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A MANUAL OF INSTRUCTIONS

THE BESSEMER GAS ENGINE

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

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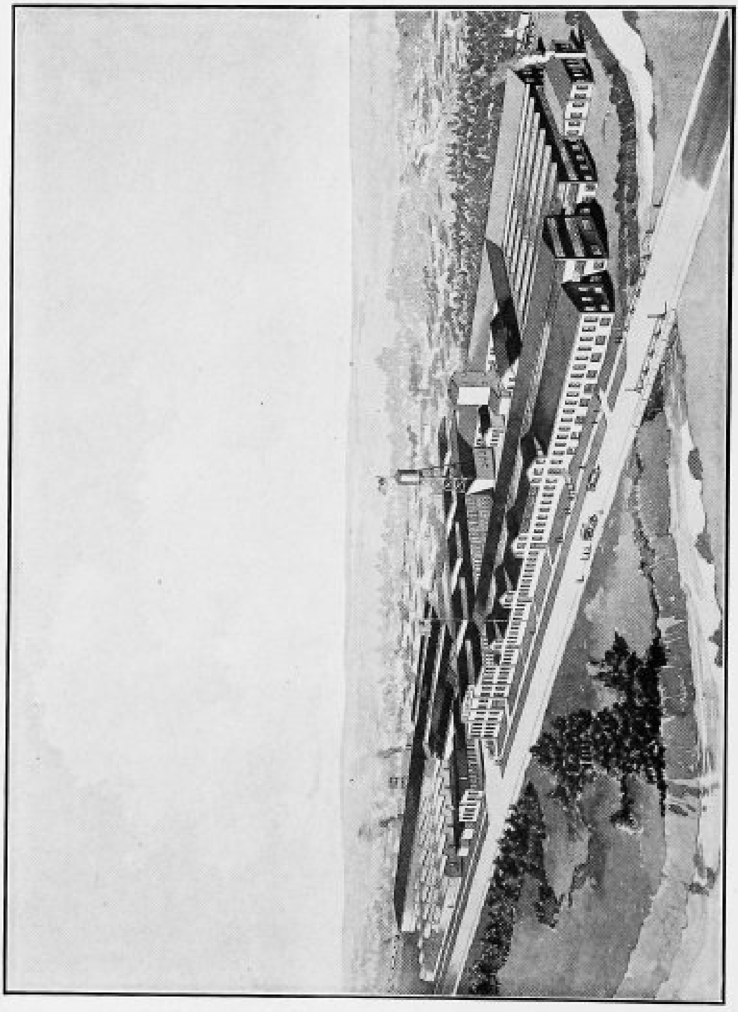
A MANUAL ON THE CARE AND OPERATION OF THE BESSEMER GAS ENGINE

THE BESSEMER GAS ENGINE CO.
GROVE CITY, PENNSYLVANIA



Home Office and Factory of The Bessemer Gas Engine Co., at Grove City, Pa., U. S. A.

INTRODUCTION

WHILE it has been our object during the last twenty 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, complete freedom from trouble can come only through a thorough understanding of the machine and the proper care of its various parts.

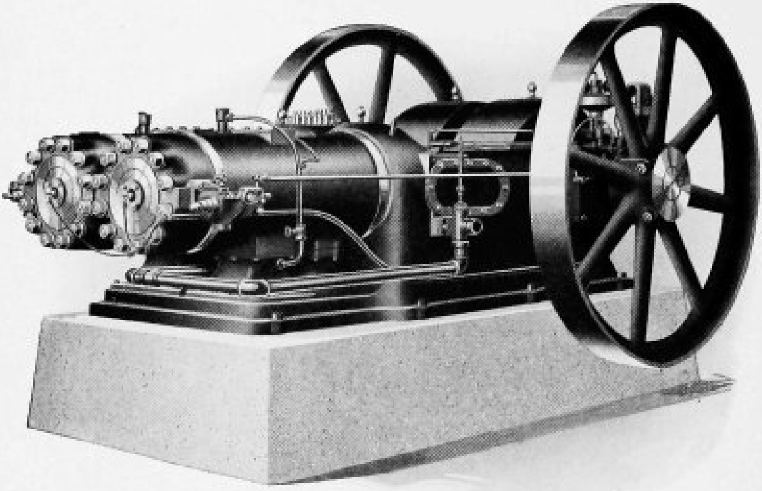
It must be remembered that a gas engine, like all machinery, will not work properly if misused, so it is important that the handling and care of same be understood if satisfaction is to be assured.

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.

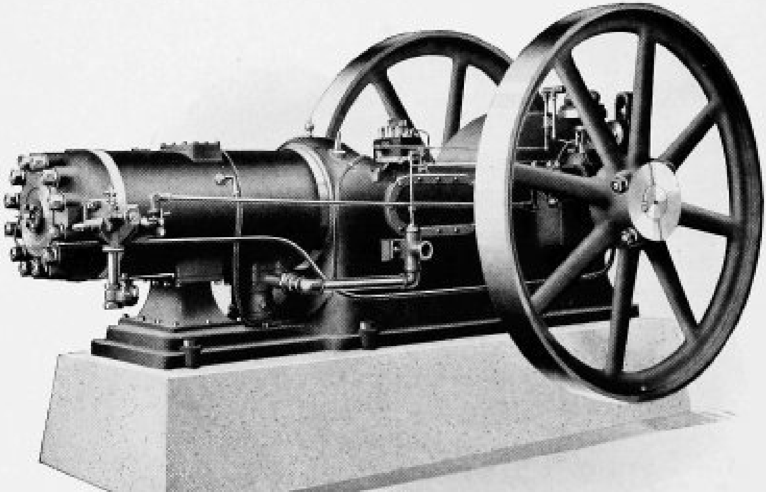
At all times the Bessemer Gas Engine Company stands ready to furnish you with information, advice and assistance, so please feel free to write, asking for any information on our machinery you may desire.

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



SINGLE CYLINDER ENCLOSED CASE

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 sufficient 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 extending 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

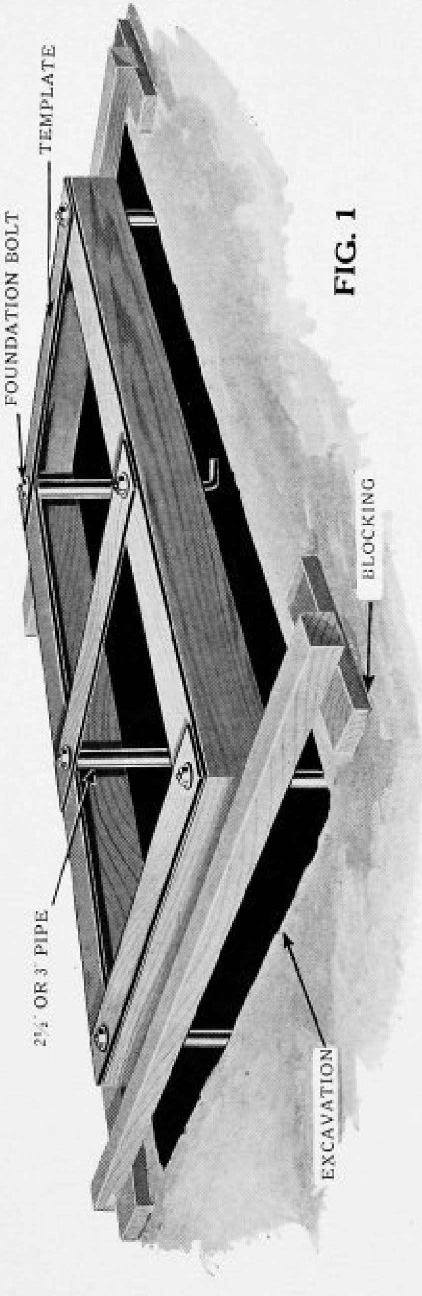


FIG. 1

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 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.

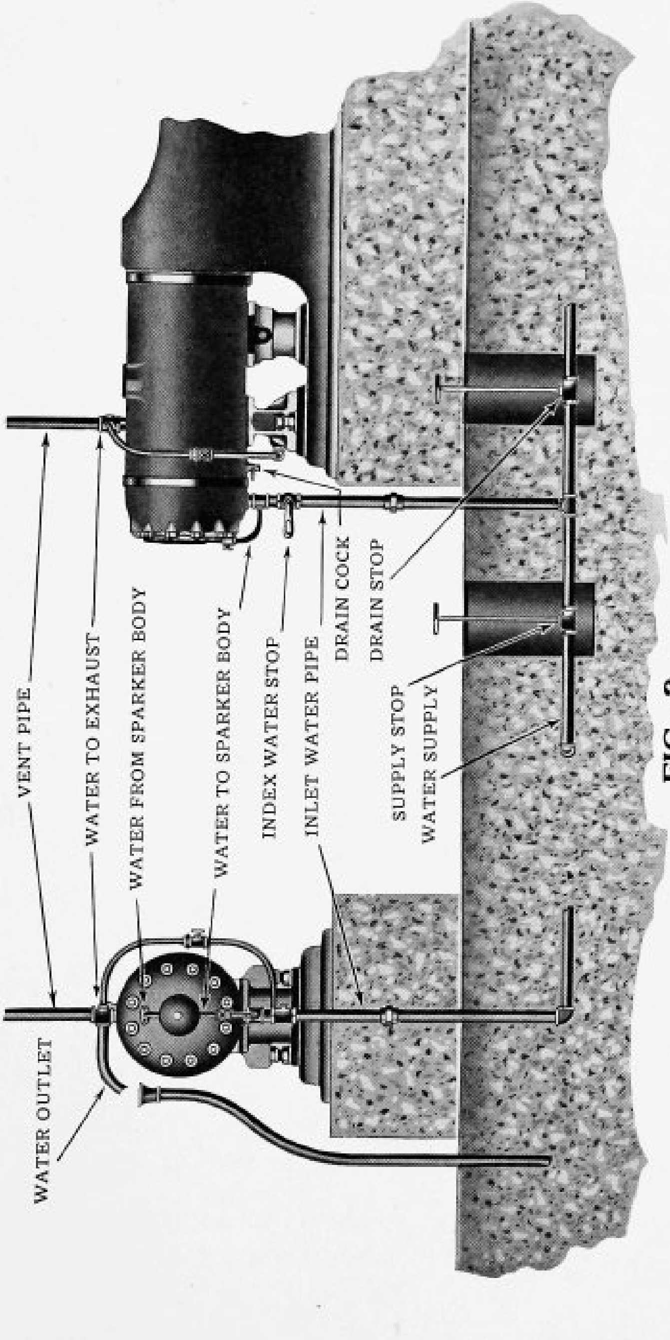

VENT PIPE
WATER TO EXHAUST
WATER FROM SPARKER BODY
WATER TO SPARKER BODY
INDEX WATER STOP
INLET WATER PIPE
DRAIN COCK
DRAIN STOP
SUPPLY STOP
WATER SUPPLY
WATER OUTLET

FIG. 2

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.

