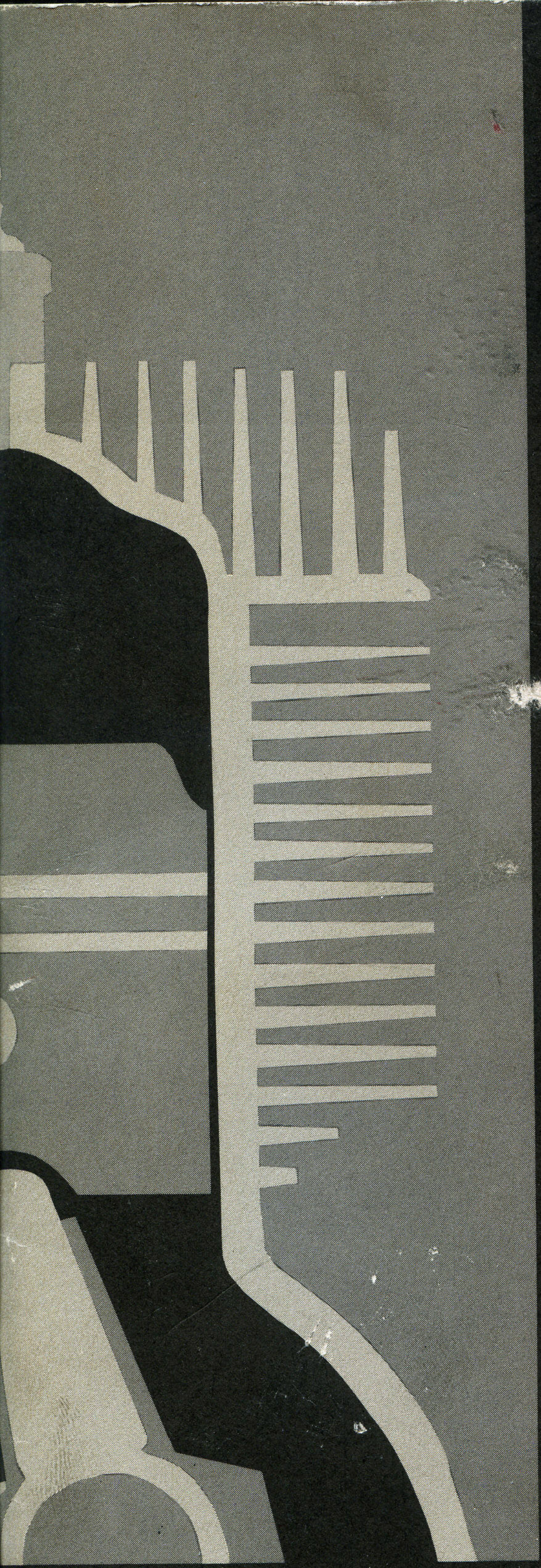

ENGINE SERVICE MANUAL

MODEL 321

HORIZONTAL —— VERTICAL

Price $2.00

JACOBSEN

LAWN EQUIPMENT ®

ABOUT THIS MANUAL

This manual has been prepared by the Product Training Center and Engineering Departments of The Jacobsen Manufacturing Co., Racine, Wisc. 53403, USA. Material in Section I — Understanding Horsepower and Torque, and in Section II — Horsepower, Speed and Torque in Engines was adapted from UNDERSTANDING AND MEASURING HORSEPOWER published by the American Association for Agricultural Engineering and Vocational Agriculture, Athens, Ga., and is reprinted here with their kind permission. For Section III — Theory of Operation, information was supplied by Wico - The Prestolite Company, West Springfield, Mass.; Briggs & Stratton Corp., Milwaukee, Wisc.; and R. H. Phelon Company, Inc., East Longmeadow, Mass.; their assistance is gratefully acknowledged.

ADDITIONAL COPIES

Additional copies of this publication may be obtained. The single copy price is $2.00. Teachers wishing to use this manual in the classroom may obtain a sample copy and information on multi-copy orders by writing on school or institutional letterhead.

A set of 35 mm color slides in 2 x 2 mounts duplicating the illustrations provided in the manual is also available.

