the engine and is accompanied by a rattle in the connecing rod bearings through the sudden reversal of the pressure on the piston. If, however, the spark is advanced too far, the maximum effort of combustion is exerted so long before the dead center position that it tends to retard the speed of the engine and causes what is known as premature ignition. This is accompanied by a thumping sound in the combustion end of the cylinder and sometimes the pressure goes so high that the joint between the cylinder and the cylinder head is strained so that it will leak. Premature ignition will occur when engines are heavily overloaded, and sometimes even with light load when an extremely rich gas is used, or if some gasoline which has condensed in the line is sucked into the engine. If there should be any question as to the possibilities of the heavy hydrocarbons condensing in the gas line there should be a receiver located near the engine through which the gas should pass before entering the engine. Again, a gas with a high percentage of hydrogen makes it peculiarly liable to pre-ignition by compression, and in such cases, it may be necessary to lower the compression below the standard.

Remember, that in all cases, engines are tested thoroughly, and if the engine, under your conditions, does not work as it should, it is on account of some local trouble, which should be located.

Ignition

High Tension Oscillating Magneto

The high tension oscillating magneto is a special equipment on Types OC and EC engines, and is constructed in such a way that it produces a high tension spark without the aid of coil, transformer, etc. The entire system is self contained and consists of a very limited number of parts.

It is necessary, as with the rotating type magneto, to operate it in synchronism with the engine. The method is illustrated in Fig. 12. A mechanical device pulls the armature around, opposing the springs which tend to hold it in neutral position, while the piston is traveling on its compression stroke. When the piston reaches the firing point, the armature is released, the springs causing it to return abruptly to its normal position, and it is at this point that the spark occurs. With this magneto, the speed of the engine is not a factor in the production of the spark, as the same density of spark will be produced while turning the engine over by hand. The fundamental principles are exactly the same as those of the rotating type.

Setting Magneto

Fig. 12 illustrates the proper setting of the oscillating magneto and its operating mechanism when the engine is to be started by hand. The crank is 12 degrees above dead center while the eccentric is on dead center, and the distance between the two vertical lines drawn through the center of the rocker arm bearing and the eccentric arm bearing is 9-16 of an inch. If, with this setting, it is impossible to tramp the flywheel hard enough (in starting) to trip the magneto, retard the eccentric and at the same time shorten the eccentric rod enough to make up for the change in travel of the eccentric and it will be found that the magneto will be tripped at the same crank position when the engine is turned in the direction it runs, but when turned backward against the compression for starting it will be tripped earlier. This position should be such that the maximum exertion is required to pull the engine back far enough to trip the magneto, especially on the larger size engines as it adds to the ease in starting.

The time of ignition may be changed by loosening the clamp on the magneto bracket and rocking the magneto either backward or forward. To move it forward or towards the eccentric causes later ignition and to move it in the other direction causes earlier ignition.

The method of starting the engine is exactly the same as when starting with hot tube ignition except that it is necessary to pull the engine back far enough to trip the magneto to get an ignition, while with the hot tube ignition, the distance the engine must be pulled back against the compression varies with the quality of the mixture and the length and temperature of the hot-tube.

Enclosed Case Gas Engine Ignition

The "H. T. K." High Tension Magneto is standard equipment on the enclosed case gas engine and direct driven gas engine compressors. This magneto is very rugged and powerful; it has been designed and built for heavy duty work.

Impulse Starter

Impulse Starters are supplied with Type H. T. K. Magnetos. This device adds to the ease of starting as it produces a spark at the slow starting speed, just as hot as that produced at nor-

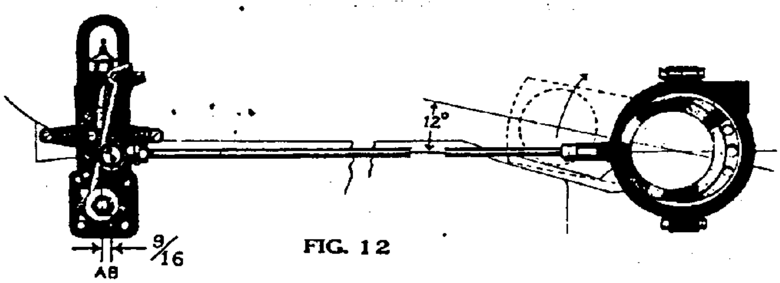


FIG. 12

mal running speed, by holding back the rotor of the magneto until the firing point of the magneto is reached, when it is tripped, and by means of a spring inside a drum, is driven forward at a high rate of speed, thus producing a retarded hot starting spark. It operates only when latch located directly above the rotor is tripped by pressing trigger located at upper part of latch, and when the engine comes up to speed, the starting device is automatically thrown out of action and simply revolves with the rotor.

Spark Plugs

The spark plugs furnished with Bessemer Gas Engines are the very best that the market affords and will give satisfaction when properly cared for.

The distance between the points of the spark plug should be about 1-64 inch, the guage furnished with the magneto for setting the breaker points can be used to gauge these points. It is best to have the points set with a minimum gap to start with, as this gap gradually increases as the points burn off until misfiring results. When the points are too far apart the spark will jump at the safety gap on the magneto which furnishes less resistance than the wide gap on the spark plug. The plug should be kept clean to prevent short circuiting, and if the plugs are clean and the points properly adjusted and the engine still misfires on a good fair load, the trouble is almost sure to be due to a cracked porcelain or the circuit breaker on the magneto being out of order.

When examining the plug for defect, remember that the smallest crack in the porcelain, which is hardly distinguishable to the eye will short circuit part of the current and cause a very weak spark at the plug points. Also, remember, when cleaning the spark plugs, not to use emery cloth or sand paper. Porcelain is porous, and to prevent the escape of the current the outside of the porcelain is glazed. So if this glaze should be removed the pores would be exposed, opening a path of escape for part of the current which otherwise would be conducted to the spark plug gap. Use kerosene for cleaning spark plugs.

Oil Field Engine Ignition

Hot Tube or Wico Electric Ignition

Hot Tube Igniters are made from either nickel alloy or wrought iron, having an inside diameter of from 5-16 inch to 3/8-inch, and a length usually within the limits of 6 to 8 inches. In extreme cases, however, the limits may run from 3 inches to 10 inches. A long tube causes an earlier ignition than a short tube, when the inside diameters are the same, or a larger inside diameter tube causes an earlier ignition than a smaller inside diameter tube of the same length, so it may require some experimenting to determine the length of the tube that will give the best results.

For a gas that is free from sulphur, the nickel alloy tube is far superior to the wrought iron tube. But, should the gas be high in sulphur, a nickel alloy tube will last only a few hours, and the best tube found by experience for a sulphur gas is made from wrought iron pipe.

Tube ignition at the present time is confined to the small and medium size engines and more especially to those used in the oil country.

The open flame, as usually employed to heat the tube may under certain conditions be dangerous on account of the possibility of gas accidentally accumulating in the building from leaky connections, gasometer, stuffing box or gaskets, thus increasing the fire hazard.

For engines larger than 35 H. P., the hot tube zone is usually too far from the center of the charge, and the hot surface is too small in comparison to the volume of the mixture in the combustion chamber to be ignited with satisfactory results. Hence in either case, the electric ignition is safer and better.

Furnace

The furnace is an enclosure in which heat is produced for keeping the tube hot, and the performance of the engine depends a great deal on its condition, as the tube must be kept hot or the engine will behave badly, back fire, run irregularly, and not pull the load satisfactorily.

The inside of the furnace is lined with asbestos to prevent the heat from escaping through the wall, and should the lining be wasted to any extent the radiation of heat through the wall will be so great that it will be impossible to keep the tube hot enough.

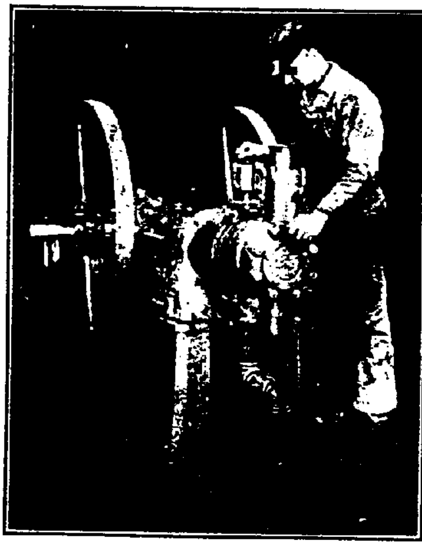


FIG. 13

When adjusting the mixer for the furnace it is very common for the engineer to watch the flame by looking down into the furnace while the engine is running as illustrated in Fig. 13. This habit is very dangerous on account of the possibility of the tube bursting and blowing either part of the tube or other foreign matter into the eyes and causing permanent injury. A safe way for making such observances would be by using a small looking glass, as illustrated in Fig. 14.

Wico Magneto

The Wico Magneto is operated from an eccentric and strap through a connecting rod fitted with turn-buckle. With the crank shaft at an angle of 51 degrees, as shown in Fig. 14, this being easily obtained with the use of a bevel protractor, the eccentric should be turned on the crank shaft until the driving bar, or plunger, of the igniter is in such position that the igniter trips, or fires. This condition can be easily ascertained by cable from the magneto being held away from the engine frame at such a distance that will cause the spark to pass between the end of the cable and the engine frame. With this adjustment made, secure the eccentric through the crank shaft and the adjustment is completed.

The advance and retard of the spark is controlled through a lever mounted on a dial, located in an accessible position.

FIG. 14

The cable from the magneto to the spark plug should be kept at least 3. inches away from the frame or cylinder of the engine. The reason for this being that the spark is so heavy that coming in closer contact will often times cause a short if the cable is not new.

The turn-buckle is provided for making minor adjustments in the timing, and if the timing is badly off it should not be used to reset same. Use the eccentric for retiming.

Lubricating System

General Principles

The Bessemer enclosed case gas engines and compressors are lubricated through two combined systems, splash and force feed. The splash system affords a bath of oil for all the working parts inside of the bed plate. All surplus oil from the bearings drains back to the crank case. Oil rings are placed on the shaft to keep the oil from being carried out and oil guards are provided to force its return to the crank case. The cylinders, governor and eccentric, are lubricated by a mechanical force feed

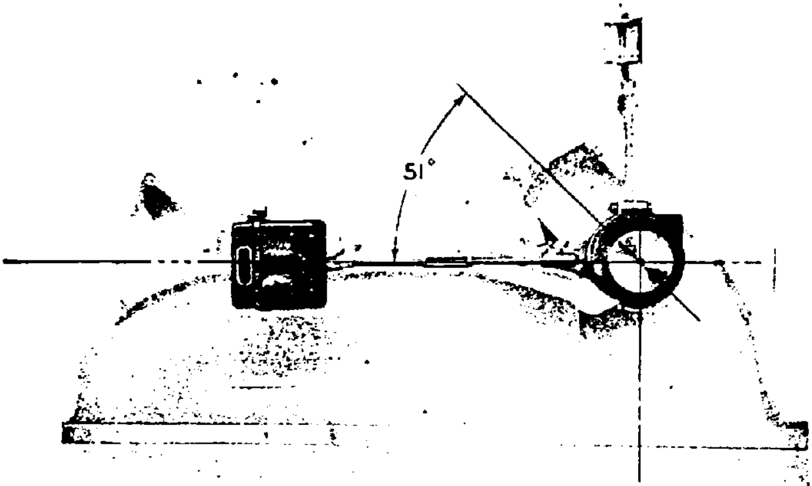


FIG 14 A

lubricator which delivers oil in direct ratio to the speed of the engine. Three feeds are provided on each cylinder on all the larger size engines and one on the smaller sizes.

Importance of Lubrication

Proper lubrication of a gas engine is more important than any other item in its care, and you cannot be too careful in seeing that your lubricators are filled and feeding properly, also that the proper amount of oil is carried in the crank case.

More machinery is sacrificed each year as a result of friction than from any other legitimate cause.

Not only does carelessness in lubrication destroy machinery, but it seriously diminishes the useful energy by absorbing it in friction, thus reducing the mechanical efficiency of the engine.

Specifications

The oil specifications for our engines are rather broad. Under normal working conditions the lubrication question is not at all serious. The only thing to be sure of is that the oil is made for the purpose intended. Any of the well known oil com-

Suitable Oil Level in Crank Case for Various Size E. C. Engines and E. C. Twin Engines. Table 15:

SINGLE CYLINDER		TWIN CYLINDER	
H. P.	F.	H. P.	F.
15	15 15/16		
20	15 15/16		
25	17 11/16		
30	17 11/16	110	19 5/16
35	17 11/16	125	19 11/16
40	20 5/16	150	19 11/16
50	19 15/16	165	19 11/16
60	20 15/16	200	19 11/16
70	20 15/16		
80	20 15/16		

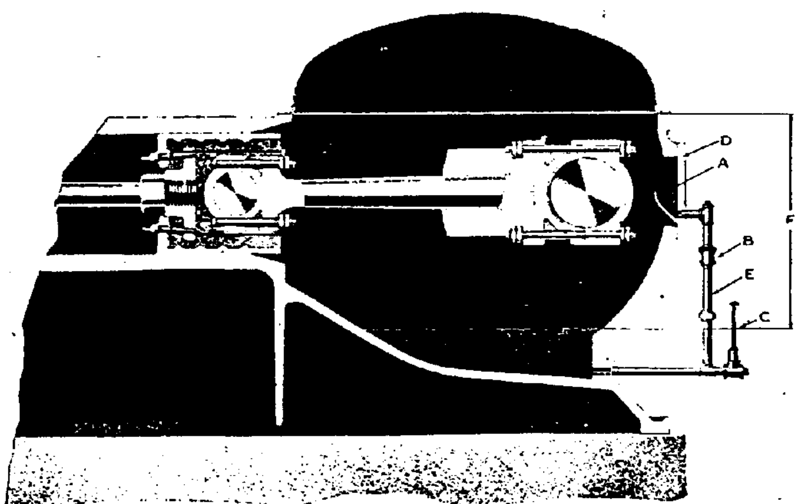


FIG. 15.

panies can furnish suitable oil as they have for some time past made a very broad and comprehensive study of the requirements. They have their own engineers who have for years made tests under field conditions and from such information they can always furnish an oil that will meet even the most severe requirements.

To make specifications so that almost any Oil Company can meet them, taking both the paraffin base and asphaltic base oil into consideration we give the following:

Flash	350 or higher
Fire	400 or higher
Visc. @ 100° F	360 or higher

Cloud O-35 depending on weather conditions.