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.

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

FIG. 4

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.

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 flywheels be placed opposite to the crank pin—see Fig. 4. It is not strictly essential that the counter-

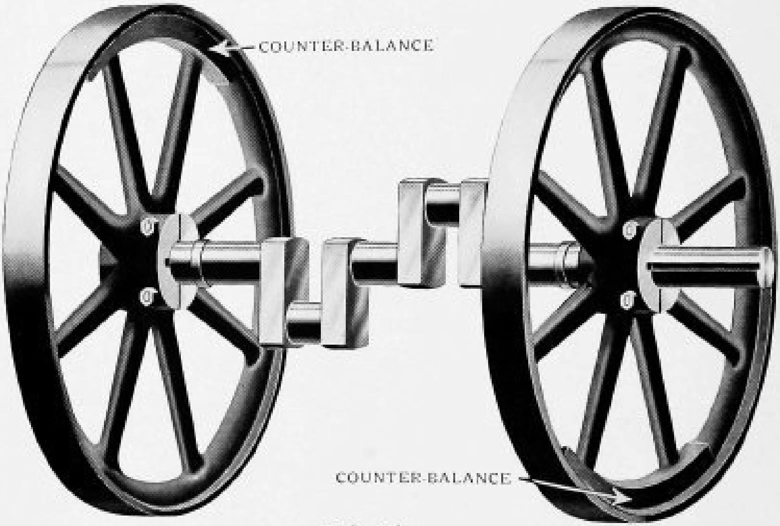


FIG. 5

balance 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 counterbalance 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 Figs. 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

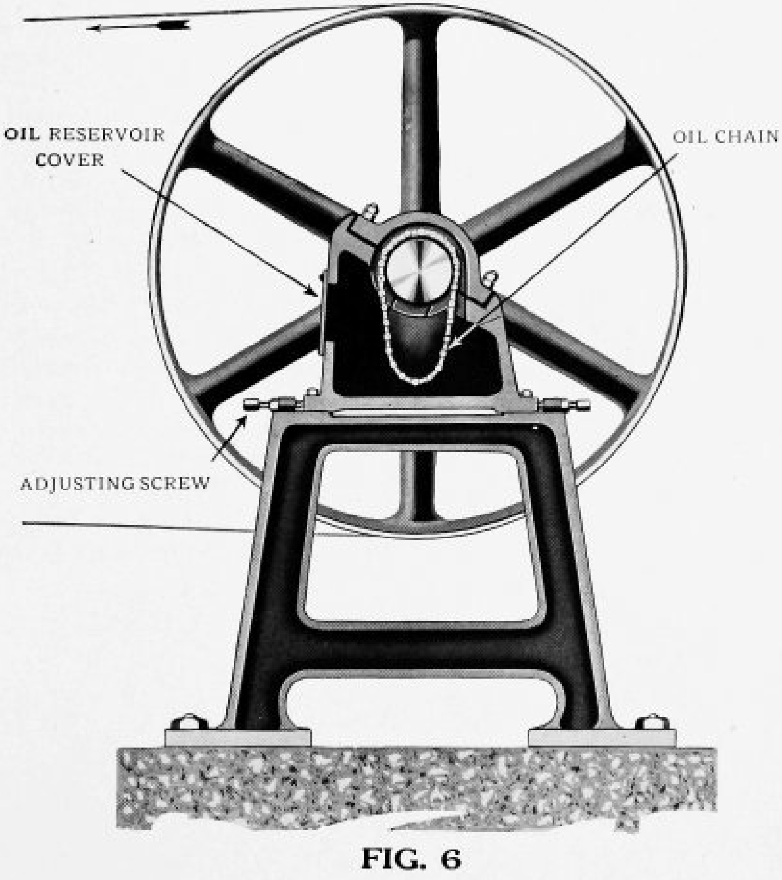


FIG. 6

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 gets its power through the burning of gas and air in proper proportion, and for a given size engine, a definite amount of gas is required, depending on its heating value, rated H. P. of engine, and the B. H. P. load. To get absolute satisfaction, then, it is absolutely necessary to adhere strictly to the following specifications:

In general, the gas system consists of a regulator, meter, gasometer and a gas reservoir, the gas being piped from the reservoir to the governor and thence to the mixing valve on the engine.

Regulator

A low pressure regulator should be placed in the piping system so that the gas supply to the meter will be at the required constant pressure, which may vary from 6 to 10 ounces. Of course, a higher pressure may be used, but it is accompanied by greater care in starting on account of the added danger of choking the engine by giving it too much gas. Both regulator and meter are usually furnished by gas companies under contract.

Gasometer

The volumetric displacement of the gasometer through the action of the diaphragm maintains constant gas pressure in the reservoir during the charging stroke of the piston. Without the gasometer, the fluctuations of gas pressure in the system would be such that reliable meter reading would be impossible unless the meter is placed at considerable distance from the engine.

Locate the gasometer as close to the reservoir as possible, and the meter as far from the gasometer as possible, for the best results.

It will be noticed that there is a breathing hole in the top of the gasometer in order to maintain atmospheric pressure on the upper side of the diaphragm. This hole is tapped for 3/8-inch pipe and should be piped to the outside of the building thus allowing the gas to escape to the outside instead of the inside of the building, should the diaphragm become defective.

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.

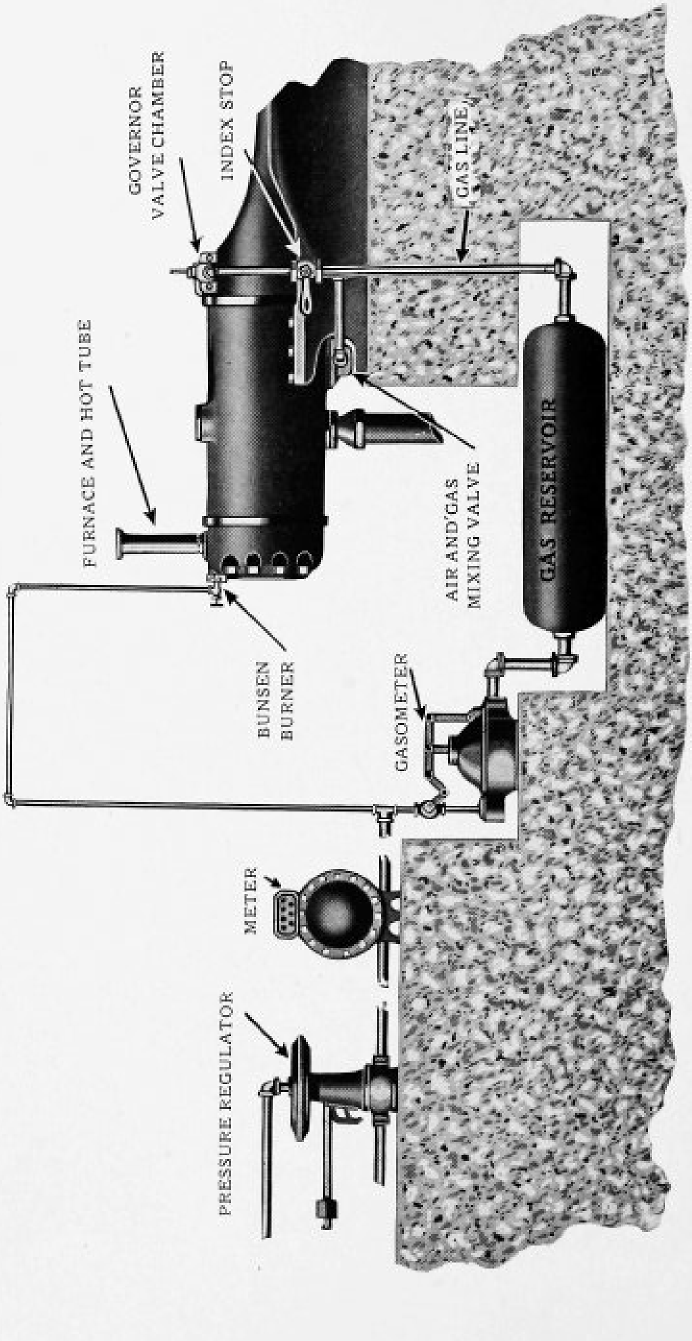

GOVERNOR VALVE CHAMBER
INDEX STOP
GAS LINE
FURNACE AND HOT TUBE
AIR AND GAS MIXING VALVE
GAS RESERVOIR
BUNSEN BURNER
GASOMETER
METER
PRESSURE REGULATOR

FIG. 7

Gas Pipe

For general system of piping, refer to Fig. 7 which shows the relationship that the regulator, meter, gasometer, 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 gasometer and the reservoir is greater than ten feet, a larger size pipe should be used than corresponds to the tap size in the gasometer, and the size line leading to the gasometer will depend upon its length, also the line required to reach the main, or the low pressure regulator. 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 $\frac{3}{16}$-inch lift guarantees reliable spring service.