Requests for additional copies or for information on the slide sets should be addressed to:

Product Training Center
Jacobsen Manufacturing Co.
1721 Packard Avenue
Racine, Wisconsin 53403

The Jacobsen 501 Heavy Duty Engine is basically very similar to the 321 Engine including tolerances, principles of operation, troubleshooting procedures and torque ratings. Slight differences do exist in the oil mixture, governor location, internal material composition etc.

The 501 Heavy Duty Engine Manual is also available for $2.00 through the Jacobsen Consumer Service Department.

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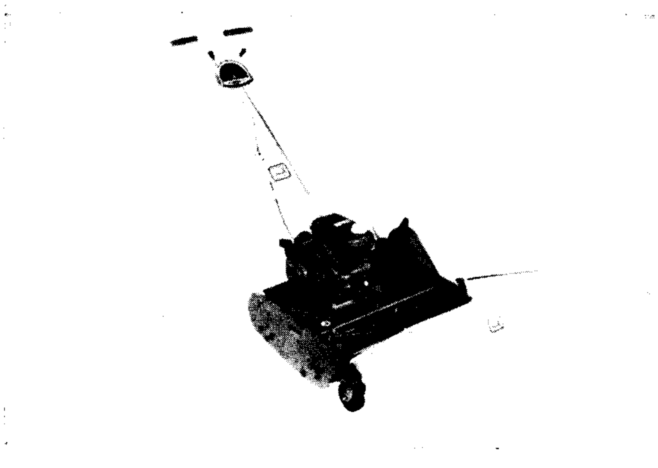
INTRODUCTION

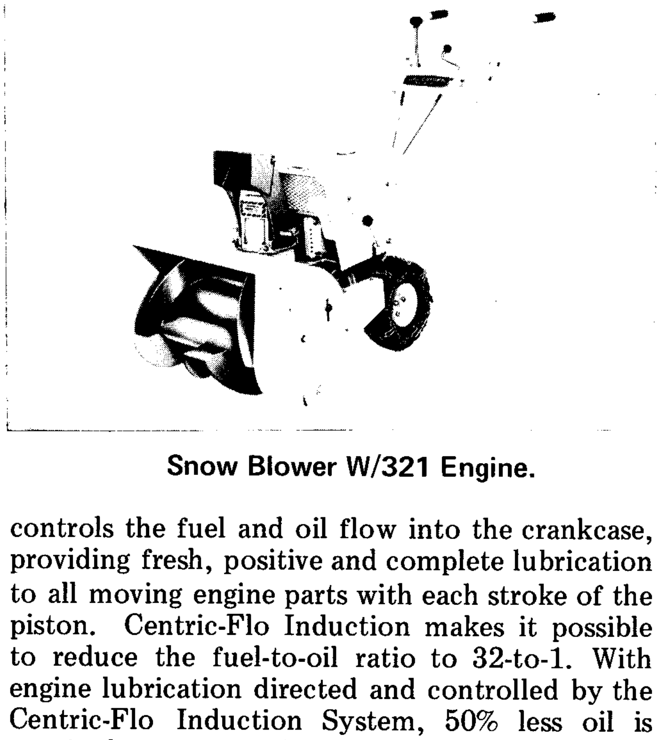
This service manual has been prepared for use by servicemen and owners of equipment powered by the Jacobsen 321, 2-cycle engine.

All models of the Jacobsen 321 engine are covered. Both horizontal and vertical types are discussed. The manual includes an explanation of how horsepower and torque figures relate to engine ratings and capacities, a discussion of 2-cycle engine theory, detailed service data, a comprehensive troubleshooting guide and complete overhaul and maintenance instructions. Everything has been arranged for easy reading and quick reference.

All disassembly, inspection, repair and reassembly instructions are set out in step-by-step sequence. Every procedure has been shop-tested in the Jacobsen Product Training Center and approved by the Jacobsen engineering staff. Servicemen or owners — anyone using this manual as a repair or maintenance guide — can be assured that the information is accurate, authorative and complete.



Reel Mower W/321 Engine.



Snow Blower W/321 Engine.