This does not mean that it is safe to use the figures in above specifications on all engines, regardless of their working condition, as a higher flash and visc. may be required. Some engines pulling a heavy overload will require a better grade of oil than when run ½ or ¾ load, or even full load.

Cost of lubricating an engine is the first thought, taking into consideration the abnormal wear that may take place if a poor grade of oil is used. In the case of a small engine running light a reasonably low grade of oil may be used with entire satisfaction. On the other hand, if a larger engine pulling full load were to be lubricated with the same grade of oil, its life would be materially reduced through the abnormal wear of the cylinder, so in the long run the cheap oil will be very expensive.

Unless the operator knows from experience the best grade of oil to use we would recommend that a dependable lubricating engineer be consulted or write to The Bessemer Gas Engine Co.

The oil level in the crank case, while the engine is not running, should correspond to the measurement "F" in table 15 as shown by the oil gauge "C." This level may, however, vary slightly and still sufficient oil will be caught up by the crank to lubricate all bearings perfectly.

In order to assure the engineers that there is enough oil in the crank case while the engine is running, and do away with any guess work as to when oil should be added, a sight feed glass has been placed in the system as illustrated in Fig. 15. This sight feed will at all times show whether or not the crank brasses are dipping into the oil.

A brief explanation of the system will suffice as the illustration shows the method very clearly. Referring to Fig. 15 "A" is an oil cup integral with flange "D." "E" is a drain pipe leading from the bottom of oil cup to the oil guage connections at the bottom of bed. "B" is a sight feed glass in the said return line "E."

The crank brasses dip into the oil and throw it in all directions in the crank case, and the oil cup "A," being directly in line with the crank pin, catches part of the oil that is being thrown from the crank, oil thus accumulated in the oil cup is returned to the crankcase through the drain pipe "E."

The sight feed "B" in this drain pipe shows at all times the amount of oil that is being returned. Without the sight feed the usual engineer, to be absolutely sure that there is sufficient oil in the crankcase, adds possibly twice as much as is necessary, as it is impossible to tell just how much oil is in the crank case by the gauge "C," while the engine is running. This excess amount of oil causes a violent splash which in turn is the cause of abnormal waste.

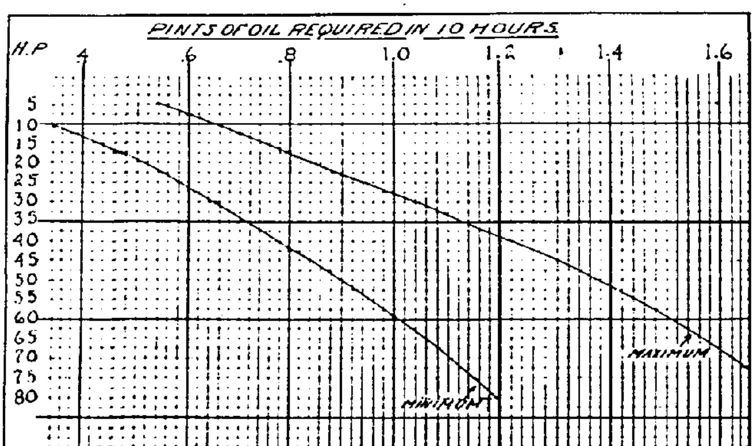


FIG. 17

Table 15 shows the right amount of oil to start with, then by noting the amount of oil that is being returned to the crank-case while the engine is running, you can tell at any future time as to whether a like amount of oil is being returned. Usually from one pint to a quart of oil added at any one time is sufficient.

Drawing Off Old Oil

After the first month, the old oil should be drained from the bed, and the bed thoroughly washed out with kerosene, then filled with fresh oil. This should be done again in about 9 months, and thereafter when the engine is being overhauled.

Care should be exercised in cleaning the bed out thoroughly, especially the first time or two by using a scrub brush and plenty of kerosene.

Force Feed System

The cylinders, eccentric and governor, are lubricated through the mechanical force feed lubricator. Easy means for filling is provided and a guage glass in the corner shows the level of oil in the lubricator. Each feed is provided with a feed glass so that the exact number of drops of oil from each of the feeds can be seen at any time, and check valves are placed in all the feed lines close to the discharge so that the pipes are always full of oil when starting engine. If it were not for these checks, some of the oil would siphon out of the pipe while the engine is standing, and after it is started the lubricator would have to fill this line before the cylinder will again be lubricated. Each unit has independent adjustment and can be set to deliver one drop or a full stream per stroke.

The amount of cylinder oil required for various size engines depends to some extent on the load they are pulling. Referring to chart 17, the amount of oil required in ten hours for lubricating the cylinders of various size H. P. engines is readily found. The number of drops of oil required per minute corresponding to one pint in ten hours is usually between 20 and 30, depending on the viscosity and temperature of the oil. To be on the safe side, a new engine should receive the maximum amount of oil shown by curve on chart 17, and after a month or two may be reduced to the minimum curve.

These curves referred to are for a single cylinder engine. A twin cylinder engine with rating double that of a single cylinder

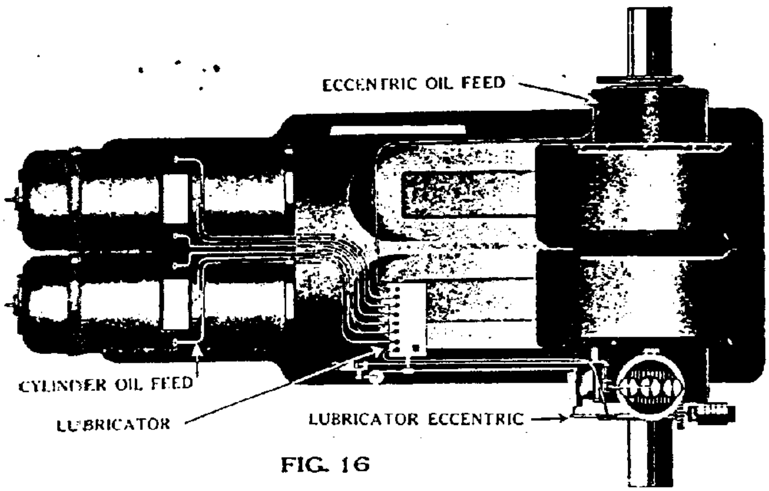


FIG. 16

will require double the amount of oil required for the single cylinder engine.

Thus: If a 50 H. P. single cylinder engine requires 1.2 pints of oil in 10 hours, a 100 H. P. twin will require 2.4 pints in the same length of time.

Judgment, however, must be exercised in the amount of cylinder oil used. For instance, if the engine is pulling an overload and running hot, it will possibly require twenty-five per cent more oil than it will on normal load and with proper cooling. On the other hand, if the engine is running light and comparatively cool, oil consumption may be reduced considerably.

The above specifications are based on Bessemer Gas Engine Oil. If there is any question in regard to the quality of the oil you may be using, you had better have it analyzed. *Safety First.*

As an approximate guide for determining the number of drops of oil per minute for various size engines, multiply the number of pints required in 10 hours by 25—thus: 1.2 pints of oil are required for a 50 H. P. engine in 10 hours, the drops of oil per minute will equal about 30, i. e., a cylinder lubricated at 3 points will require 10 drops per minute for each feed.

The governor and eccentric require very little oil, so the feeds for same may be set for as little oil as will guarantee reliable lubrication.

Governors

Methods of Governing

The standard method of regulating the speed of all types of Bessemer Gas Engines is by changing the quality of the charge, which is carried out by regulating the opening of the gas valve. The quantity of the charge and the compression pressure remaining constant, however, an option may be had on Type O. C. engines, which give the engine constant quantity and quality mixture through a Hit and Miss governor. Hit and Miss governing is carried out by uncovering or covering the transfer ports with a slide valve controlled by an oscillating pendulum which by its own inertia disengages or engages a pick blade that causes the valve to be opened or to remain closed.

It is obvious that the Hit and Miss method of governing should not be considered when close regulation and stability are required, since its periodical interruption of the power stroke causes considerable change in speed with almost constant load, while with the centrifugal governor as used, the change in speed under the same conditions would scarcely be perceptible.

The quantity governing method, where only the gas is under governor control, allows a full charge of air to enter the cylinder at all times unless the butterfly valve on air intake should be partly closed. In that case, a part of the burned gases would be drawn back into the cylinder from the exhaust pipe, the percentage depending on the adjustment of the butterfly valve.

Operation of Centrifugal Governor

The general construction of the Bessemer Gear Driven Centrifugal Governor will be easily understood from studying Figure 18.

In dealing with the operation of the governor, it must be borne in mind that no centrifugal governor holds the engine at normal engine speed, but that there is a definite speed variation, i. e., that there is a speed for no load and a speed for each fraction between no load and full load. This speed variation, as it is called, should never be more than 9 revolutions, and will usually be found to be less, although the less speed variation is in itself of advantage for close governing, governors so made are apt to act not only under changes of load, but also to react with the variation of the effort within the cycle. This leads to a restless governor play, familiarly known as "hunting." To avoid this

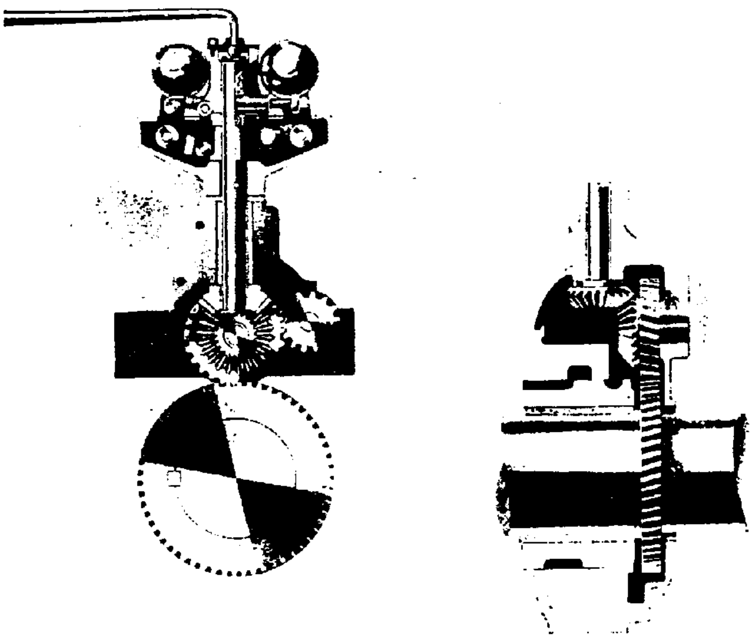


FIG 18

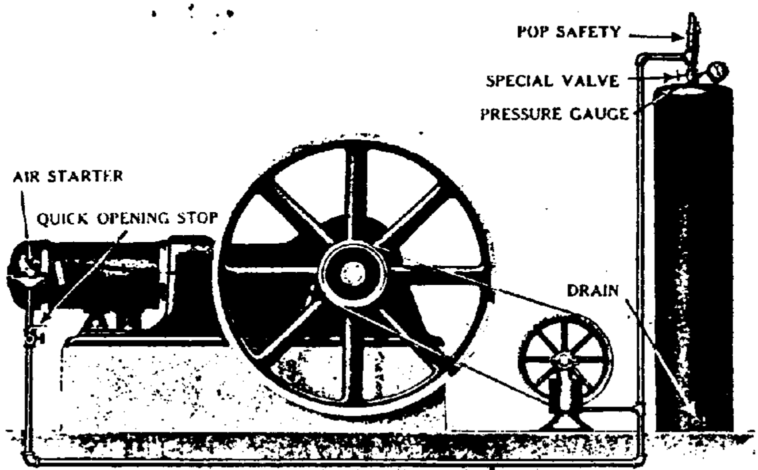

POP SAFETY
SPECIAL VALVE
PRESSURE GAUGE
AIR STARTER
QUICK OPENING STOP
DRAIN

FIG. 19

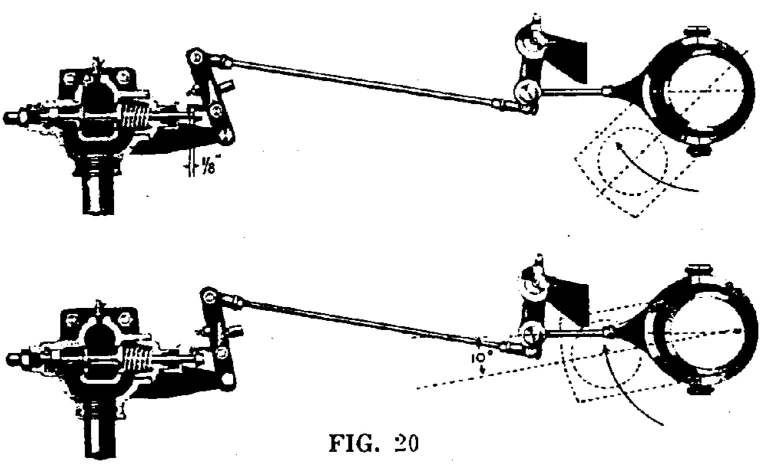

1/8"
10°

FIG. 20

possible tendency, our standard speed change runs between 3 and 4 per cent, thus when the engine speed with full load on is 180 R. P. M., the speed will go up to about 188 R. P. M. when the load is thrown off. However, the general construction of the governor is such that when a maximum degree of sensitiveness is required and the flywheels are of such weight that the co-efficient of regulation is less than 2 per cent—the governor can be so balanced that a very small co-efficient of sensitiveness can be attained. To make this possible, the centrifugal mass in the governor is driven through springs which absorb part of the angular variation of the flywheel which would be transmitted to the flyballs if driven direct, also it will be noted in referring to Fig. 18 that there is very little internal friction, the motion being transmitted to the governor rods through a ball and socket joint at the extreme top of the governor. In this way, the usual friction drag on the sliding sleeve is practically nil.

Adjustment of Governor

The governors are all built to run with a pre-determined speed, and the scale of springs furnished are best suited for that speed. However, while it is possible to adjust the tension on these springs to vary the engine speed within certain limits, it is best when from 15 to 20 R. P. M. change of speed from normal is required and close regulation is necessary, to consult us and get suitable springs.