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

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	3/4"	3/4"	3/4"	1"	1"	1"	1"	1 1/4"	1 1/4"	1 1/4"	1 1/2"	1 1/2"
10	3/4"	1"	1"	1 1/4"	1 1/4"	1 1/4"	1 1/2"	1 1/2"	1 1/2"	2"	2"	2"
15	1"	1"	1 1/4"	1 1/4"	1 1/2"	1 1/2"	1 1/2"	2"	2"	2"	2"	2 1/2"
20	1"	1 1/4"	1 1/4"	1 1/2"	1 1/2"	2"	2"	2"	2"	2 1/2"	2 1/2"	2 1/2"
25	1 1/4"	1 1/4"	1 1/2"	2"	2"	2"	2"	2"	2 1/2"	2 1/2"	2 1/2"	2 1/2"
30	1 1/4"	1 1/4"	1 1/2"	2"	2"	2"	2"	2 1/2"	2 1/2"	2 1/2"	3"	3"
35	1 1/4"	1 1/2"	2"	2"	2"	2"	2 1/2"	2 1/2"	2 1/2"	3"	3"	3"
40	1 1/4"	1 1/2"	2"	2"	2"	2 1/2"	2 1/2"	2 1/2"	3"	3"	3"	4"
50	1 1/2"	2"	2"	2"	2 1/2"	2 1/2"	2 1/2"	3"	3"	3"	4"	4"
60	1 1/2"	2"	2"	2 1/2"	2 1/2"	2 1/2"	3"	3"	3"	4"	4"	4"
70	1 1/2"	2"	2 1/2"	2 1/2"	2 1/2"	3"	3"	3"	4"	4"	4"	4"
80	2"	2"	2 1/2"	2 1/2"	3"	3"	3"	4"	4"	4"	4"	4"
110	2"	2 1/2"	2 1/2"	3"	3"	4"	4"	4"	4"	5	5	5
125	2"	2 1/2"	2 1/2"	3"	4"	4"	4"	4"	4"	5	5	5
150	2 1/2"	2 1/2"	3"	4"	4"	4"	4"	4"	5	5	5	6
165	2 1/2"	2 1/2"	3"	4"	4"	4"	4"	5"	5"	5"	6	6

TABLE. 8

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.

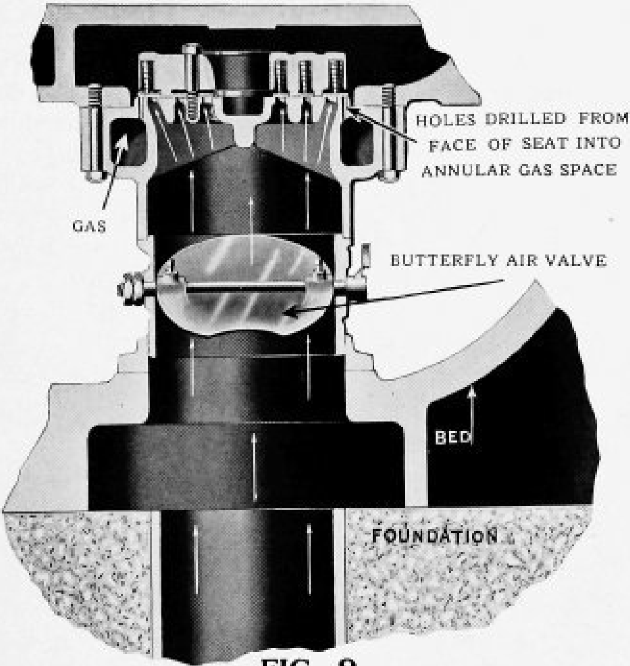


FIG. 9

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

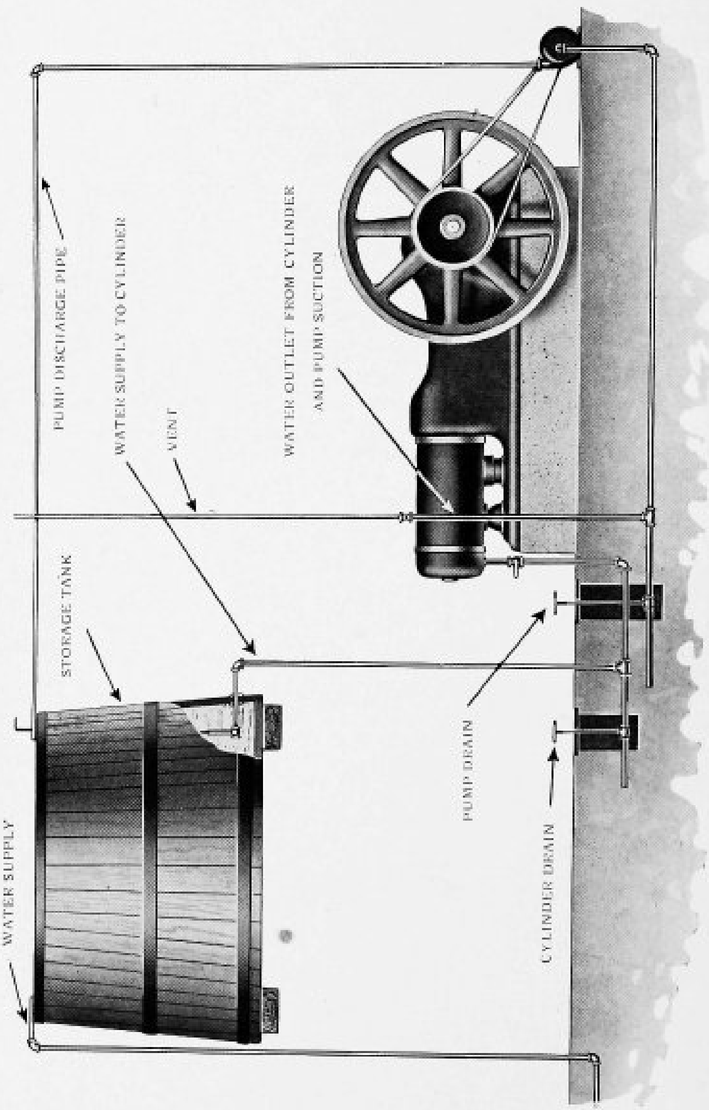
Experience has shown that approximately one-third of the total heat supplied per B. H. P. is lost in the external cooling medium and with an assumption that the average H. P. engine requires 13,500 B. T. U. per H. P. hour, it will be seen that the cooling medium must be able to carry off approximately 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 9 gal. per B. H. P. hour, especially for large size engines. To be on the safe side when designing the water system, figure 10 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.

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



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

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 installation 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

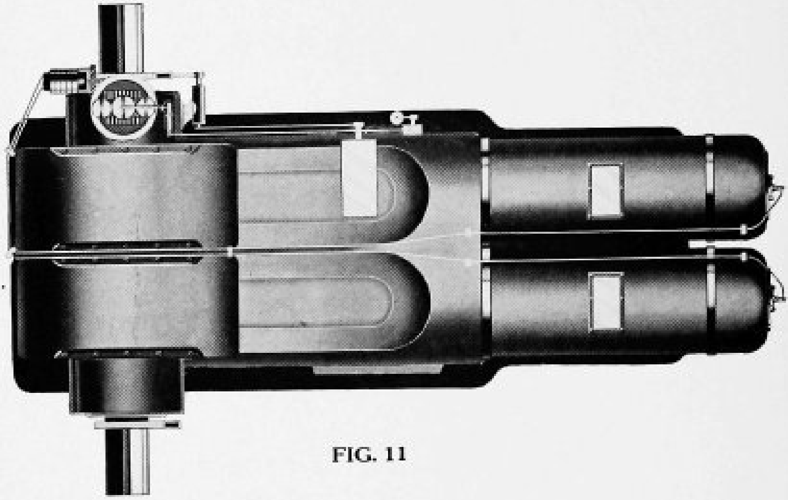


FIG. 11

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.

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 maximum 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 connecting 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 O, OC and S. E. 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 $\frac{9}{16}$ 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.

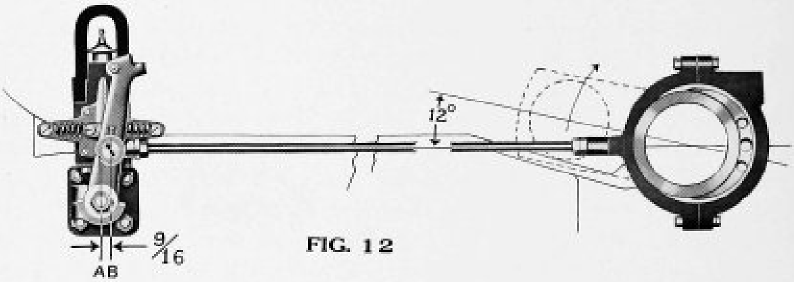


FIG. 12

Impulse Starter

Impulse Starters are supplied with Type H. T. K. W. 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 normal 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 $\frac{1}{64}$-inch, the gauge 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

Hot Tube Igniters are made from either nickel alloy or wrought iron, having an inside diameter of from $\frac{5}{16}$-inch to $\frac{3}{8}$-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.