ABOUT THE 321 ENGINE

The Jacobsen 321 Super Torque engine is the product of more than fifty years of experience in small engine design, manufacture and application. Jacobsen has been a leading name in turf care equipment since 1922 and its mowers, trimmers and related equipment are used around the world. Golf courses, parkways, lawns and gardens in all types of climate, on all types of terrain are maintained with equipment carrying the Jacobsen name. Probably no other manufacturer has had so extensive experience in engineering for difficult or demanding small engine applications.

The Jacobsen 321 Super Torque is the engineering solution to requirements for a tough, durable, economical and easy-to-maintain portable power source. The 321 Super Torque is an air-cooled 2-cycle engine. In developing the 321, Jacobsen engineers have taken advantage of all the features of the standard 2-cycle design and have made notable improvements in several critical operating characteristics. The 321 features a Centric-Flo Induction System (Patent No. 3008459) which controls the fuel and oil flow into the crankcase, providing fresh, positive and complete lubrication to all moving engine parts with each stroke of the piston. Centric-Flo Induction makes it possible to reduce the fuel-to-oil ratio to 32-to-1. With engine lubrication directed and controlled by the Centric-Flo Induction System, 50% less oil is required for safe and efficient 2-cycle operation.

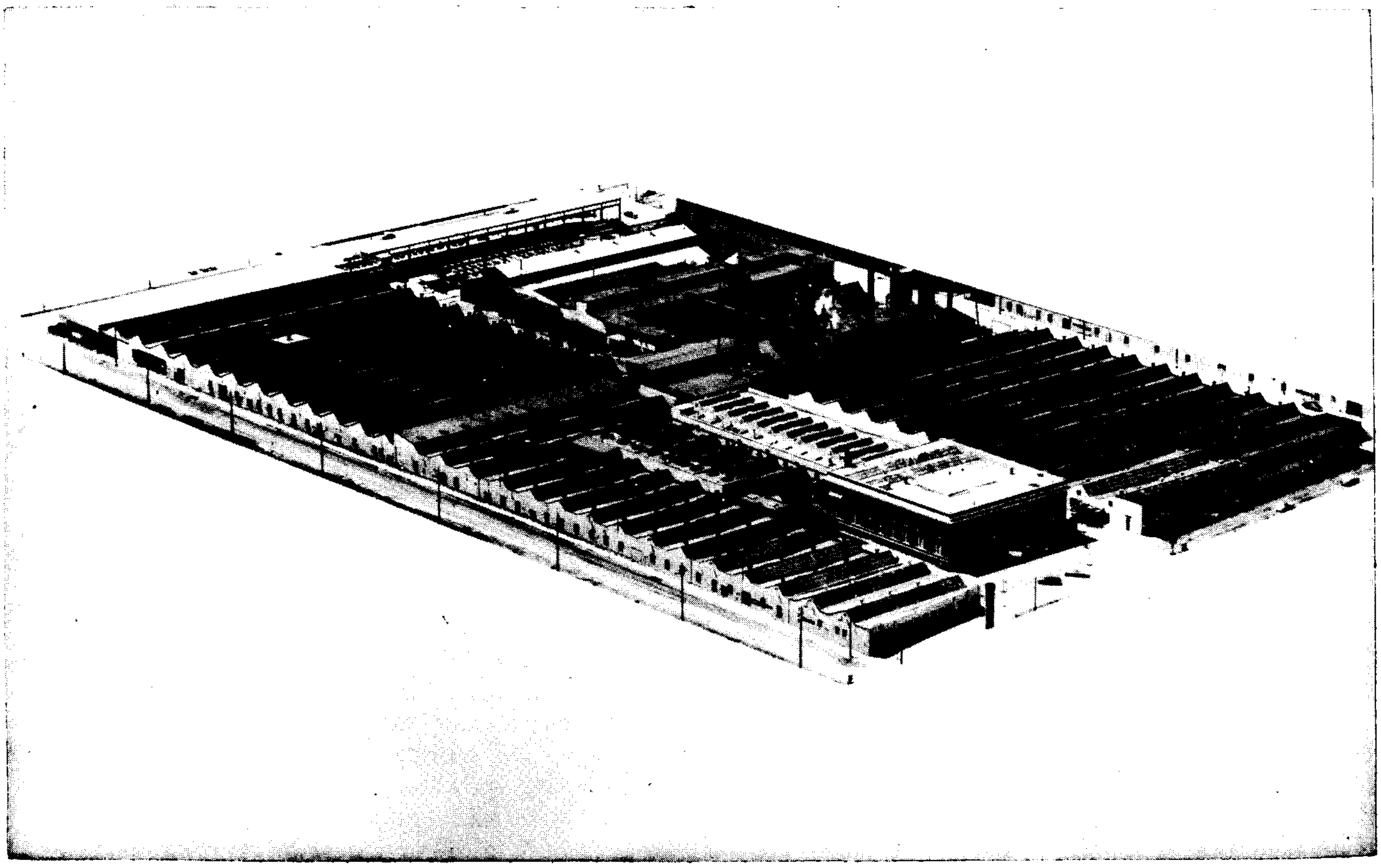
Designed with automotive type crankshaft throws, the Jacobsen 321 Super Torque engine is available in both horizontal and vertical configurations. The basic engine, with only minor changes in the housings and mountings, is used on both reel type and rotary mowers. It is also used on a variety of other turf care equipment. A complete list of 321 applications appears in the Service Data Section of this manual.