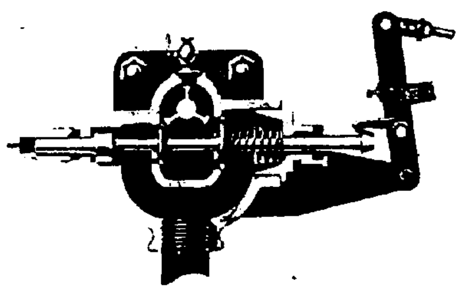
The approximate extension of springs for rated speed is three-quarter inch but this may vary some, depending on whether the spring is wound with or without tension. A spring wound with a slight tension will not require the extension that a spring would without any initial tension, so no exact extensions can be named for a given speed, but taking three-quarter inch as the base, a turn or two in one direction or the other will usually bring the engine to its normal speed. If the rated speed is not attained through the spring adjustment, loosen locknuts on valve stem and readjust valve.

Air Starting System for Type E. C. Engines

General Principles

The Bessemer Air Starting device supplants the laborious tramping and pulling on flywheels, and while the system is very simple and positive in its operation, it should be thoroughly understood by the operator. It is obvious that some auxiliary source of power must be applied to turn the engine around, allowing it to take up its various functions. To this end we have given the various methods careful consideration, and have adopted a method which is absolutely safe and reliable. The general assembly of parts required for a complete starting system is shown in Fig. 19 and consists of a small air compressor of suitable capacity, driven either by the engine itself, auxiliary engine or by a motor, and an air receiver with its fittings, and the air starter with a special quick operating lever valve.

The air receiver may be located at any convenient place, but it is desirable to have it as close to the air starter as possible to reduce the friction of air passing through the pipe. Unless the receiver is within ten feet of engine, two inch pipe should be placed between engine and receiver on all sizes above 35 H. P. and one and one-half inch on the smaller sizes.



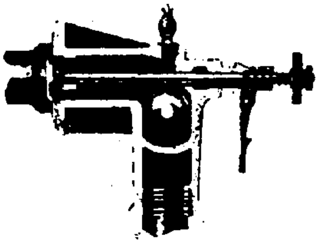


FIG. 21

The Air Starter

Figures 20 and 21 show sectional views of the starter which are self explanatory. The intake valve, which is mechanically operated, is of the balanced type and has a dash pot at one end to prevent its hammering the seat when it is released by valve gear. The valve gear is simple and absolutely fool proof. It consists of a rocker arm on which is carried a pawl, one end engaging with tooth on valve stem, while the other end extends vertically and is controlled by a spring and adjusting screw, which can be adjusted to make the valve gear release the valve at any point in the stroke.

At right angles, and directly above the inlet valve is located a check valve, with a long stem extending through the stuffing box to the outside. The purpose of this valve is to separate the combustion chamber in the cylinder from the air starter body when the pressure in the cylinder is greater than the air pressure in the body, thus, when the starter is working and an ignition occurs in the cylinder, the valve closes instantly, keeping the explosive pressure out of the starter. On the extreme end of the stem is noticed a handwheel which locks the valve to its seat when screwed up against the face of the spring retainer. A latch is provided which can be hooked over the edge of the handwheel when it is screwed out against stop nut, thus holding the check valve open so that the compression may be relieved through the relief cock on top of starter body when turning the engine over by hand.

Adjusting Air Starter

If, for any reason, the air starter requires adjusting or resetting, first turn the engine around until the crank pin is about 10 degrees below dead center—then rotate the eccentric on the shaft and see that the pawl on the rocker arm has about ⅛-inch over travel when the eccentric is on dead center—see Fig. 20. After noting this, turn the eccentric in the direction the engine runs until the pawl on the rocker arm begins to open the inlet valve and fasten with the set screw. Turn the engine in the direction it runs until the crank pin stands vertical, or nearly so, and adjust the pawl so that it releases the valve. The valve gear may be adjusted to the trip earlier in the stroke when high air pressure is used, but the average setting is for a one-half cut-off, with air pressure between 100 and 150 pounds.

General Principles and Operation of Engine

The Bessemer Gas Engine is a two stroke cycle giving a power stroke every revolution. The first stroke, or cycle, the piston travels from the bed end of the cylinder to the cylinder head end and is called the charging stroke on the bed end of the piston and the compression stroke on the cylinder head end of the piston. The second cycle, or remaining half of the revolution is the power stroke. Near the end of the compression stroke the mixture which was transferred to the combustion end of the cylinder in the previous stroke is ignited and the pressure derived from the burning of this mixture gives out a pressure in excess of that required to compress it. This average excess pressure is called the mean effective pressure. Near the end of the power stroke the exhaust ports in the bottom of the cylinders are opened by the piston which allows the pressure in the cylinders to drop to atmospheric pressure.

Just a little farther in the stroke after the exhaust ports start to open, or about the time the pressure in the cylinder has dropped to that of the atmosphere, the transfer ports in the top of the cylinder are opened by the piston. The mixture which has been drawn into the cylinder through the air and gas mixing valve having been compressed in the charging end of the cylinder to about eight or ten pounds is then transferred into the combustion end of the cylinder, and so on,—every revolution of the engine there is a fresh charge taken into the cylinder, a power stroke and the exhaust gases in the combustion chamber expelled and replaced by the fresh mixture.

Piston Head Position

It is important that the piston head be set in the proper relationship to the transfer ports (upper ports). There are two lugs F on the end of the piston—see Fig. 22 which must come on either side of the transfer port. These lugs, or deflectors, guide the transfer mixture along the top of the cylinder. If it were not for these deflectors part of the transferred mixture would travel around the end of the piston down toward the exhaust ports and not only waste part of the mixture, but cause frequent back-firing. This mixture, when transferred toward the rear end of the cylinder, makes a sweeping return and drives out approximately 80 per cent of the burned gases. The remaining 20 per cent represents the clearance in the cylinder. When the piston is at the bed end of the cylinder on the extreme stroke, the transfer ports should be wide open and the edge of the piston should match the edge of the transfer ports as nearly as possible. However, 1-16 of an inch in either direction from that preferred will answer. In some cases, where the character of the gas is such that premature ignition occurs, the piston may be screwed in a turn or even two turns without seemingly interfering with the

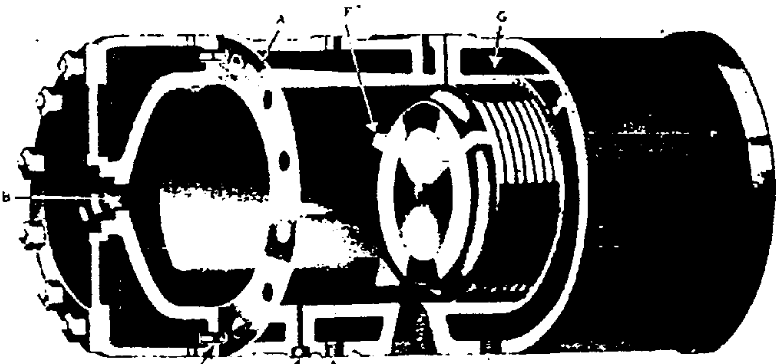


FIG. 22

best operation of the engine. The object in screwing the piston in would be to reduce the compression pressure. Usually, however, when this trouble exists, it is best to decrease compression pressure by inserting a ring between the face of the cylinder and the cylinder head, thus allowing the piston to remain in its true relative position to the transfer ports. By referring to Fig. 22 (B) shows spark plug hole, (A) gasket, (C) drain from main jacket to head, (D) and (E) drains, (G) air and gas mixture passageway.

Starting Engine

To start type E. C. engines after gas, water, oil and high pressure starting air is at command, open the relief cock on top of air starter and with handwheel on air starter check valve screwed back against stop—see Fig. 21—push in and engage latch. This will hold the valve open so that in turning the engine around to starting position, compression will be relieved; trip impulse starter latch. Open the special high pressure air valve on air tank, and open gas index stop ⅛ to ¼, depending on gas pressure, then hook the air starter connecting rod up with the rocker arm—see Fig. 23—turn on the cooling water to both cylinder and exhaust stool. Disengage the latch from the check valve hand wheel so the valve will seat, then turn on the air through the quick opening air valve, and the engine will start to roll over. If the gas is set at the proper point relative to the pressure, ignition will occur in three or four revolutions and

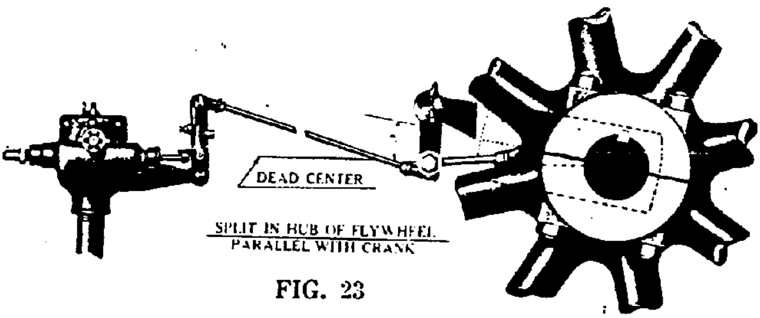


FIG. 23

speed will increase rapidly. At the instant first ignition occurs, disengage air starter connecting rod, set gas index stop at the running point and shut off the air. The impulse starting mechanism on the magneto will automatically disengage itself at about 75 R. P. M.

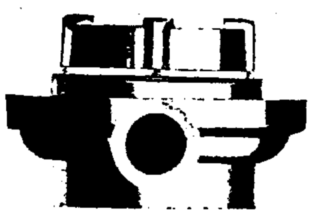


FIG. 24

Important! Do not open the gas index stop wider than is absolutely necessary to carry the peak load. If this stop is wide open and the engine is pulling a good load, it may happen that a momentary overload will slacken the speed of the engine enough so that the governor will open its valve and the excess gas will make the mixture so rich that it will not burn and the engine will stop. And again, the engine may miss ignition occasionally after long running when the ignition points are in bad shape. Then, of course, as the speed diminishes, the governor will open its valve for more gas and if the stop is wide open, the mixture again will be too rich and the engine will stop. On the other hand, if the index stop is opened just wide enough to supply the right amount of gas for the rated H. P. of the engine, the engine may under the same conditions slack down in speed, but immediately pick up and resume its normal speed.

Adjustment of Bearings

Main Bearings

The main bearings are provided with a vertical adjustment by means of shims; and with a horizontal adjustment by means of a wedge—see Fig. 25—as the wear is almost equal in both directions, it is imperative, when making the adjustment, that the bearing be tightened in both directions. All liners removed from between the boxes must be placed between the upper box and the cap in order that the cap may clamp the assembly se-

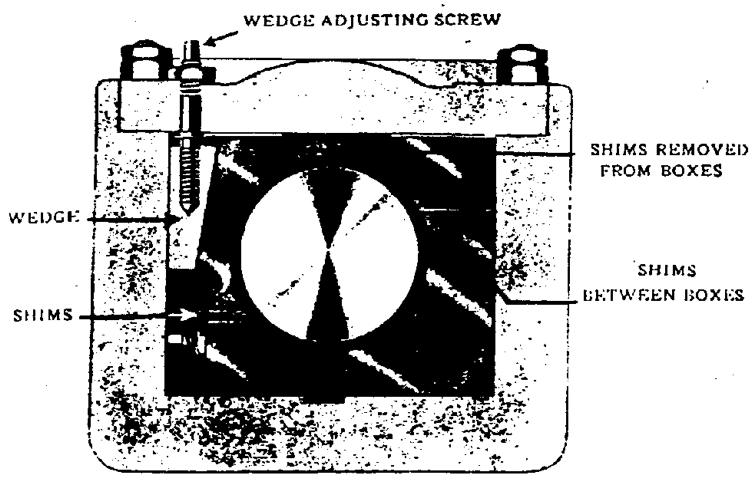


FIG. 25

curely in place. The vertical adjustment is best obtained by using a pry under each flywheel in turn, and there should be a slight play or lift perceptible when cap is drawn down firmly. The wedge for horizontal adjustment may be forced down as far as possible, then withdraw slightly by means of the wedge bolt to secure the proper freedom of the bearing. To determine whether or not the shaft has worn out of line, due to the belt pull, it is best to remove the upper bearing and caliper between the shaft and the side of the bearing jaw toward the cylinder and if the shaft is found to be out of line, shim between the bearing and the bearing jaw until the distance between the shaft and the bearing jaw is the same on either side. It is important that the cap be bolted down securely—the jamb nuts must not be used as means of adjustment.

All adjustments are to be made by means of the shims and wedge and thus the whole must be clamped in place firmly to avoid the inevitable working which would destroy the accuracy of the flat faces on the box seats and wedge in a short time.

Connecting Rod

The connecting rod bearing brasses are provided with shims or liners which may be removed at intervals in numbers sufficient to compensate for the wear and thus take up the lost motion. After tightening up either the crank pin or the wrist pin box, it should be tested by prying the box sideways from shoulder to shoulder by using a short wrench as a lever. When properly adjusted, either of the boxes should be easily moved from side to side. If they are too tight to play sideways, they will surely heat and cause trouble. Although the wrist pin box may be considerably tighter than the crank pin and still not heat, it is not safe to take chances unless the engine is to be run only a short time—then shut down and examined. Do not depend on the nuts as means of adjustment. The boxes must be drawn up against the liners tightly. In taking up wear, remove an equal number of liners from each side of the box, and should the removal of a set of liners make the box too tight, while it has seemed too loose before, do not be tempted to loosen the nuts in order to get the proper adjustment, but replace the liners and tighten the jamb nuts tight. It is better for the bearings to be a trifle loose, as the oil film takes up an appreciable amount of room and at the same time allows for the proper tightening of the bolts.

Crosshead Shoes

The adjustment of the crosshead shoes is important in that an improperly adjusted crosshead may bind the piston rod in the stuffing box as well as the piston in the cylinder and thus absorb a lot of the useful power in friction; also a piston rod which is not running true in the stuffing box causes abnormal wear on the packing and soon causes it to leak. The piston rod should be parallel with the guide and to make the adjustment turn the engine to the outer center and with a pair of calipers compare the distance from the crosshead guide to the piston rod at the extreme points, and if the distance is not the same, adjust the crosshead shoes until the rod is exactly parallel. Apply a wooden pry under the piston rod and at intervals during adjustment lift the crosshead and allow it to drop, and when there is no appreciable amount of lift, but the oil film between the guide and shoe is seen to work when pressure is applied to the pry and relieved alternately, the adjustment is about right.

A tight crosshead has a peculiar knock at both ends of its stroke, and when this is noticed after adjustment, the upper shoes should be loosened at once until the knock or heating disappears.