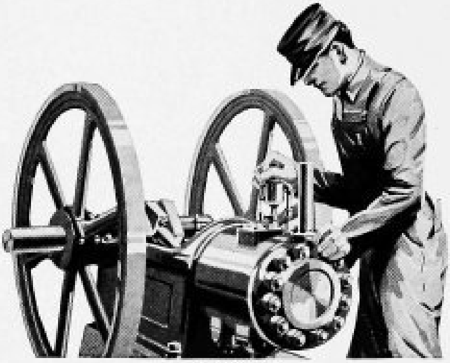


FIG. 13

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.

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

FIG. 14

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.

Lubricating System

General Principles

The Bessemer Type E. C. and E. C. T. gas engines 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 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 one 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.

Lubricants

It pays in the long run to use the best quality of lubricants. Money saved in buying cheap oils or grease will be lost in worn cylinders and bearings. There are many good cylinder oils on the market with varying specifications. Some, of course, are better suited for Bessemer Gas Engines than others. We do not, however, lay down any rigid specifications as to the physical or chemical characteristics other than it must be free from animal or vegetable oils, acids or alkalies, and show no gumming after being heated to 250° F. for one hour and allowed to cool slowly. The flash, fire, viscosity, cold and residue tests are all important, and if you are buying other than Bessemer Gas Engine oil you should consult a lubricating engineer as to whether or not the particular oil you contemplate using is suitable for Bessemer Gas Engines.

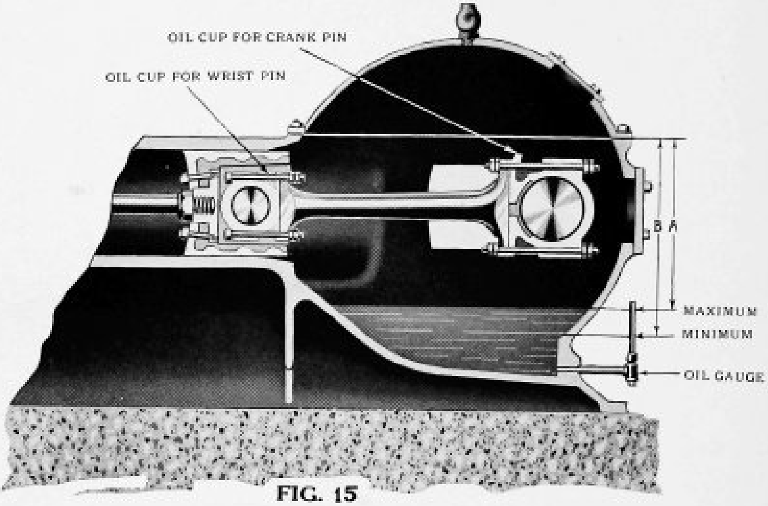


FIG. 15

Bessemer Crank Case Oil is also specially compounded to suit the Bessemer Gas Engine requirements, and to buy oils labeled Bessemer would only be taking advantage of our knowledge gained through our oil chemist and years of experience.

Splash System

The splash system lubricates all bearings inside of the bed and is accomplished by maintaining a proper oil level so that the crank and connecting rod will strike the oil every revolution—see Fig. 15—thus throwing the oil in all directions. Bearing caps have a basin which catches the oil—from there it runs to the shaft through suitable oil holes. The crank and pin bearings have large cups with suitable oil holes into which oil is splashed. The crosshead shoes run in a bath of oil at all times and just the proper amount of oil reaches the piston rod to insure perfect lubrication, guaranteeing maximum life to it as well as to the packing.

Suitable Oil Level in Crank Case for Various Size E. C. Engines and E. C. Twin Engines. Table 17.

SINGLE CYLINDER			TWIN CYLINDER		
H. P.	A.	B.	H. P.	A.	B.
15	14 3/4	15 1/2	65	17 1/2	18 1/4
20	14 3/4	15 1/2	75	20	20 3/4
25	17 1/2	18 1/4	85	20	20 3/4
30	17 1/2	18 1/4	110	20	20 3/4
35	17 1/2	18 1/4	125	21 1/4	22
40	20	20 3/4	150	21 1/4	22
50	20	20 3/4	165	21 1/4	22
60	21 1/4	22			
70	21 1/4	22			
80	21 1/4	22			

The oil level should correspond to measurements *A* and *B* in the preceding table, *A* being the maximum allowable amount of oil for best oil economy, and *B* the minimum level that will guarantee perfect lubrication.

While it will do no harm to allow the oil level to be higher than measurement *A*, and in some cases the amount of oil used will not be any more, in other cases it may happen that the splash will be so violent that excess waste may occur.

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 gauge 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 18, 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 18, 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 will require double the amount of oil required for the single cylinder engine.

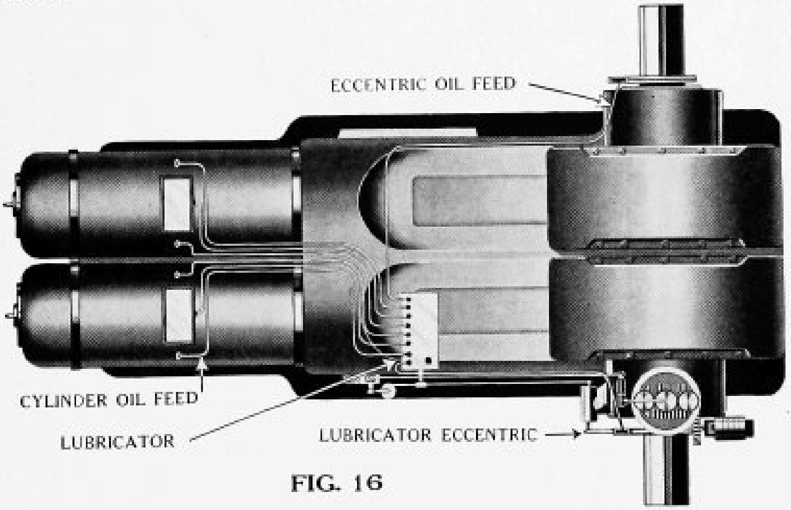


FIG. 16

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

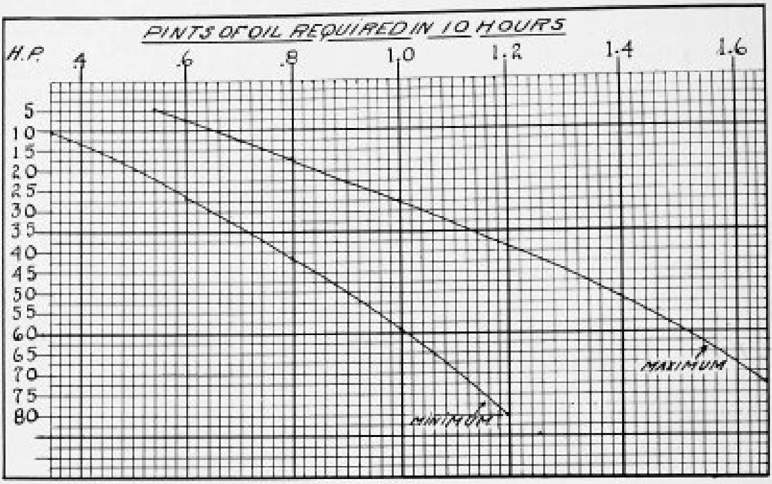


CHART 18.

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.

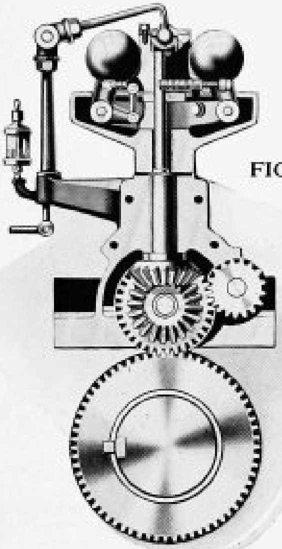


FIG. 19

Operation of Centrifugal Governor

The general construction of the Bessemer Gear Driven Centrifugal Governor will be easily understood from studying Figures 19 and 20.

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 possible tendency, our standard speed change runs between 3 and 4%, 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%—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. 19 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.

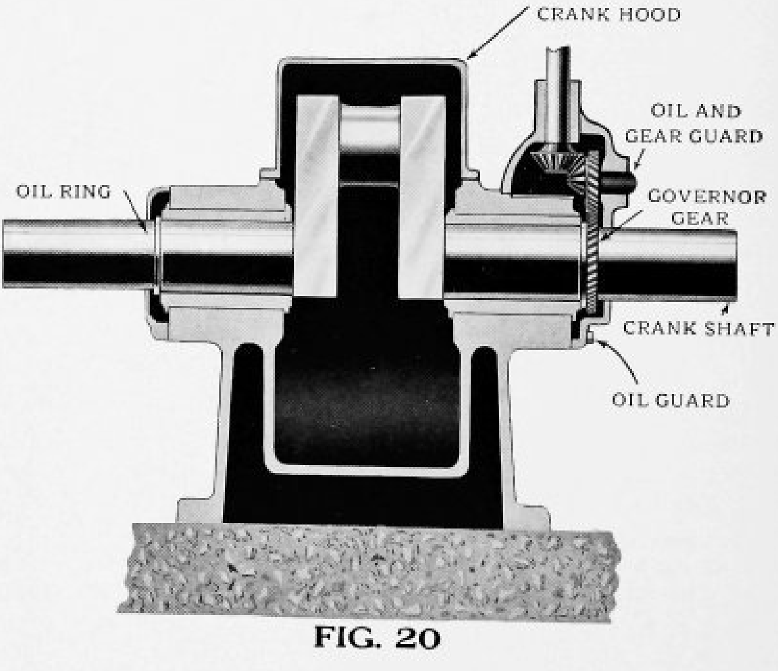


FIG. 20

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.