ABOUT THE JACOBSEN MANUFACTURING COMPANY

The 321 Super Torque engine is only one of many Jacobsen's engineering accomplishments. The first of scores of successful Jacobsen products was the precedent-breaking "4-Acre" mower which appeared in 1921. A heavy duty mower, powered by a custom designed engine, the "4-Acre" was an innovative solution to the problem of maintaining extensive grass areas and parkways.

In 1923 Jacobsen introduced a mower — the Estate 24 — more specifically designed for trimming residential lawns. In the same year the company brought out the revolutionary "Greensmower". The Greensmower was the first power mower designed for cutting and trimming the fine turf and the close growing bent grasses of golf course greens. It featured a lightweight cast aluminum engine and marked the beginning of Jacobsen's domination of the turf care equipment industry.

Jacobsen's preeminence in turf care equipment manufacture is no accident. Steered by a vigorous and active management, Jacobsen has consistently led the industry with new ideas and new products — all designed to make turf care easier, safer or more convenient. The first automatic recoil starter on a power mower was introduced by Jacobsen on the dependable Jacobsen 2-cycle engine. Jacobsen pioneered such developments as riding attachments for power mowers, rotary mowers with four retractable, replaceable blades and pneumatic tires on turf care equipment. The list of Jacobsen "firsts" is long and still growing. Since 1923 the Jacobsen line has expanded to where the products number in the hundreds. Today Jacobsen manufacturers mowers and turf care equipment of all types and sizes — 18" reel types for the homeowner with a small plot of fine grass to tend; 60" riding rotaries for estate keepers with acres of lawn to care for; gang mowers and special purpose equipment for the professionals who mow and trim parks,



Jacobsen Manufacturing — Racine, Wisconsin.

boulevards, fairways and putting greens. And, in addition to the impressive list of mowers, tractors and attachments which carry the Jacobsen name, Jacobsen produces a wide variety of related turf-care equipment. Aerators, thatchers, sod-cutters, edgers, trimmers, sweepers, garden tractors and snow blowers are among the items manufactured by Jacobsen or its subsidiary companies.

The growth of Jacobsen's product line has been matched by the expansion of its manufacturing facility. In 1921 Jacobsen mowers were produced in a tiny, two-story building in Racine, Wisconsin. Fewer than 35 people were employed. Today Jacobsen's main plant — still at Racine — sprawls over a half a million square feet. Other plants in Brookhaven, Mississippi; Olathe, Kansas; and Minneapolis, Minnesota support the Racine operation.

In 1969 Jacobsen, after nearly five decades of growth, became one of the family of progressive companies assembled under the banner of Allegheny Ludlum Industries of Pittsburgh, Pennsylvania.

Since 1922 the company has weathered wars and depressions. But at no time in its long history has the company failed to recognize its obligations to its employees, dealers and — most important, — to its customers. Now, as in 1922, Jacobsen is dedicated to excellence.

ABOUT THE JACOBSEN PRODUCT TRAINING CENTER

Since its inception, the Jacobsen Company has been aware of the need for adequate training for the people who sell, service and maintain its products. The Jacobsen Product Training Center is the natural outgrowth of this interest. Operated by members of Jacobsen's Product Training Center, the training school is open to Jacobsen Distributor Personnel, Jacobsen Service Station and Dealer Personnel, Golf Course Park

Jacobsen Product Training Center.