Piston Head, Rod and Rings

The piston rings should be inspected occasionally by removing the plate over the transfer ports. With this plate removed, the various rings on the combustion end of the piston may be seen after turning the engine around to a suitable position. When making the inspection, it is advisable to run a little kerosene oil around the rings to loosen any carbon that may have accumulated. While it is possible for the engine, when using the right kind of cylinder oil, to run for months with no sign of piston rings sticking, it is best to be on the safe side and occasionally squirt a little kerosene oil around them, especially the end ring.

Should it become necessary for any reason to remove the piston or change its position, the jamb nut at the cross head must be loosened. For this purpose, use a long stout bar or set with the end flattened or made to fit the groove in the nut. A few firm blows on this with a sledge will loosen it. If the piston is to be withdrawn from the cylinder, the stuffing box should be loosened.

Troubles

Advice

Do not touch any adjustments until you know what causes the trouble. Otherwise, you may get everything out of adjustment. When in doubt, don't do anything until you have thoroughly analyzed the problem.

Engine Fails to Start

(1) *Lack of Gas.*

See that the gas is turned on from the main supply pipe. Is the regulator stuck? Has someone placed a blind gasket somewhere in the line? Is the gas pressure too low? Is the air and gas valve perfectly free? If the gas pressure is questionable, it should be tested with a guage.

(2) *Lack of Ignition Current.*

If there is a switch in the system, see that it is thrown on. Look for a disconnected or broken wire. Be sure that the latch on the impulse starters S T-13 is tripped.

Engine Misses

(1) *Broken Wire or Loose Connections.*

Be sure that all the wire connections are tight. A broken wire inside of the cable insulation will cause trouble. Be sure that the wire from the high tension magneto does not touch any metal on the engine. If it should, there will be a drain in current through induction that will reduce the current strength.

(2) *Defective Plugs.*

Plugs may cause missing on account of a cracked porcelain or a punctured mica insulation. If dirty, they will short circuit and cause trouble, and too wide a gap at the points will make spark jump at the safety gap instead of at the points.

(3) *Water in Cylinder.*

The cylinder head gasket may be defective and allow water to enter the cylinder. The moisture in the cylinder will short circuit the spark plug and cause missing. See that no water is carried through gas lines from the source of gas supply.

(4) *Circuit Breaker.*

The points may have become pitted so they do not make contact. The separation may not be the proper amount. Oil may have accumulated on the points. Distributor segments may have become so burned or carboned that a good contact is not formed.

Engine Knocks

(1) *Bearing too Loose.*

Loose bearings on a two-cycle engine usually knock only at a slow speed, i. e., when starting up or shutting the engine down. Do not neglect them because they run quietly when the engine is running at normal speed. Flywheel loose on shaft may be the cause of a knock.

(2) *Spark too Far Advanced.*

When the spark is advanced too far, it ignites the mixture too early and causes an abnormally high pressure at the time the piston is passing over its dead center position. This high pressure causes a knock in the cylinder. See page 28.

(3) *Lack of Proper Lubrication.*

The lack of proper lubrication either in the bearings or the cylinder will cause a knock.

(4) *Defective Water System.*

Improper water circulating system—not sufficient water to keep the engine cool. See page 22.

(5) *Choked Exhaust.*

Exhaust pipe too small, or too long for its diameter, too many turns in exhaust piping, exhaust ports filled with carbon, exhaust pit filled with water.

(6) *Gas Characteristics.*

Mixture too rich, gas rich in gasoline, gasoline accumulation in line and periodically sucked into the engine—a gas rich in hydrogen.

Loss of Power

Loss of Compression.
Mixture too rich.
Weak ignition.

Spark retarded too much.
Lack of oil or water.
Hot bearings.
Poor gas supply. (See page 22.)
Gasket in cylinder head leaking water in cylinder.
Leaky stuffing box.
Choked exhaust.
Improper adjustment of butterfly valve on air supply.
Back firing. See page 28.
Premature ignition. (See page 28.)

Friction Clutches
Types LDS & LDL

To Place on Shaft

First remove the pins which connect the links to the shifting sleeve 13, then take the cap screws out of the shifting sleeve guide flange 22 (if the clutch is the short shaft type) and remove the assembly. This will give access to the keyway after placing the clutch on shaft. For keying the sub on shaft, follow instructions for former type. It will be observed that this clutch, unlike the former type, the hub of which could be removed and keyed on the shaft first, has to be put on with the pulley and spider assembled. It is very important, then, that the key be not driven so tight as to expand the hub inside of the surface on the inside of the friction hub. This may be done by using a hardwood stick or any suitable instrument to aid in turning the clutch on shaft. For keying the hub on shaft, follow in-in front of the end of the rack on either side and turn the gears back from three to four teeth and insert racks, being sure that the first tooth in the gear that the rack engages with on either side is the same distance from the tooth that has been marked. When so set, the pressure will be evenly distributed over the friction surface when the shoes are expanded and the clutch will work perfectly. Now, shove the mechanism clear on so that the sleeve is against the flange *B*. Then fasten the dental nut on the end of the stud and the clutch is again ready for duty.

By studying the mechanism of the clutch you will readily see that the gears must be in the right relationship to each other in order to expand the shoes evenly against the friction ring without cramping pulley hub, as this would necessitate the removing of the assembly in order to file the expanded portion of the hub. After the clutch is keyed to shaft, reassemble the dismantled parts.

To Assemble Shifting Lever and Support

For the short shaft clutches first cut a piece of three-inch pipe Fig. 26 to a length that will, when screwed into the flange *16* and the shifting lever support *19*, bring the lever *10* central with the shifting mechanism and at the same time bring the bottom of the flange *16* flush with the top of the finished floor. Cut the brace pipe *20* to a length that will bring the flange *21* flush

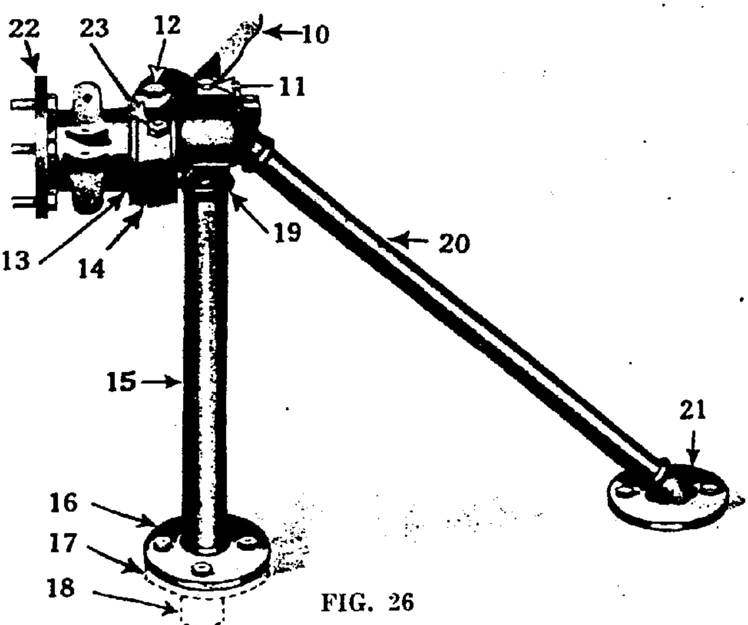


FIG. 26

with the finished floor when the pipe *15* stands vertical. Screw a nipple *18*, which should be from four to six inches long, into the lower flange *17* and support this whole mechanism in such a way before cementing that the shifting lever *10* with its maximum shift will travel as far one way as the other from mid-position without binding.

The shifting mechanism for the long shaft clutch is supported by the out-board bearing and can hardly be assembled wrong.

Outside Friction Lever Clutch

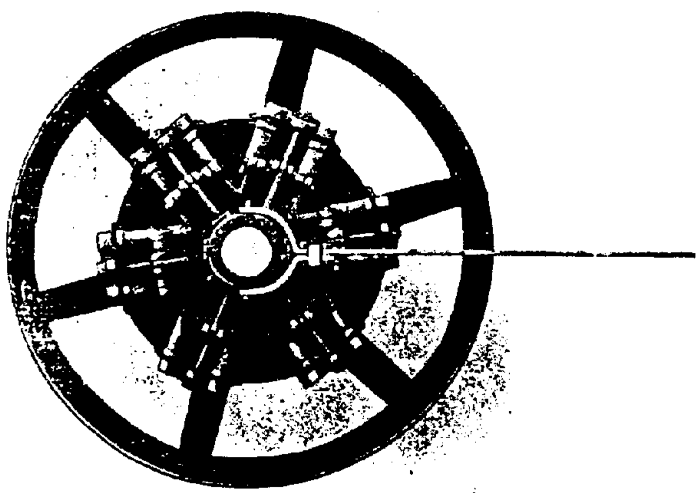


FIG. 27

The six-shoe clutch as illustrated above is usually furnished with the larger engines.

When Bessemer Engines are directly connected to machinery on which the load may be placed after the machinery is in operation, as an electric generator, it is customary to use a flexible coupling instead of a friction clutch, and when direct connected to pumps or line shafting a friction cut-off coupling is used. The Bessemer Cut-Off-Coupling is also of the outside friction type, similar to the friction clutch illustrated, except that no pulley is used.

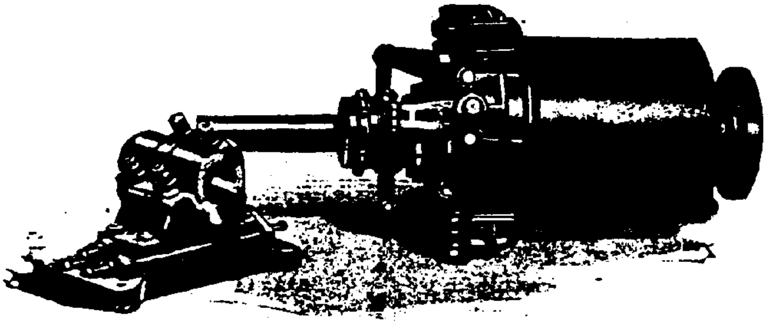


FIG. 28

Friction Clutches

A good clutch is one of the most important parts of the equipment that goes with any engine. No expense has been spared in making this part of the Bessemer of the same high quality material and workmanship as the engine proper.

Above is shown the 18C—2 Clutch and outboard bearing.

The clutch is flanged so that it can be bolted to the fly wheel hub. It is provided with a split hub which is bolted and keyed to the clutch shaft. Solid asbetos composition shoes are used. A heavy shaft supports the clutch, the end of which is supported by the outboard bearing herein illustrated. Note that the bearing has a 30° split—so that the belt pull is taken entirely by the bottom or solid half—and is set on wedges for vertical adjustment. The outboard bearing also has set screws on each end for horizontal adjustment. This arrangement permits adjustment in any one of the four directions which allows perfect clutch alignment with the engine.

This same style clutch can also be furnished so as to be keyed on a shaft extension.

Adjustment

This type of clutch is not automatic in adjusting the friction pressure in proportion to the load. So it is important that it be adjusted so that it will not slip under maximum torque. When the clutches are tested in our factory, the shoes are adjusted so that the pressure is evenly distributed and suitable for a smooth, even torque. If the load is impulsive, it may be necessary to adjust a new clutch to prevent slipping. When adjusting, loosen set screws *A*, Fig. *29*, and turn the nut *B* to the right. One-sixth of a turn brings the next hole in the nut opposite the dog point set screw. If one nut is turned this amount, turn all the others the same, and the pressure will be kept equally distributed on all shoes. In case the shoes have been removed in order to replace the friction shoes, readjust by shifting the lever to its operating position and tighten all shoes gradually, one after the other, with a wrench, maintaining, as nearly as possible, an equal pressure on all shoes until they are tight enough to carry the load.

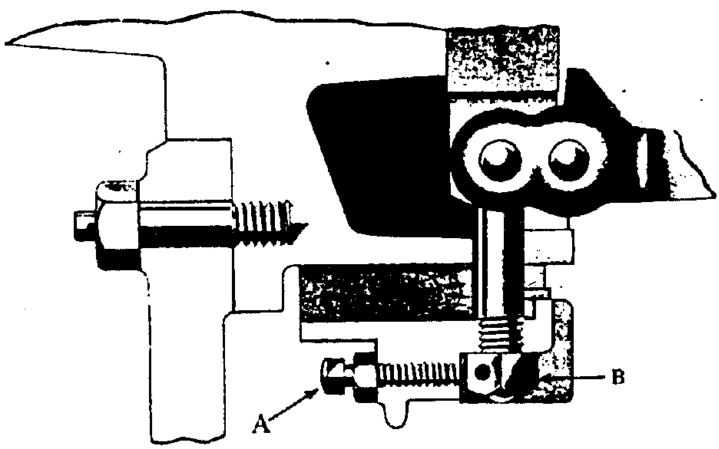


FIG. 29

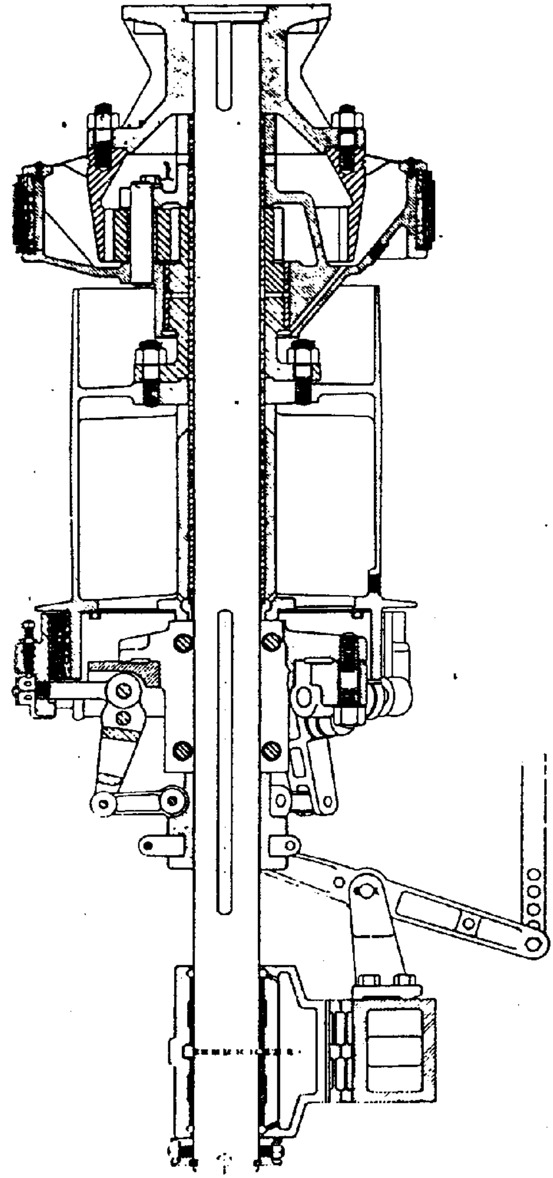
Friction Clutches

Care of Clutches

The various type clutches used on Bessemer engines are very simple and as a rule, the principles well understood. So very few suggestions as to care will suffice.