Hit and Miss Governor

As the Hit and Miss governor controls the speed of the engine through the valve covering the transfer ports during the period of time that the piston uncovers them, it is important that when the speed of the engine drops to a certain point, that the valve over the ports opens them, so that another charge of air and gas may be transferred into the combustion chamber when the piston uncovers the ports. The construction of this governor is reverse to the usual practice in that the governor disengages with the pick blade when the speed exceeds a certain point instead of the usual way of engaging the pick blade to diminish the speed. With this method there is positively no danger of the engine running away. Should anything go wrong with the governor, the spring will return rock arm and hold valve over ports, shutting down the engine.

To fit governor, place crank on forward dead center position, so that the piston completely uncovers transfer ports, then place eccentric on opposite dead center position so that when the pick blade is engaged the valve uncovers the ports. When the engine is turned over on the opposite dead center position, see that there is from $\frac{1}{8}$ to $\frac{3}{16}$-inch clearance between dog and pick blade, so that the inertia of weight will be sure to draw the pick blade down out of line with dog as the speed increases. Fig. 21 shows a general arrangement of governor which is easily understood. When once in position the only adjustment is the speed control thumb nuts *C*. By tightening the spring the speed of the engine will increase, and by loosening—decrease.

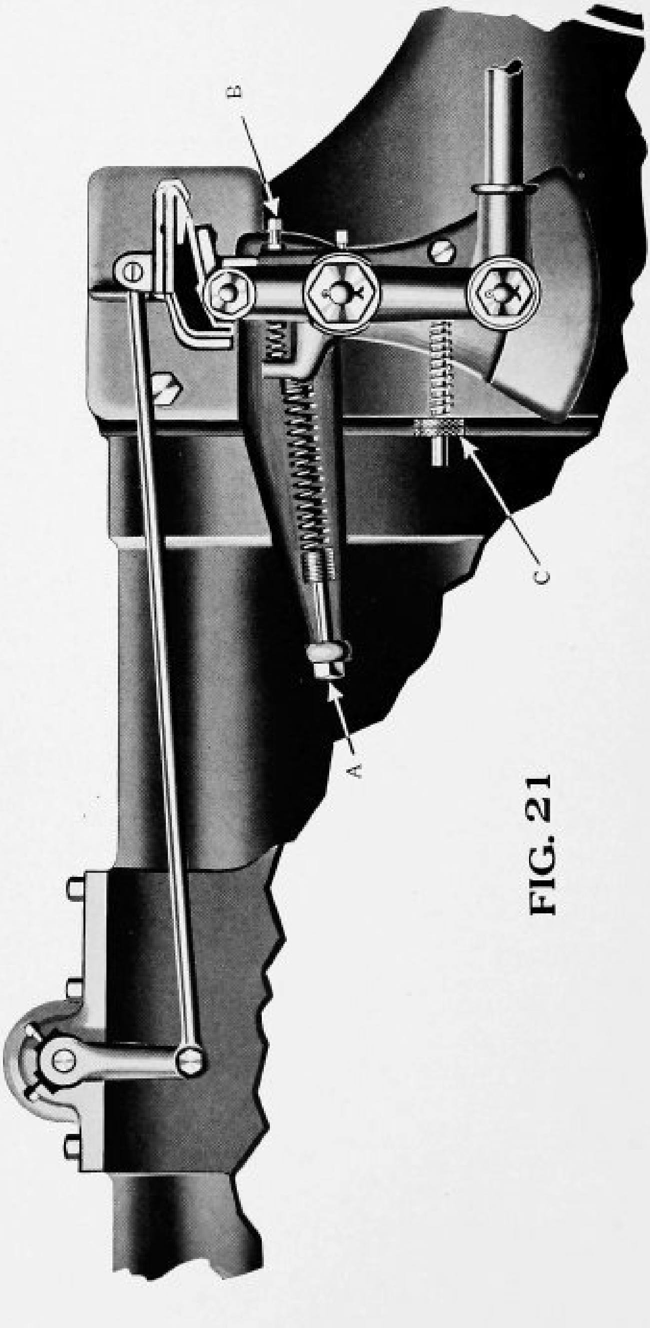


FIG. 21

The set screw *B*, adjusts the relative position of the pick blade to the dog and when once adjusted so that the blade completely engages with the dog while the governor is at rest needs no further adjustment.

The spring just opposite this set screw which holds the pick blade arm against said set screw, absorbs the differential motion between the weight and the pick blade arm when the inertia causes the weight to be out of synchronism with the arm which carries the pick blade.

The spring whose tension is controlled by the adjusting screw *A*, holds the dog tight against the pick blade while they are engaged, and, when not engaged, holds the arm back so that the governor valve closes the transfer ports during the time that the piston uncovers them.

Air Starting System for Type E. C. and E. C. T. 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. 22, 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.

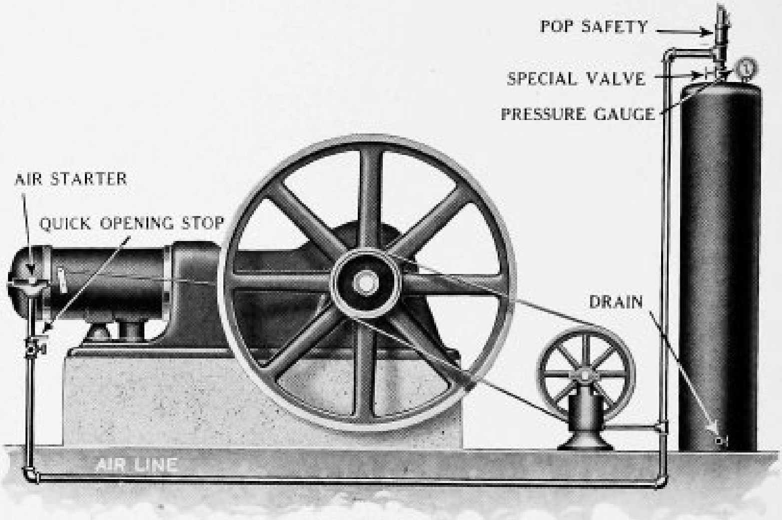

POP SAFETY
SPECIAL VALVE
PRESSURE GAUGE
AIR STARTER
QUICK OPENING STOP
DRAIN
AIR LINE

FIG. 22

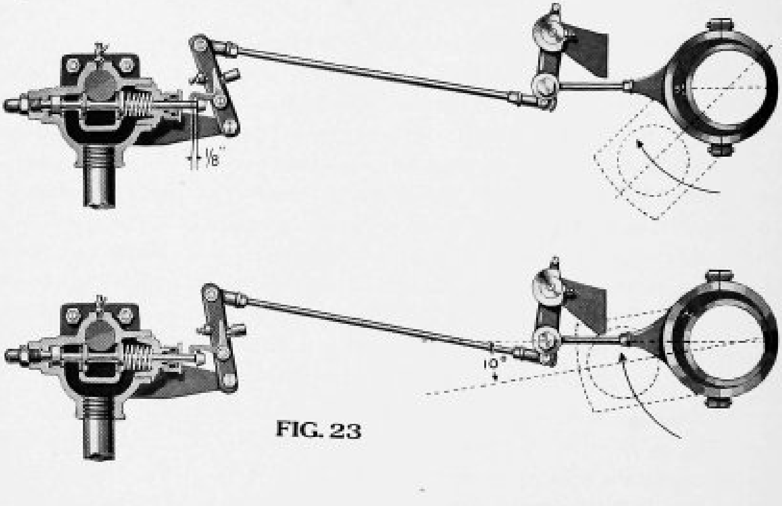
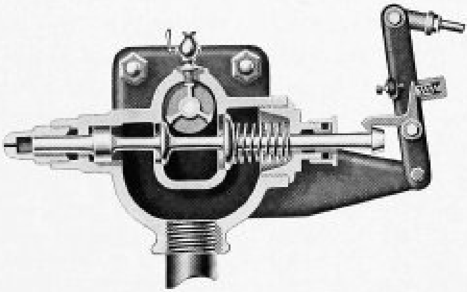

1/8"
10°

FIG. 23

The Air Starter

Figures 23 and 24 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



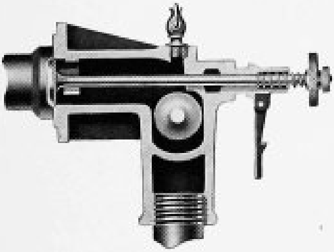


FIG. 24

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. 23. 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. 25—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

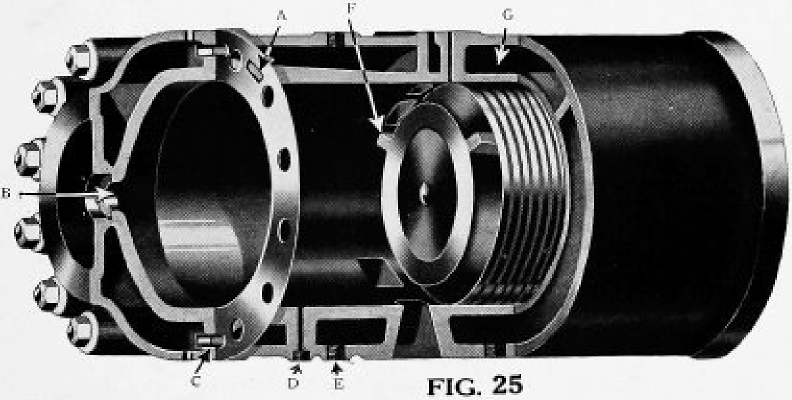


FIG. 25

toward the rear end of the cylinder, makes a sweeping return and drives out approximately 80% of the burned gases. The remaining 20% 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, one-sixteenth 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 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. 25, (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. *24*— 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, and at the

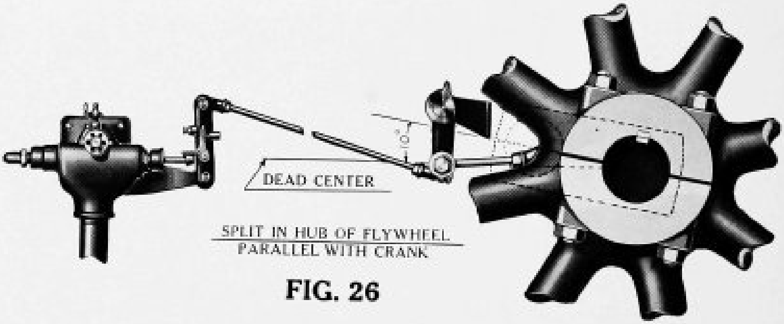


FIG. 26

same time oil the various bearings on the governor. 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. *26*— turn on the cooling water to both cylinder and exhaust stool, and if the engine has been standing some time and is cold, loosen air and gas valve—see Fig. *27*—by lifting the valve from its seat a few times, as cold viscous oil sometimes sticks the valve to its seat. 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 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. 27

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. *28*—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 securely 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

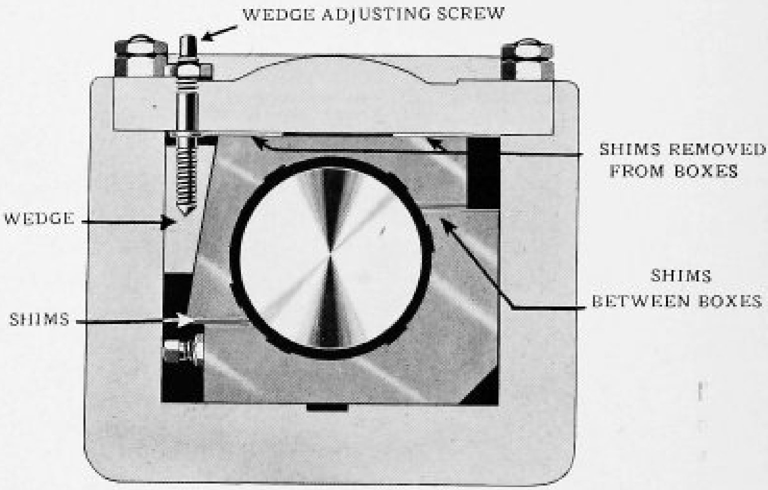


FIG. 28

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 these 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 oosened 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 gasometer 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 gauge.

(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 26.

(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 21.

(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 20.)
Gasket in cylinder head leaking water in cylinder.
Leaky stuffing box.
Choked exhaust.
Improper adjustment of butterfly valve on air supply.
Back firing. See pages 26 and 30.
Premature ignition. (See page 26)

Friction Clutches

Types CFS & CFL, Fig. 29

To Place on Shaft

First turn the handwheel in the direction that releases shoes from the friction hub. If the clutch is for the left hand side of the engine (this being standard) turn the wheel clockwise. If the clutch is for the right hand side (which is special) turn the wheel anti-clockwise,

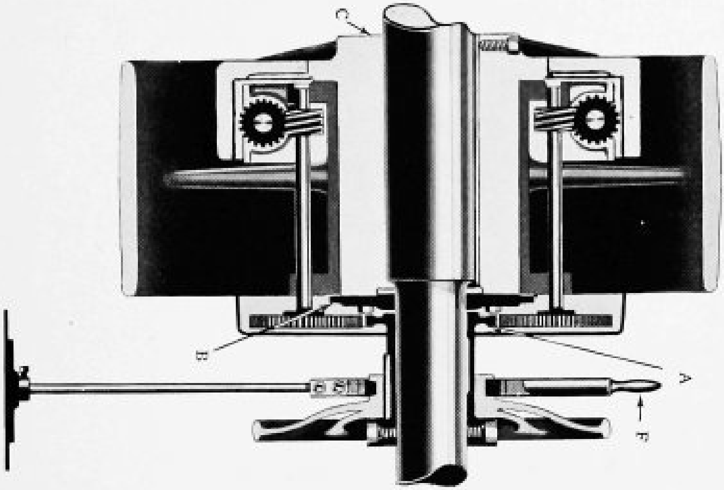
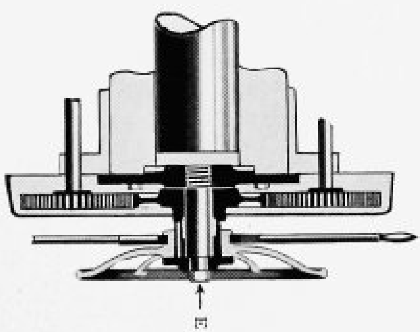


FIG. 29



thus drawing the shoes away from the friction surface. The dental nut then should be removed and the handwheel slipped off sleeve. Next remove the hood which encloses the mechanism. This allows the center gear *A* to be pulled off stud exposing the cap screws which hold flange *B* to hub *C*. After removing these cap screws the hub can be removed and placed on shaft. *Important:* Do not push the hub on the shaft too far; the flange *B* has a boss which centers in the end of the hub and if there is not enough room between the face of the hub and the end of the shaft for this boss, it will rest against the end of the shaft instead of against the end of the hub. This allowable

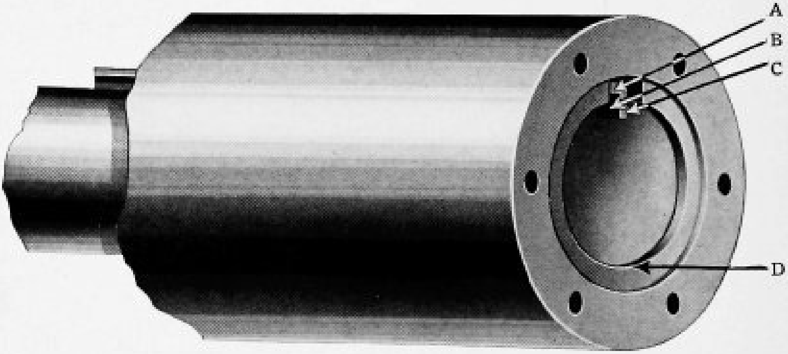


FIG. 30

distance varies from ½ inch to 1 inch depending on the size of clutch. Measure the distance from the face of the flange to the end of the stud where it is riveted and add about ¼ inch for clearance. This will give the distance from the face of the hub to the end of the shaft. The key furnished is of the three piece type, and is so made that it completely fills the keyway in all directions. Fig. *30* shows the end of clutch hub with the key in place. The lower piece *C* should be placed in position first, *B* can then be driven, expanding and tightening these two pieces sidewise in the keyway.

Before driving very tight, determine whether the wedge key will drive in far enough to clear the flange. It may be necessary to loosen them and relocate piece C. It must be remembered, however, that there must be some additional keyway so that in case the clutch is to be removed C and B can be driven in to loosen A. However, B can not be driven as far as C in order that all three pieces may be loosed. After making sure that the location is right, drive B good and tight.

A should be driven just tight enough to bring the hub and shaft in firm contact at D. If this wedge is driven too tight, it will swell the hub so that the pulley cannot be put on without considerable filing.

In assembling be sure that the position of the two outer gears has not shifted before engaging the center gear A. If there is any question as to these gears having moved, it would be well to turn them alternately until the friction shoes press evenly with equal pressure against the friction surface, then the center gear may be engaged. Before replacing the hood, coat the worm and spur gears thoroughly with grease. A small can of grease is furnished for this purpose and is also intended to be used in the compression grease cup for lubricating the clutch pulley hub.

After thoroughly greasing and oiling all the working parts, replace the hood, handwheel and dental nut, being sure that the hood is fastened to the pulley hub securely.

To Assemble Shifting Yoke and Brake

Cut a piece of one-inch pipe sufficiently long to reach from the end of the pipe socket in the yoke to one or more inches into the floor. The floor plate should then be located and with the pipe extending through this plate, set screw the collar on pipe so that when it rests on floor plate, the brass shoes are central with the hand wheel. When so arranged there will be no excessive brake drag to cause undue wear on the shoes.

Before starting the engine be sure that the clutch is completely disengaged by turning the handwheel in the opposite direction to that in which the pulley runs.

To Engage Clutch

To engage clutch, or throw it in, turn the handwheel in the direction the engine runs, and take up the load smoothly and gradually. As the pulley gains speed, give the handwheel a few quick short twists, and when the handwheel is seemingly running as fast as the pulley, or nearly so, pull it outward into engagement with the dental nut E. The differential motion, if there is any between the pulley and friction hub, will be automatically stopped through the dental rotating the handwheel until the friction between the shoes and the hub is great enough to carry the load. The automatic feature, then, is seen to be in engaging the dentals on the handwheel with the corresponding dentals on the dental nut, and when so engaged, should there be an additional load thrown on the clutch, it will take care of it automatically by increasing the friction pressure. It is then *important* that these dentals be engaged. Otherwise, should the clutch start to slip, it may be damaged unless there is someone present.