Reverse Clutch

On the following page is found a sectional assembly view of our spur gear reversible clutch. In a reversing mechanism



SECTIONAL VIEW OF BESSEMER SPUR GEAR REVERSE CLUTCH much depends on the gears, and instead of using cast iron gears we use machine cut steel gears. These gears are carefully milled from the solid steel by special gear cutting machinery which means perfect intermeshing and quiet operation of the entire mechanism.

One other point that we wish to call your attention to is that all the parts that go to make up this clutch, particularly the wearing parts are insured against undue wear by the use of bronze bushings. On the main shaft shown are three separate bronze bushings which have drilled in their surface small holes to permit the free access of lubricants. Also the pinion gears have a bronze bushing, not only insuring long life, but these bushings are so constructed and put in place that when undue wear has taken place all that is necessary is to remove the bushings and replace them with new ones, thereby obviating any loss of time and delay caused by sending the parts to the factory for repairs.

Setting Up

When placing reverse clutch in position, follow very carefully previous instructions given on the aligning of the flywheel on engine, also the proper placing of the outboard bearing.

All clutches are tested before leaving our factory in order to make sure that they will work perfectly. The foundation on which the test is made is built according to our regular plan furnished with each clutch. So it is seen that if proper care is exercised in the erecting, the clutch will do its work properly.

We wish to emphasize the fact that in putting a reverse clutch in position one should be absolutely sure that the face of the clutch hub as well as the face of the flywheel hub is perfectly free from burrs or dirt of any kind. Also, do not forget the split ring that goes on the end of the engine shaft over which the clutch hub is bolted. If perfect care and attention are given to the aligning of the flywheels as given in previous directions the flywheel hub should run perfectly true. Then when the clutch is placed in position, it will also run perfectly true. However, if the flywheel should be damaged in transit, or other conditions arise which cause the outer end of the shaft to run out of true, this can be overcome by loosening the clutch hub and placing very thin shims between the clutch hub and the flywheel hub to equalize the eccentricity of the clutch. This is a very delicate undertaking, however, and extreme care should be exercised as it takes but a very thin shim to make a big difference at the extreme end of the clutch shaft.

When attaching the clutch to the engine first remove the cap on the engine shaft and see that the shaft is level. Then block up under the pulley until the clutch shaft is level with the engine shaft when flange is bolted to the flywheel hub. After replacing the engine cap, turn the flywheel, allowing the clutch shaft to revolve inside of the pulley and note whether or not the extreme end of the shaft has any horizontal motion. If it has none, the flywheel hub is perfectly true; if it has, then either the flywheel hub has to be altered or shims placed between the flywheel hub and clutch hub flange to make the shaft perfectly true. The outboard bearing stand can be used as a gauge support to determine whether or not the shaft runs true. If it does, and at the same time is perfectly level with the engine shaft, the outboard bearing can be set and adjusted to the shaft.

The relative position of the outboard bearing to the engine must be maintained however, by having the foundation integral. Otherwise, one or the other may get out of line and cause a strain with ensuing damage.

When assembling the shifting lever for forward drive be sure that the linkage will throw the clutch clear in. If it does not, the pressure of the shifting sleeve against the shifting yoke will soon cut the bearing and cause unnecessary renewing.

When the engine is to be operated any great length of time without using the reverse mechanism, it would be well to remove the brake band and thus avoid undue wear on the brake lining.

Lubrication

One thing that should never be overlooked is the proper lubrication of the reverse clutch. A card attached to each clutch covers all points of lubrication and should be closely followed. Give particular care to outboard bearing and be absolutely sure at all times that there is sufficient oil to give perfect lubrication.

Should the outboard bearing leak or drop oil it is evident that the bearing is not level, or it may be clogged up. In the event that neither of the above are causing the trouble it may be a good idea to remove the cap and examine the wood liners placed between the top and bottom bearing, as it may be that these wooden liners are too tight and have a tendency to wipe the oil off of the shaft and not allow it to drop down into the oil receptacle at the end of the bearing.

Compressors

By referring to page 66 you will find thereon a cut showing longitudinal section of our Type X direct driven Gas Compressor. The power end of this unit is taken up in detail in other parts of this book and in the treatise following we will devote to the care and operation of the compression end of the unit.

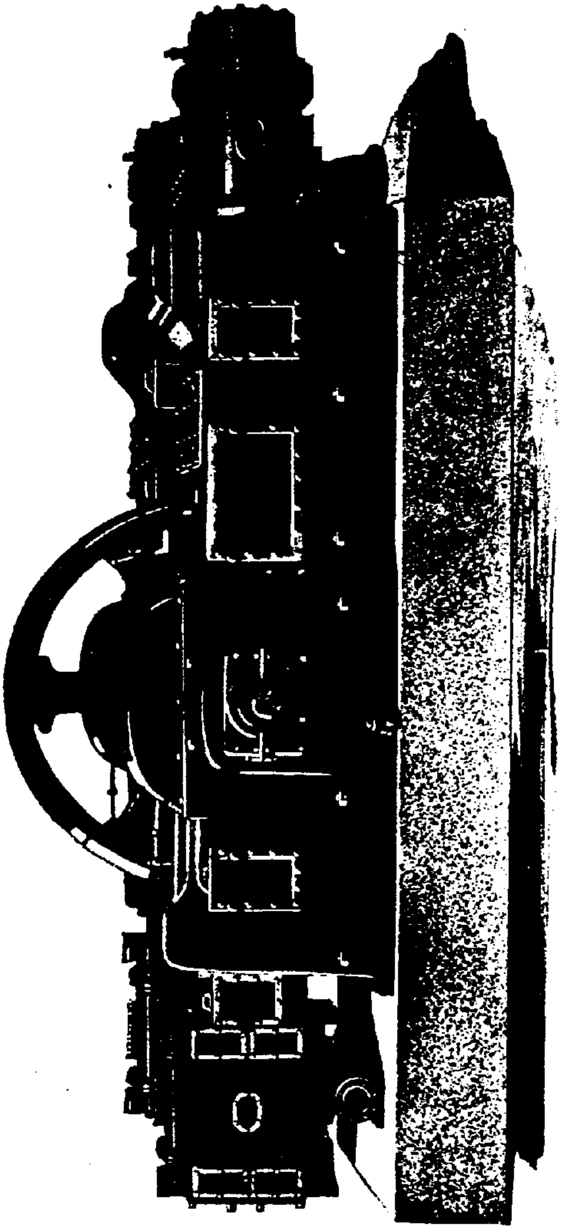
Cylinder

All cylinders used on our compressors are cast from semi-steel which increases the strength of the cylinder and gives a more uniform grain than is found in cast iron. A high percentage of steel also corrects the internal shrinkage which is present in cast iron. The general construction is such that the minimum clearance is obtained, and this minimum clearance should at all times be maintained in order to secure the highest volumetric as well as mechanical efficiency. In other words, do not increase the clearance by using heavier gaskets under the heads than is necessary to just give sufficient cylinder clearance to provide for expansion of the piston rod.

Valves

The present Bessemer valve is of the disc type. The disc valve is essentially a high speed valve and the valve itself is a light, thin piece of steel plate of special composition and if dirt or a piece of foreign substance should work in between the valve and seat, it would result in a bent or broken disc.

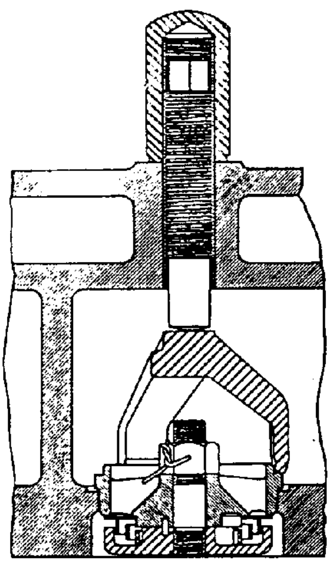
Many times dust, gravel and metal chips come from the line and thence into the cylinder. A portion, of course, passes through the cylinder, but the bulk of this dirt seems to collect about the valves. Special precautions should be taken to prevent any foreign matter, solid or otherwise, from ever reaching the compressor cylinder. This can be done by placing a screen or strainer in the intake line from the field. Any liquid accumulation should be trapped off before it reaches the plant.



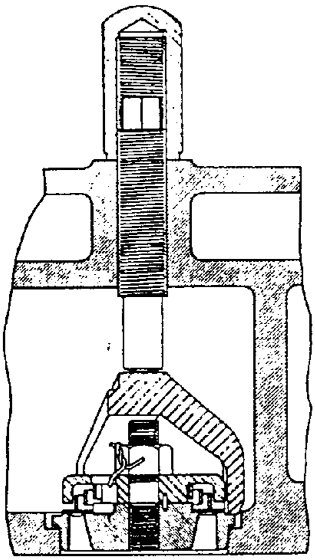
BESSEMER 165 H P TYPE 10 D DIRECT DRIVEN AIR OR GAS COMPRESSOR

While the Bessemer Disc Valve is made from the very best steel obtainable, and is intended to operate under high piston speed, yet we find that occasionally a valve will become crystalized from high pressures and constant seating and crack across the face. There is also the possibility that a small piece might drop out, causing a leak which would be difficult to locate while the machine is in operation, yet would be very wasteful of gas.

Therefore, we would suggest that occasionally time be taken to look at the valves and any that may appear to be cracked or unduly worn be replaced with new discs. Do not wait until a valve breaks down entirely.

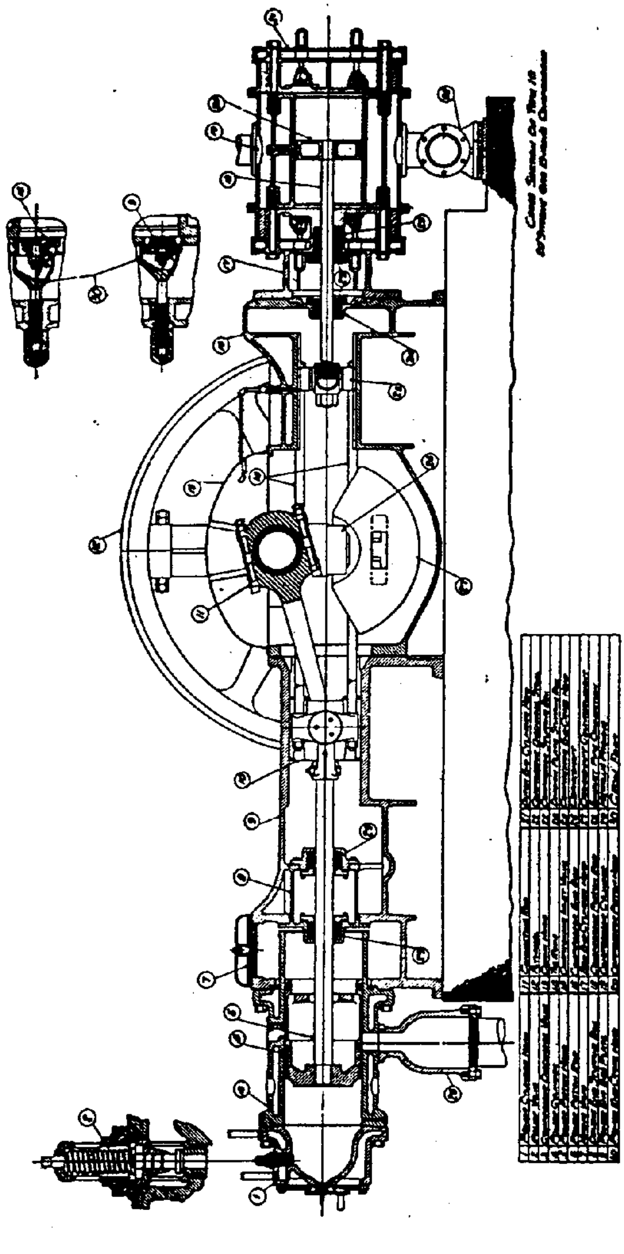


Bessemer Disc Valve; Showing Inlet Valve in Place, and General Construction



Bessemer Disc Valve; Showing Discharge Valve in Place, and General Construction

The new type of valve in head compressor cylinder is so constructed that the gases have a straight line of ingress and egress and do not create eddy currents, as in the case of cylinders with valves located around the circumference of the cylinders, thereby reducing to a considerable extent the accumulation of foreign matter about the valves, as would be the case where eddy currents existed, causing dust to settle about the recesses of the valves.



The valves in these cylinders are made with a taper fit, giving a perfectly gas tight joint without the use of gaskets of any kind. These valve cages should be seated only tight enough to assure a good joint, an ordinary eight-inch wrench will do this—do not under any circumstances use a wrench longer than ten inches.

The cages are held in place by a crowfoot with three legs, assuring a uniform contact at three equally spaced points, and care should be taken to see that the crowfoot is properly placed before the tension screw is tightened against it. Do not try to force cage in until it rests against the rim, as this would force the valve cage into the cylinder far enough to strike the piston at the end of the stroke and might result in considerable damage to both piston and valve cage and possibly the cylinder head walls.

If for any reason the valve cage should need to be taken apart, be careful to note the position of every part before removing any portion, and be careful to have every piece put back in its original position.

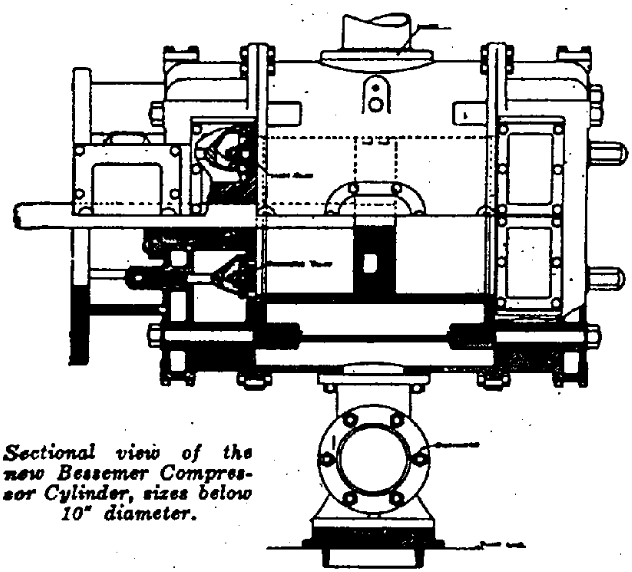
Lubrication

No fixed rule can be given for the amount of lubricating oil required for a compressor cylinder, as the conditions may vary to a great extent. When compressing gas, if the compression ratio is high, or if the gas is rich in heavy hydrocarbons, the oil required will be a great deal more than when the compression ratio is low and the gas is dry. A fair estimate for average conditions would be from $\frac{1}{5}$ to $\frac{1}{3}$ the amount of oil used in the power cylinder. While an excessive amount of oil used in a gas compressor cylinder when vaporized under high temperature conditions will not burn, such is not true when compressing air. While the limit to the relative proportion of air and of volatilized oil ingredients is narrow that will cause a dangerous explosion, never-the-less, if the mixture happens to be just right and the temperature of the air is high enough to fire any carbonaceous deposits which have accumulated on the valves or in the air passage, there may be an explosion that will be very disastrous.

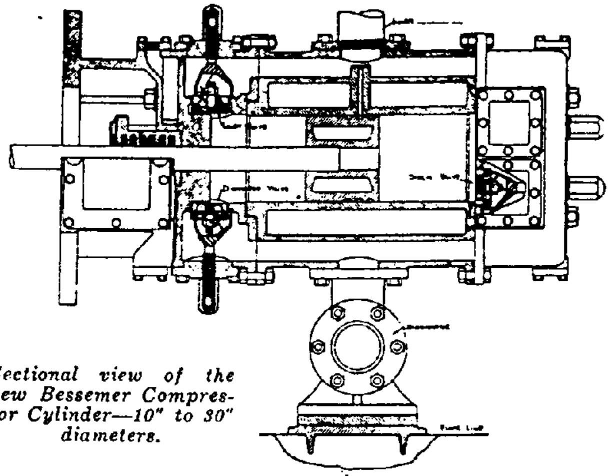
Therefore, if compressing air to a high ratio of compression, an oil that will not readily vaporize or carbonize under high temperatures should be used to lubricate the compressor cylinder. Otherwise, if the air is to be used for pneumatic tools, one not only takes a very serious chance of having a disastrous explosion, but the collection of carbon will foul the tools and cause an expensive shutdown of the plant.

It sometimes happens that when compressing gas, two stage for extracting gasoline, that the gas entering the high pressure cylinder after leaving the intercooler condenses and cuts the lubricant from the walls of the cylinder. Such cases are abnormal. However, if it should occur it would be best to warm the gas slightly after leaving the first stage accumulator before it enters the high pressure cylinder, or use some lubricating compound that the gasoline will not cut.

The lubricating of the crosshead and wrist pin on the compressor end is by gravity. Since the crank runs over toward the compressor it does not throw any oil on the upper guide. So we have arranged a pocket in the crank hood with a pipe leading to the guide. The oil caught in this pocket from the splash is carried to the crosshead guide through this pipe, and from there finds its way to wrist pin through a small tube in crosshead shoe.



Sectional view of the new Bessemer Compressor Cylinder, sizes below 10" diameter.



Sectional view of the new Bessemer Compressor Cylinder—10" to 30" diameters.

Cooling Water

All of the cooling water should first pass through the compressor cylinder jacket and then through the power cylinder jacket, ordinarily the cooler the compressor the better, however, in some extreme cases when compressing a gas rich in gasoline, it would be well to run independent water connections and keep the compressor cylinder warm enough so there will be no condensation. The amount of water for the compressor and engine can be figured approximately 25% above that which is specified for cooling engines alone, a total of about 80 lbs. per H. P. hr., except in hot climates where a greater quantity may be required.

Pipe Line

The suction line leading to the compressor should be thoroughly blown out before connecting to the compressor, as there is always sure to be scale and dirt that will be carried into the compressor cylinder unless this precaution is taken.

Some gas wells yield a fine carbon formation along with the gas and is very annoying in that it rapidly accumulates on the valves and interferes with their working properly, and also shortens the life of the cylinder due to rapid wear. Under such conditions it is always best to provide a field receiver into which the gas must pass before going to the compressor, and if the carbon is very fine, it may be necessary to wash the gas before it is delivered to the compressor in order to get entirely rid of this substance. This field receiver then will act as a trap for any condensation in the line as well as catch any scale or dirt that would otherwise find its way to the compressor.

The gas that may escape from stuffing box should be piped from the top of the spacing hood to the outisde of the building.

Precautions

Owing to the possibility of gas leaking in a pump station it is necessary to have good ventilation. Liberal size ventilators in the roof will usually get rid of the gas unless it is heavier than air, and care should be taken to exclude any space under the building where the gas may collect.

The building must be lighted by electricity and the generator must be installed in an auxiliary building which should be at least 10 feet away from the main building.

Safety lamps should be used throughout and no electric switches should be placed in the compressor building.

An automatic safety valve should be placed on the discharge line between the gate valve and compressor and both the gate valve and safety valve should be on the outside of building.

Do not under any conditions pull the ignition cable off the spark plug or magneto while the engine is running. The spark created when disconnecting the same may ignite the gas in the building and cause serious damage.

Do not open the relief cock on air starter and at same time push in on the check valve while the engine is running, a flame may escape that will ignite gases in the building.

If you notice a spark plug leaking slightly, shut the engine down at once and change plugs, a cracked insulation or defective packing around same may cause a dangerous spark.

Do not polish wheels with a brick or anything that will cause a spark.

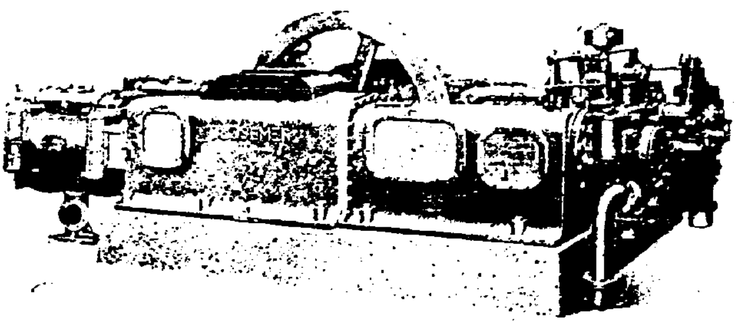
Close the gate valve on the suction when starting the compressor.

For other starting instructions, see page 48.

Positively do not run gas pumps or compressors over 200 R. P. M., and if a gas pump is pulling very little vacuum and has no discharge pressure, run same at about 150 R. P. M. till the vacuum reaches at least 10 points.

Be thoughtful at all times and before doing anything with the compressor consider the results. Safety first always.

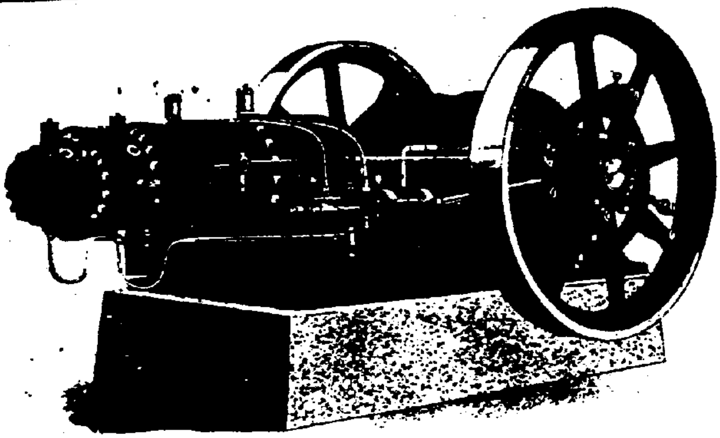
Other complete units built by the Bessemer Gas Engine Co. are illustrated in following pages. Descriptive catalogs will be gladly furnished upon request.



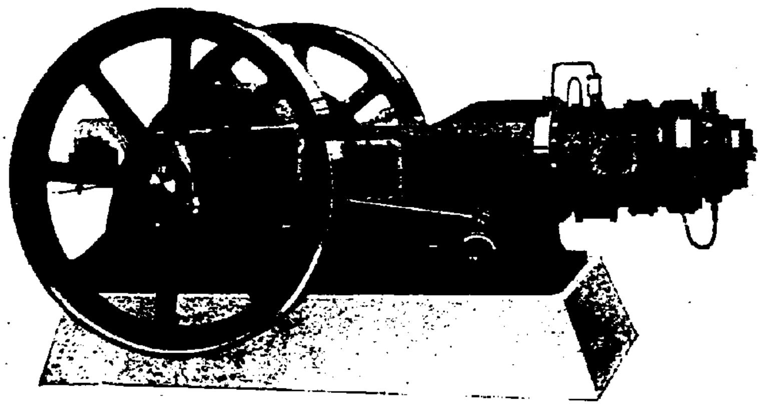
SIDE VIEW OF THE BESSEMER TYPE FC-1 COMPRESSOR

This is a perfected four-cycle direct driven compressor built to consume the smallest possible quantity of fuel. All parts are quickly and easily accessible for inspection, adjustment or replacement.

Ask for Bulletin on Four-cycle Compressor.



THE BESSEMER TWIN CYLINDER TYPE IV OIL ENGINE

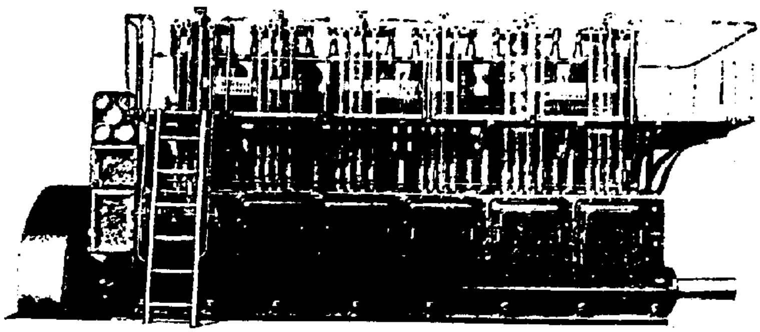


TYPE IV BESSEMER OIL ENGINE, SINGLE CYLINDER, VALVE SIDE

A larger, more flexible oil engine for use where an abundance of steady power is required. They are used in pipe line and irrigation work, lighting and refrigeration, as well as in oil field use. These engines are the two-cycle type, with cross head construction, adjustable main bearings and enclosed crank case.

Built in both single and twin cylinder types and in sizes from 25 H. P. to 180 H. P.

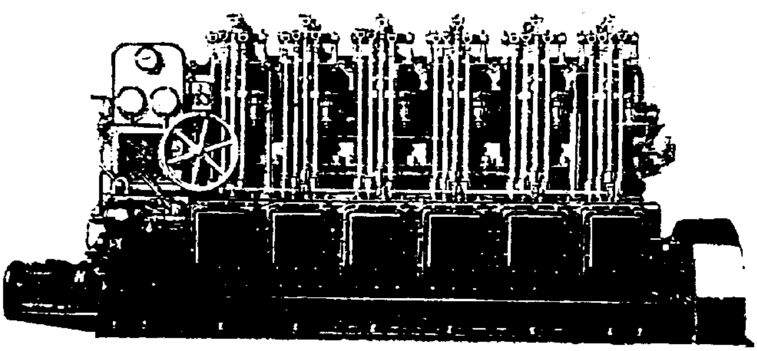
Ask for Catalogue No. 101.



SIX CYLINDER STATIONARY DIESEL ENGINE

Pipe lines and industrial plants equipped with Bessemer Diesels secure power at the lowest cost per H. P. Perfected air-less injection gives positive fuel injection with a resulting fuel economy unequalled in any other engine.

Ask for Catalogue No. 701. Gladly sent upon request.



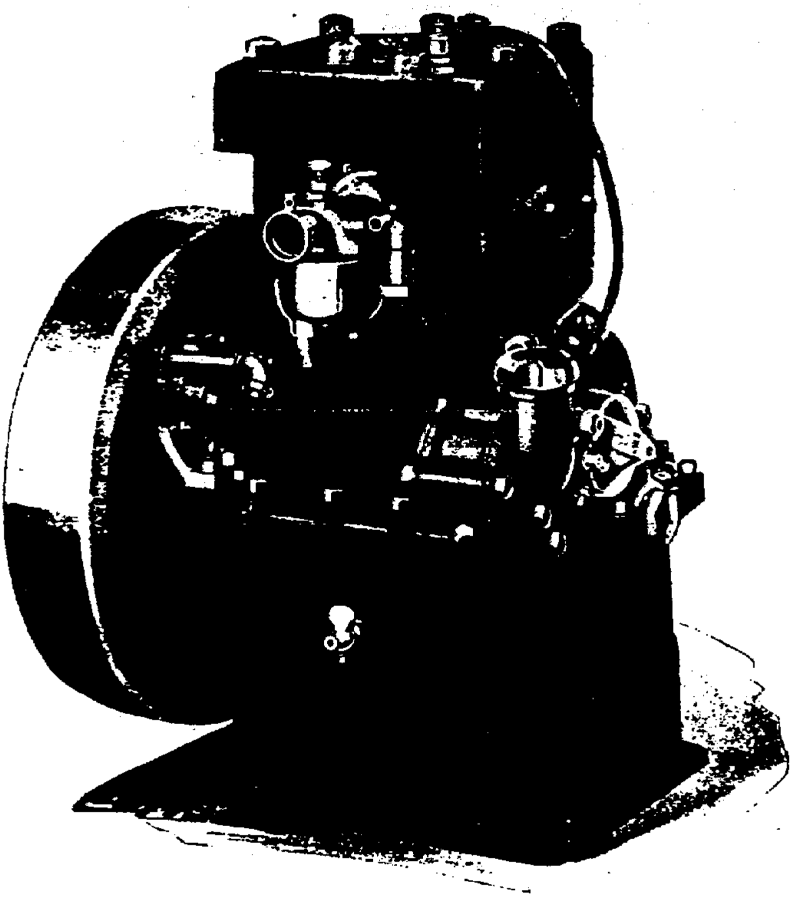
SIX CYLINDER MARINE DIESEL ENGINE

Tugs, fish boats, yachts, cargo vessels and ferries are proving Bessemer Diesel economy. This six-cylinder marine engine can be secured direct reversible if desired.