To Disengage Clutch

To disengage, or throw out, take hold of the shifting yoke handle and shove in, disengaging the dentals. Then apply brake *F* (Fig. 29) to the handwheel hub by screwing in the brake screw. Set the brake sufficiently tight to stop the handwheel from rotating and hold it still for from six to twelve revolutions of the pulley and then release it, allowing the handwheel to rotate with the clutch pulley. If the load is light, the pulley may rotate many revolutions through its own momentum after being completely released. However, if it continues to pull the load, release it further by holding the handwheel by hand, being sure not to hold it long enough to jam the shoes against the pulley hub. *This is very important*, for if this handwheel is held too long either by the friction brake or by hand while the pulley is still in motion, the shoes are sure to jam against the outside of the pulley hub and possibly pull the right and left hand nuts out of their sockets and break the ends of the shoes. After the pulley comes to a standstill, the clutch may be completely released by hand to insure that the shoes do not drag against the friction surface. When the load is very heavy, the clutch pulley usually stops rotating within twelve revolutions, so there is not so much danger of injuring mechanism as when throwing it out with a light load.

Types CS & CL, Fig. 31

To Place Clutch on Shaft

Turn the handwheel so that the crosshead *A* is drawn out to the position shown in Fig. 31 thus drawing the shoes away from the friction surface as far as possible. Then remove the cap screws which hold the flange *B* to the end of the hub; loosen no other parts and *under no conditions remove racks from engagement with the gear wheels,* or *cotter pins from racks.* Clutches are all tested and properly set before shipment and should require no adjustment for some time.

With the cap screws out, the hub can be removed from the pulley and placed on the shaft. To locate and key hub on shaft, follow instructions for the former type on page 52.

In placing pulley on shaft, do so by catching the rim only. If otherwise handled, the mechanism may become disarranged and require setting. Be sure to oil and grease all working parts thoroughly before putting the clutch in service.

To Engage Clutch

Follow the instructions for former type.

To Disengage Clutch

These clutches do not have the shifting yoke and brake to aid in disengaging them as they are very easily controlled by hand. To disengage, give the handwheel a quick shove with the palm of both

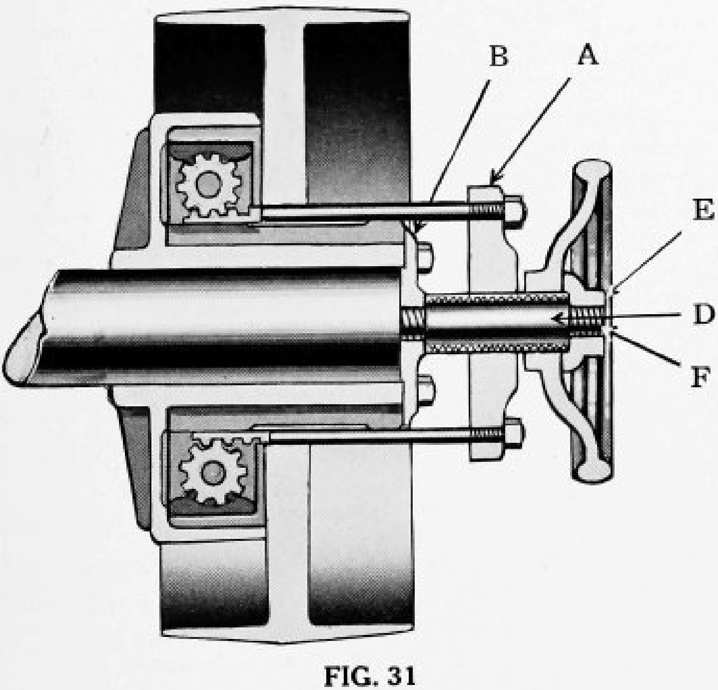


FIG. 31

hands to free it from the dental. Then, facing it, place the hands with the fingers extended parallel with the rim of the wheel, against its sides and press hard enough to keep the wheel from rotating and hold it until the crosshead *A* has traveled close to the shoulder at the end of thread on sleeve, then let it go, and the pulley will soon come to a standstill.

Do not hold the handwheel until the crosshead *A* jams against shoulder on sleeve or it will lock and be hard to loosen.

Adjustment

It will be noted that the rack and gear clutch is not automatic in taking up wear as are the worm gear clutches, consequently it will be necessary at times to adjust it.

The clutch needs adjusting whenever the crosshead *A* travels on the threaded sleeve *D* to within one-quarter inch of the heads of the cap screws which hold the flange *B* to the hub. So, when you note this condition, with the clutch out and the crosshead as close to the handwheel as it will come, remove the cotter pins from the racks, also remove the dental nut *E* from the stud *F*, then pull this assembly out evenly and slowly until the racks are just free from the gear wheels. Do not draw racks out any farther than is absolutely necessary to clear the gears. With the racks thus located, they can be used as a guide for turning the gears. Now carefully turn each gear two or three teeth in the same direction that the racks turn them when being pushed in. With each gear turned toward the center of the clutch exactly the same number of teeth, shove in on the racks, engaging them with the gear wheels. Replace the cotters and the dental nut and the adjustment is completed. If there is any question as to the adjustment not being made right through turning one gear more than the other, it would be best then to follow the directions for reassembling the clutch.

To Reassemble Clutch

Should it at any time be necessary to take the clutch apart to make repairs, the following instructions should be closely followed when reassembling. Before inserting the racks, turn the gears so that the shoes are expanded evenly all around against the friction 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 gears. Then mark the tooth on each gear that is exactly 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 the mechanism and causing the clutch to be hard to operate. Thus, if the rack on one side tightens and resists the pressure applied by the crosshead *A*, while the one on the opposite side is free, the pressure applied on one end of the crosshead *A* will throw a bending movement in stud *F* and either bend or break it, or break the flange *B*. It must be remembered that in no case should the crosshead *A* travel in far enough on sleeve to allow it to come in contact with the heads of the cap screws on flange *B*, as such carelessness is almost sure to break the mechanism. It is, then, very important that the racks be inserted in proper relationship to their gears. Usually the crosshead *A* does not have to travel in on sleeve more than three-quarters of an inch to carry the load.

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 hub 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 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. *32*—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 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 shift-

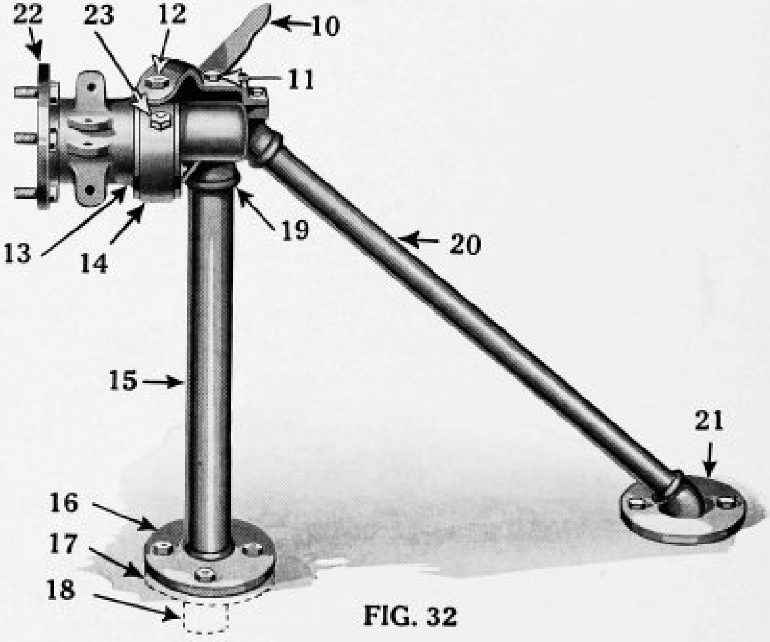


FIG. 32

ing 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.

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. *33*, 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.

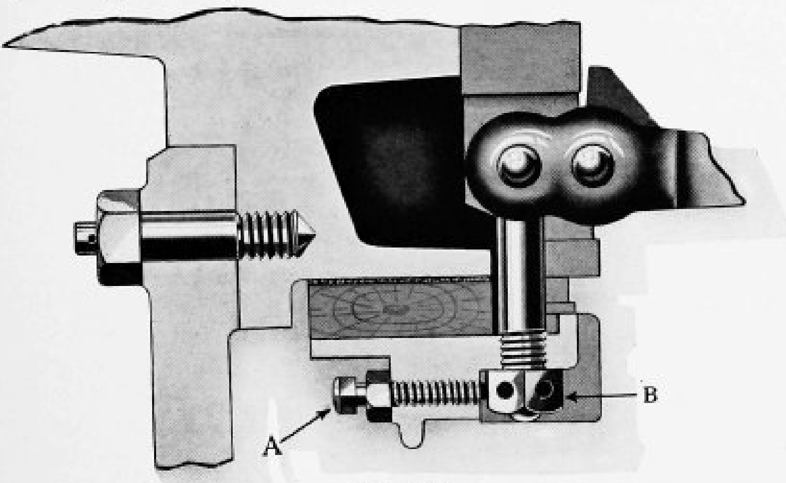


FIG. 33

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.

The lubrication of bearings on any piece of machinery is considered most important in point of care, but it so many times happens, usually through carelessness or indifference, that bearings are destroyed regardless of the attendant's knowledge of the necessity of proper lubrication, that we wish to lay special emphasis on the subject. The most important is the pulley bearing. Always be sure that there is grease on this bearing. Of course, the only time that lubrication is necessary is while the clutch is thrown out and the engine is running, and since it does not under normal conditions take very much grease, it is often seriously neglected, then trouble is sure to follow.