Ask for Catalogue No. 702.

Range in size from 50 H. P. to 1000 H. P.

AUXILIARY COMBINED STARTING ENGINE AND COMPRESSOR
TYPE "FD"

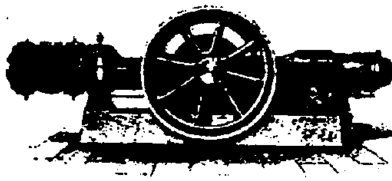


This auxiliary gasoline engine and compressor is composed principally of Ford parts.

It has a displacement of 9.74 cubic feet of free air per minute at 600 R. P. M. and 11.45 cubic feet at 750 R. P. M. This compressor is designed to furnish air at 250 lb. pressure.

For detailed information ask for bulletin No. 703.

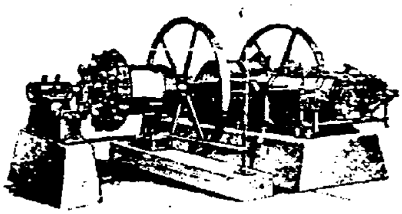
The Bessemer Oil Engine Driven Compressor



Here is a companion to the popular Type VIII and Type 10 Direct Gas Engine Driven Compressors.

It is an oil engine driven compressor—a combination of the Type IV Bessemer Oil Engine and a compressor cylinder capable of operation at engine speed, for Mines, Quarries, Shipbuilding, Construction Work or any Compressed Air Requirement. Ask for Catalogues Nos. 101 and 105.

Bessemer 45 Drilling Engine

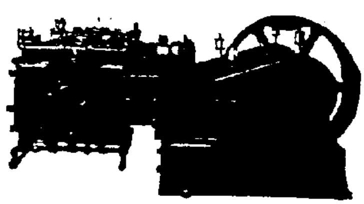


A husky engine, with special drilling clutch, that is rapidly replacing steam outfits. Economical to operate, speedy in drilling and easily transported. 45 H. P. twin. Ask for bulletin "The Bessemer 45."

Literature gladly furnished

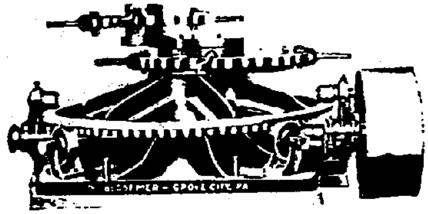
The Bessemer Belted Vacuum Pump

If you need a vacuum pump you need a good one, one that will assure you continuous service without the danger of costly shut-downs.



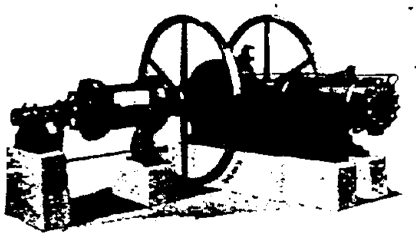
Bessemer Vacuum Pumps actually are better for maintaining a vacuum. They create and maintain vacuum efficiently and continuously. They keep on the job as long as you need them and they require practically no servicing.

The Bessemer Roller Pumping Power



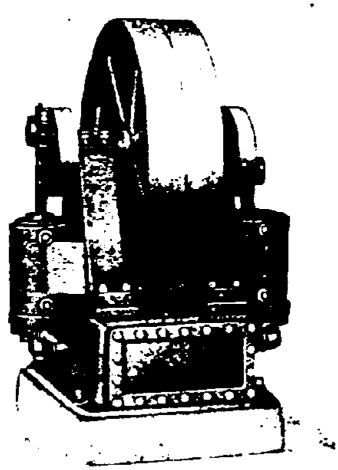
Illustrating the well known Bessemer Roller Pumping Power. This power is built with rollers both on top and bottom of master gear, which aid in its always running perfectly level. It is built in both the single eccentric and in the disk and eccentric types. Ask for Catalog No. 105.

Enclosed Case R. C. Pumping Engine



A sturdy gas engine embodying the many features of the universally well known EC Commercial type Bessemer engine. Equipped with high tension ignition, automatic air starter equipment, S G reverse clutch. A huskier and better engine especially adopted for deep well pumping.

6 x 3¼ x 6 Two-Stage Compressor



A compact, single acting, vertical, two-stage air and gas Compressor capable of handling a volume of 20,000 cubic feet 0 to 250 lbs. each 24 hours. Diameter of tight and loose pulley 30″. Floor space 30″ x 31″. Weight 1420 lbs.

A model Compressor for a gasoline testing plant or for compressing air for starting two or more large engines.

Users of Bessemers agree with the Jury of Awards—
THE BESSEMER *IS* A GOLD MEDAL ENGINE

The Bessemer Gas Engine Company

Grove City, Pennsylvania

Builders of

Bessemer Gas and Oil Engines for Oil Field, Commercial, Electric Light Work, etc.; Bessemer Roller Pumping Powers; Bessemer Gas and Oil Engine Driven Air Compressors; Bessemer Direct Driven Pumps; Bessemer Marine Oil Engines

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Ponca City, Okla.	**Sacramento St., Los Angeles, Cal.**	**Shreveport, La.**
	Gloucester, Mass.	

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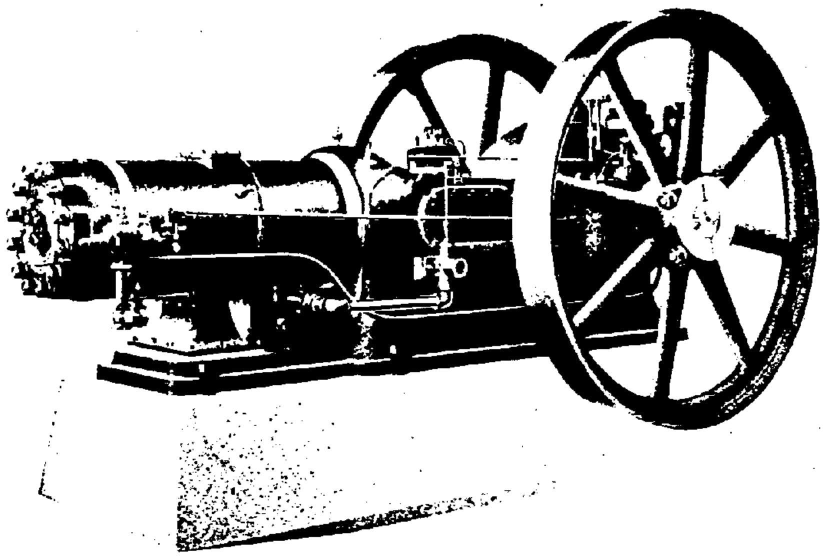
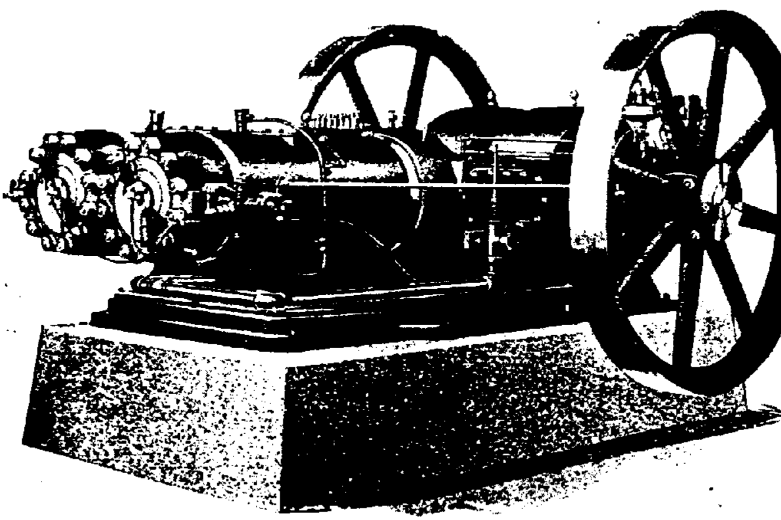
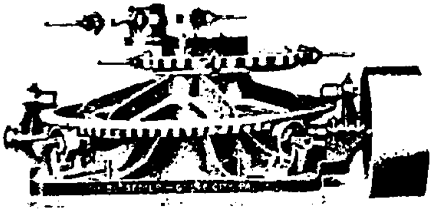
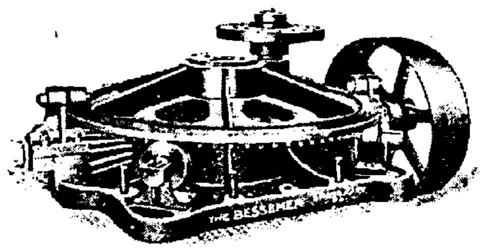


Single Cylinder Bessemer Gas Engine
Enclosed Crank Case Type

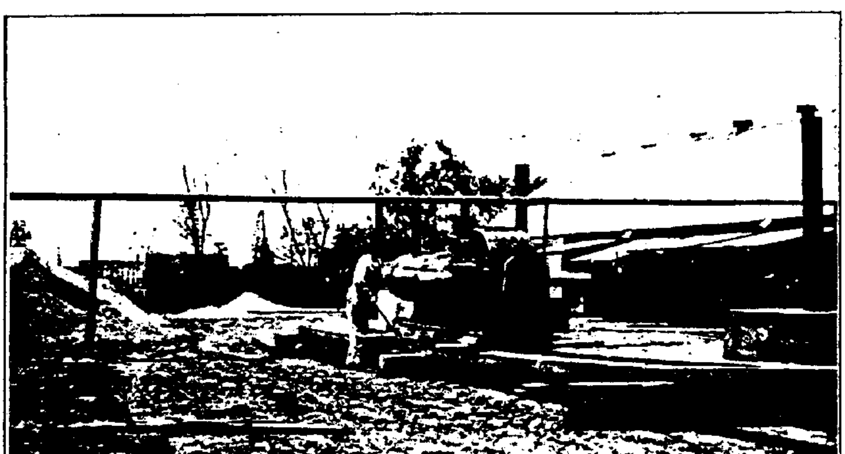


Twin Cylinder Bessemer Gas Engine
Enclosed Crank Case Type Sizes to 165 Horse Power





Bessemer Roller Pumping Powers



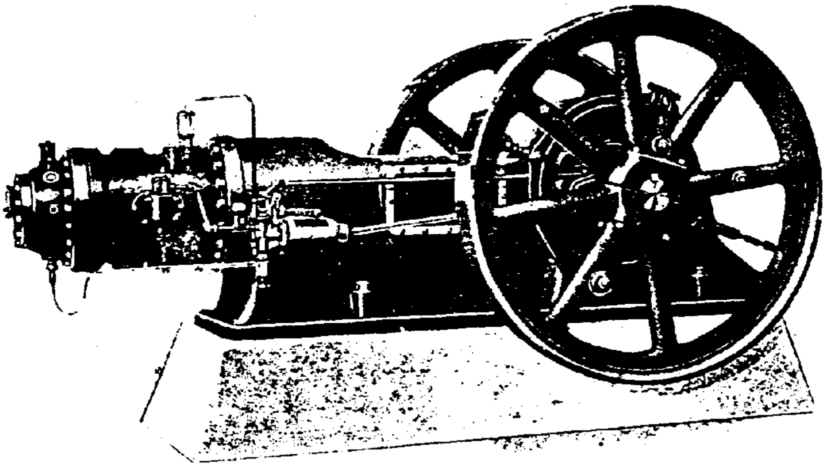
ANOTHER BESSEMER ARRIVING TO INCREASE THE CAPACITY OF A COSDEN PLANT

Dimension Sheet for Bessemer Gas Engines.

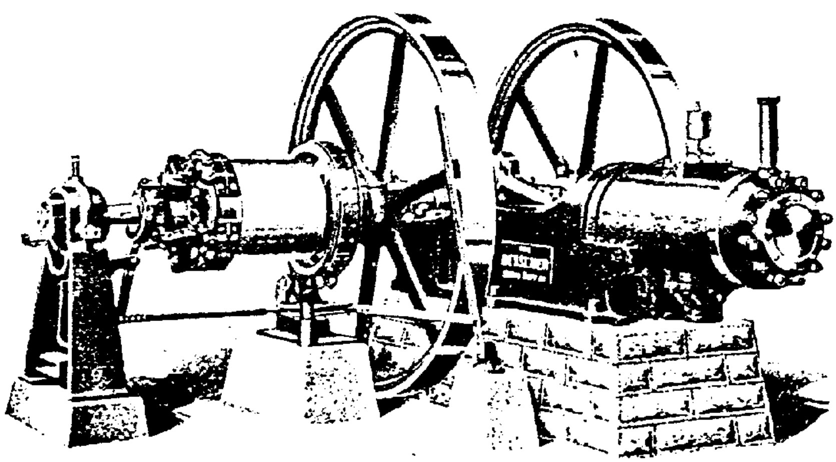
NOTE—The diameter and face of fly wheels are made to suit the various requirements. The shipping weight of engines as given is only approximate.

Type of Engine	Horse Power	Diameter of Cylinder	Stroke of Engine	Speed of Engine	Cross-head Bearing Shoe Surface, lower side	Diameter of Cross-head Wrist Pin	Length of Cross-head Wrist Pin	Diameter of Main Shaft Bearing	Length of Main Shaft Bearing	Diameter of Crank Pin	Length of Crank Pin
Open Case Single Cylinder	2½	4	5	400	13½	1¼	1½	1¾	3½	2	2
	5	5½	7	300	22	1½	2	2½	4¾	2½	2
	8	6½	9	250	40	2¼	2½	3¼	6¼	3¼	2¾
	10	7½	10	225	47½	2½	2¾	3½	6¾	3¾	3¼
	12½	7½	12	200	45	2¾	3	4	8¼	4	4
	15	8½	15	190	60	3	3	4	9	4¼	4
	20	9½	15	180	60	3	3	4	9	4¼	4
	22½	10	15	180	60	3	3	4	9	4½	4
	25	10½	16	180	60	3½	3½	4½	10½	5	4
	30	11½	16	180	70	3½	3½	5	11¼	5½	4½
	35	12	16	180	70	3½	3½	5	11¼	5½	4½
Enclosed Case Single Cylinder	15	8½	15	190	66	3	3	4½	9¾	4½	4
	20	9½	15	180	66	3	3	4½	9¾	4½	4
	25	10½	16	180	87	3½	3¼	5	9¾	5¼	4½
	30	11½	16	180	87	3½	3¼	5	9¾	5¼	4½
	35	12	16	180	87	3½	3¼	5	9¾	5¼	4½
	40	12	18	180	104	4½	5	6	10¾	6¼	5¼
	50	13½	18	180	104	4½	5	6½	11¾	6¼	5¼
	60	13½	20	180	104	4½	5	7	12¼	7	5¼
	70	14½	20	180	104	4½	5	7	12¼	7	5¼
	80	16	20	180	104	4½	5	7	12¼	7	5¼
	100	18	20	180	104	4½	5	7	12¼	7	5½
Enclosed Case Twin Cylinder	35	8½	15	190	66	3	3	4½	9¾	4½	4
	45	9½	15	180	66	3	3	4½	9¾	4½	4
	55	10½	16	180	87	3½	3¼	5	9¾	5¼	4½
	65	11½	16	180	87	3½	3¼	5	9¾	5¼	4½
	75	12	16	180	87	3½	3¼	5	10¾	5¼	4½
	85	12	18	180	104	4½	5	6	10¾	6¼	5½
	110	13½	18	180	104	4½	5	6½	11¾	6¼	5½
	125	13½	20	180	104	4½	5	7	12¼	7	5½
	150	14½	20	180	104	4½	5	7	12¼	7	5½
	165	16	20	180	104	4½	5	7	12¼	7	5½
						[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

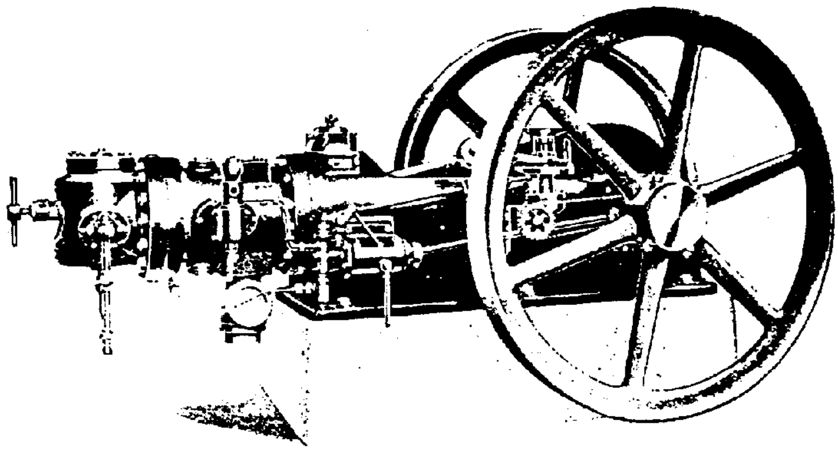
Type of Engine	Horse Power	Length of Piston Head	Diameter of Exhaust Pipe	Diameter of Air Pipe	Diameter of Gas Pipe	Diameter of Water Inlet	Diameter of Water Outlet	Diameter of Fly Wheel	Width of Face of Fly Wheel	Weight of Fly Wheel	Floor Space required for Engine	Approximate Shipping Weight of Engine	Cubic feet of Masonry in Foundation
Open Case Single Cylinder	2½	5½	1¼	1	[illegible]	[illegible]	[illegible]	24	3	143	35x43	550	11
	5	7	2	1½	[illegible]	[illegible]	[illegible]	36	3¼	250	40x60	1050	28
	8	9	2¼	2	[illegible]	[illegible]	[illegible]	44	3½	371	48x75	1900	48
	10	10½	2½	2	[illegible]	[illegible]	[illegible]	52	3½	460	54x94	2500	70
	12½	12¼	3	2	[illegible]	1	1	56	3½	640	58x101	3250	109
	15	15¼	4	2	[illegible]	1	1	68	4½	865	66x118	4450	131
	20	15¼	4	3	1	1	1	70	4½	1000	67x124	5300	139
	22½	15¼	4	3	1	1	1	70	4½	1000	67x124	5400	139
	25	16¼	4	3	1	1	1	72	5½	1350	71x127	6070	155
	30	16¼	4	3	1	1	1	74	6	1550	76x129	7500	188
	35	16½	4	3	1	1	1	74	6	1550	76x129	8000	188
Enclosed Case Single Cylinder	15	15¼	4	3	¾	1	1	68	6¼	1250	70x116	6200	153
	20	15¼	4	3½	1	1	1	68	6¼	1400	70x116	6800	153
	25	16¼	6	4	1	1	1	70	5½	1600	73x129	7800	198
	30	16¼	6	4	1	1	1	70	6	2100	73x129	8700	198
	35	16¼	6	4	1	1	1	70	6	2100	73x129	8900	198
	40	18¼	6	4	1¼	1	1	76	8	2450	84x133	11600	245
	50	18¼	8	5	1¼	1¼	1	76	8	2450	81x191	13800	322
	60	20¼	8	5	1¼	1¼	1	86	8	2600	94x159	14900	358
	70	20¼	8	5	1¼	1¼	1	96	8	2500	98x160	15000	380
	80	20½	8	5	1½	1¼	1	96	8	2500	98x160	15400	380
	100	20½	8	5	1½	1¼	1¼	96	8	2570	98x160	16000	380
Enclosed Case Twin Cylinder	35	15¼	4	3	¾	1	1	68	7	1250	104x116	10000	253
	45	15¼	4	3½	1	1	1	70	7	1400	104x116	10100	253
	55	16¼	6	4	1	1	1	70	7	1625	113x122	14000	339
	65	16¼	6	4	1	1	1	70	8	2100	113x122	14500	339
	75	16¼	6	4	1	1	1	76	8	2450	126x130	18200	512
	85	18½	6	4	1¼	1	1	76	8	2450	126x140	19500	517
	110	18½	8	5	1¼	1¼	1	76	8	2450	128x141	21000	529
	125	20½	8	5	1¼	1¼	1	76	8	2600	133x148	23650	587
	150	20½	8	5	1½	1¼	1	76	8	2600	139x148	28000	595
	165	20½	8	5	1½	1¼	1	80	10	5000	143x153	32200	626
		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	98	10	5200	143x153	34000	626



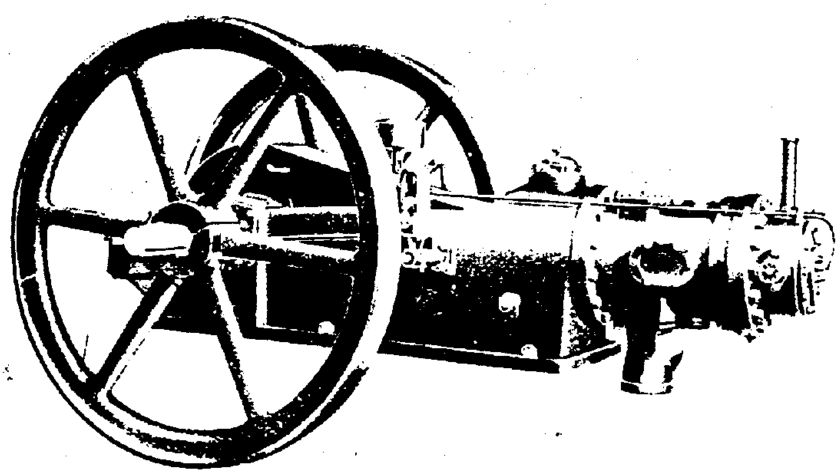
Type IV Bessemer Oil Engine—Single Cylinder



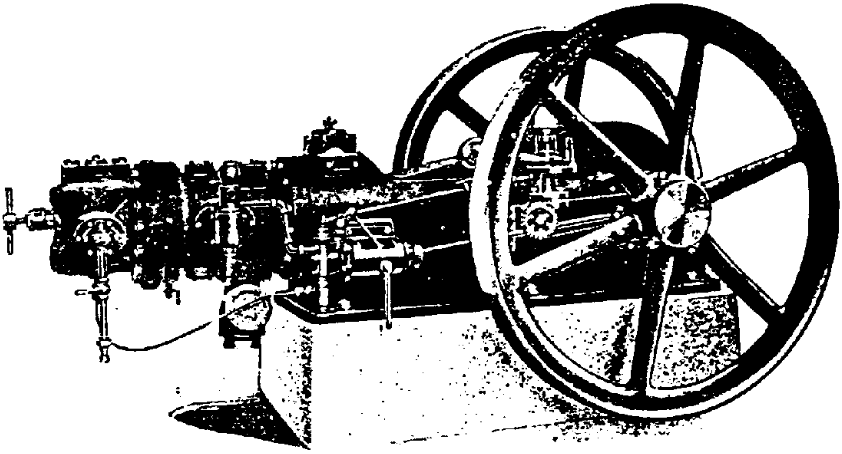
The BESSEMER Oil Field ENGINE



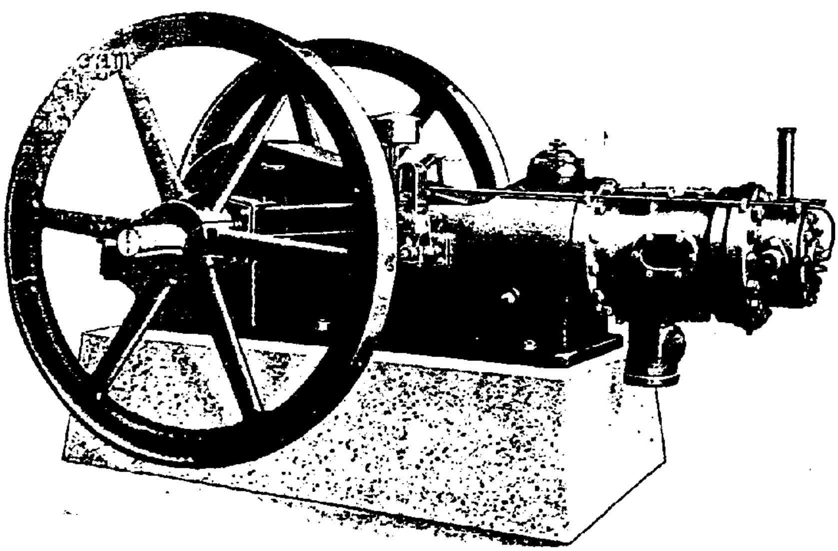
The Type OD Bessemer Oil Engine



The Type OD Engine Equipped to Use Natural Gas

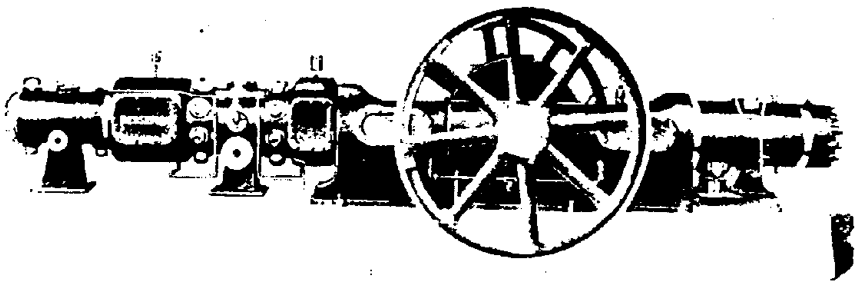


The Type OD Bessemer Oil Engine

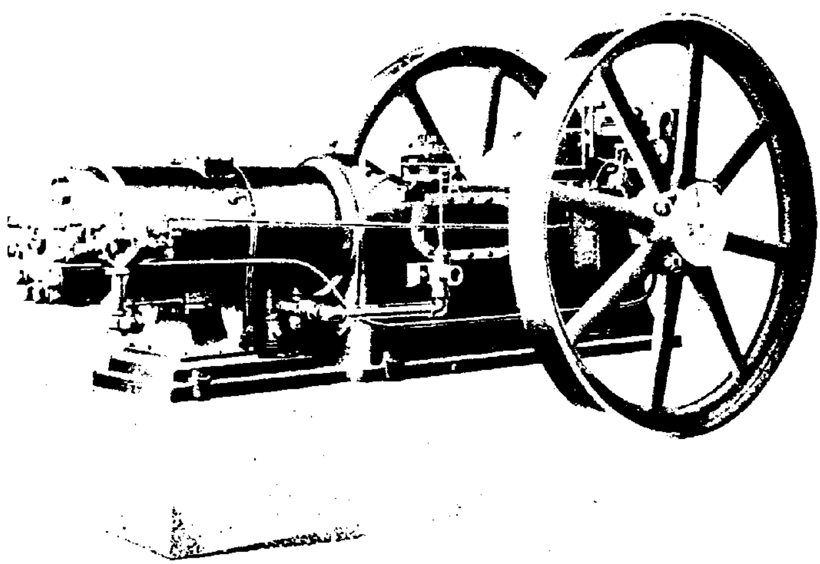


The Type OD Engine Equipped to Use Natural Gas

Ask for Special OD Catalogue



THE BESSEMER TYPE NINE DIRECT GAS ENGINE DRIVEN
TWO STAGE COMPRESSOR



BESSEMER GAS ENGINE, SINGLE CYLINDER ENCLOSED CRANK CASE

DONT'S

Don't lose patience if the engine doesn't start at the first attempt.

Don t merely read these instructions. Study them and learn them by heart, if possible, and then follow them.

Don't run the engine without lubricating oil.

Don't try to run the engine on weak batteries.

Don't forget to fill tl fuel +

Don't fail to strain your fuel.

Don't use anything but the very best gas engine oil.

Don't forget to drain the cylinder water jacket in cold weather unless you have an anti-freezing solution in the tank.

Don't advance the spark lever too far beyond a vertical position.

Don't expect to get good results on a poor or shaky foundation.

Don't run the engine if it is pounding or knocking. Find and remedy the trouble.

Don't screw the spark plug in too tight. Just enough to prevent leaking You may want to take it out again.

Don't put your wrench on the upper part of the spark plug. This may change the adjustment of point or break the plug.

Don't think it is a waste of time to clean the engine occasionally or to give it a little attention.

Don't forget that too much fuel is as bad as not enough.

Don't forget that if you keep your engine clean, firmly belted down to a good foundation---well lubricated ---and supplied with good strong batteries or magneto you will have the most obedient, serviceable, and uncomplaining mechanical servant that has ever been devised.

Don't fail to write us fully, if, after following these instructions carefully you are still unable to get your engine to run satisfactorily.