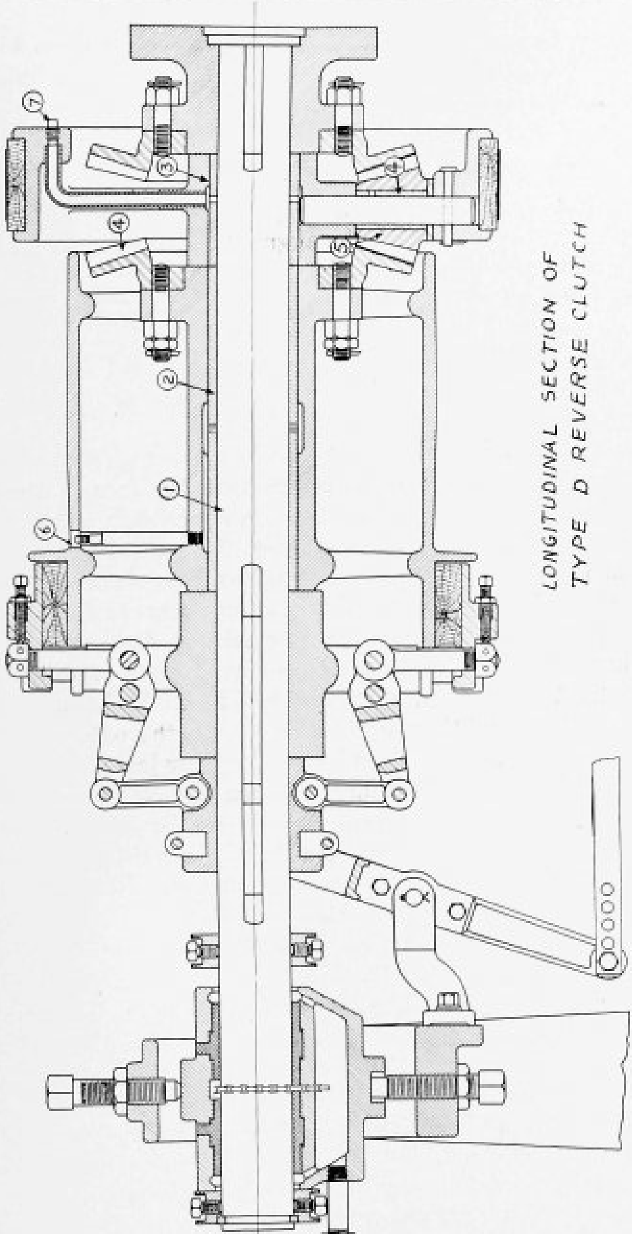
Grease and oil clutch regularly, even if there is an excess of lubricant used, as it is well worth the waste to form the habit of greasing and oiling the clutch just as regularly as you do the engine, then you are sure to get the maximum efficiency.

When throwing in the lever clutch, be sure that it is thrown clear in. Do not, under any condition, throw it in part way, then tie the handle in order to hold it in. The thrust of the shifting yoke *14* against the sleeve *13* will soon cause it to wear and cut, thus necessitate renewing. Grease cups are provided for both pulley hub bearing and shifting yoke, while the guide pins, toggle joints and lever are to be lubricated with a squirt can. Study carefully the principles and construction of the various clutches and wherever it is seen that there is friction caused by moving parts, keep them lubricated thoroughly and the reward will be the best of service.

Reverse Clutch

On the opposite page is found a sectional assembly view of our bevel gear reversible clutch. In a reversing mechanism much depends on the gears, and instead of using cast iron gears we use machine cut steel gears as shown by Nos. 4 and 5. 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 at Nos. 1, 2 and 3 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



LONGITUDINAL SECTION OF
TYPE D REVERSE CLUTCH

necessary to do 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. At Nos. 6 and 7 you will find the proper points for lubricating the sleeve or bushing. Give particular care to out-board bearing and be absolutely sure at all times that there is sufficient oil to give perfect lubrication.

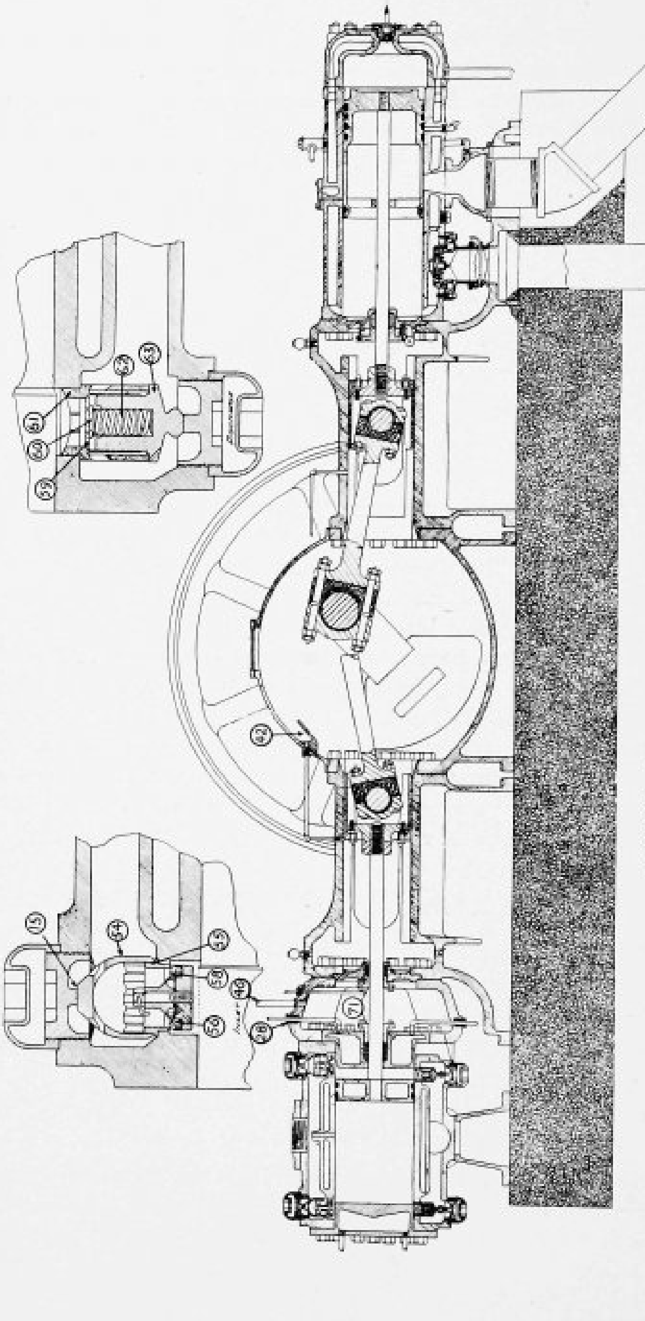
Should the out-board bearing leak or drop oil it is evident that the bearing is not level, or it may be clogged up. In the event that neither of the above are causing the trouble it may be a good idea to remove the cap and examine the wood liners placed between the top and bottom bearing, as it may be 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 VIII opposed Gas Compressor. The power end of this unit is taken up in detail in other parts of this book and 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



LONGITUDINAL SECTION OF
TYPE A.C. 8. OPPOSED COMPRESSOR

corrects the internal shrinkage which is present in cast iron. The general construction is such that the minimum clearance is obtained. This, however, is not essential as all Bessemer Compressors are furnished to do a specified amount of work under a given condition.

Valves

By referring to plate on page 66, you will find in the upper right and left hand corners sectional views showing both the inlet and the discharge valve assembly.

The inlet valve assembly consists of the valve, No. 58, valve spring No. 56, valve body No. 55, and the valve bonnet No. 54. The complete assembly is held in place by the plug which has a central bearing on bonnet at 15, this central bearing on bonnet equalizes the pressure on the gasket regardless of any slight imperfection in the machining.

The discharge valve differs in construction from the intake valve entirely on account of the abuse it receives. It is made from a high grade steel, cup shape, and with its perfect working dash pot is absolutely quiet and yet positive in action. The valve body No. 61, is held to its gasket by the screw plug pressing against the valve guide No. 63. The spring retaining thimble No. 60, entirely encloses the space between the bottom of valve and end of guide, and to get the proper action a suitable size hole is drilled in the valve for vent.

The valves should receive a certain amount of attention, the amount depending on the operating conditions of the compressor. A high compression ratio gives a high temperature to the discharged gas, so, it may happen that the valves will carbon up and then not work properly, especially if a poor grade of cylinder oil is used.

Leaky discharge valves are very detrimental, in that they not only reduce the delivery, but for a given delivery more power is required by making the compression line steeper.

Leaky inlet valves reduce the delivery also and while the mean effective pressure is reduced, the power required for a given quantity of gas or air is increased, thus it is seen that it is important that the valves be kept in first class shape.

On account of the possibility of foreign matter finding its way to the valves, either from the gas wells or pipe line it is not safe to make the valve seats integral with the cylinder, whether it be poppet or corliss valve, unless a very elaborate means of filtering is employed to remove such foreign matter. So to guard against such permanent damage, we make all valve seats removable, then should a valve start to leak it can be readily replaced and the defective one repaired at leisure.

A leaky valve can usually be detected by a rise in temperature of the cover cap immediately over the defective valve.

Discharge valves are always placed on the bottom of the cylinder so that should there be any condensation in the cylinder or any liquid carried into same from the intake line it will be expelled with the out going gas and thus save any chances of breaking the cylinder or cylinder head.

Lubrication

No fixed rule can be given for the amount of lubrication 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 1/5 to 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.

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 No. 42, 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.

Cooling Water

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.

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 outside 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 any thing that will cause a spark.

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

For other starting instructions, see page 46.

Positively do not run gas pumps or compressors over 180 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.

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THE SUPERIOR PRINTING CO.,
AKRON, O.