A Product Training Center Class.

and Highway Maintenance Personnel, and Teachers and Students. Courses are offered for Service Managers, Salesmen, Dealer Servicemen, Golf and Park Servicemen and Students.

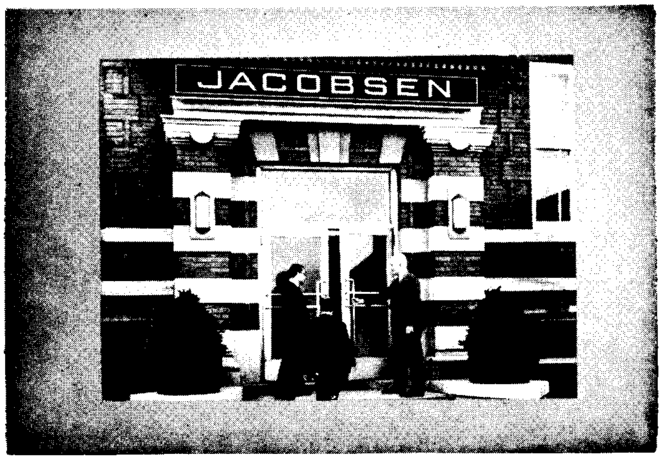
Courses are from 3 to 4 days in length. There are 15 or more each fall and winter. For information on registration, fees and accommodations write to:

Jacobsen Product Training Center

Jacobsen Manufacturing Company

1721 Packard Avenue

Racine, Wisconsin 53403



INVITES YOU
TO PARTICIPATE IN
OUR NEW JACOBSEN
TRAINING PROGRAM

SECTION 1

UNDERSTANDING HORSEPOWER AND TORQUE

One way of rating the output of any engine is to express it in terms of "horsepower". What this means is that the engine is capable of producing enough energy to do a certain amount of work.

For you to better understand what horsepower means and how it is measured, you will need to know the answers to the following questions.

- What is energy?
- What is force?
- What is work?
- What is torque?

Complete answers for each of these questions would require careful discussion of all the scientific principles which determine how engine power is measured. The following explanation of horsepower, although it is based on scientific principles, deals only with those factors which you must understand if you are to know how horsepower is calculated and how it affects engine performance.

WHAT IS ENERGY?

A common definition of energy is the capacity or ability to do work. Since horsepower is a way of measuring the capacity to do work, energy must be present if horsepower is to be developed.

But what do we mean when we talk about energy?

- Do we mean something like the current that makes an electric motor go when we throw the switch?
- Do we mean something like activity, motion, restlessness?

If you think of energy in either of these ways, your ideas of what energy is are quite correct. Actually there are two kinds of energy: potential energy and kinetic energy.

To understand horsepower you will need to know how the two forms of energy differ from one another.

Potential energy is inactive energy. It is energy which is stored for later use.

Kinetic energy is active energy. Kinetic energy is energy at work.

The difference in the two forms of energy will become clear if you think of a heavy weight suspended by a rope. (See Figure 1.) So long as the rope holds and nothing moves, the energy stored in the lifted weight is potential energy. If the rope is cut and the weight begins to fall, the potential energy is changed into kinetic energy – active energy. When the weight strikes the ground, the kinetic energy developed in the fall is dissipated in three ways: as shock waves into the air (which creates noise), as the heat generated by the impact (which is absorbed by the soil), and in the motion of the soil particles as they are compressed or driven away by the force of the blow.

WHAT IS FORCE?

When energy is used to do any kind of work, force is involved. In the situation we just discussed, force was required to hoist the weight into position above the ground. Force is required to either start an object moving or to change its speed or direction once it is moving. (See Figure 2.) In the first example the force is the pulling action needed to lift the weight. If the weight weighs 330 pounds, a force of 330 pounds is required to move it. Actually, because of friction in the pulley and because the rope itself weighs something, more than 330 pounds of force would be needed to lift the weight in the example shown.

In the second example, the force of the batter's swing and the resulting force of the impact of the bat against the ball changed the speed and

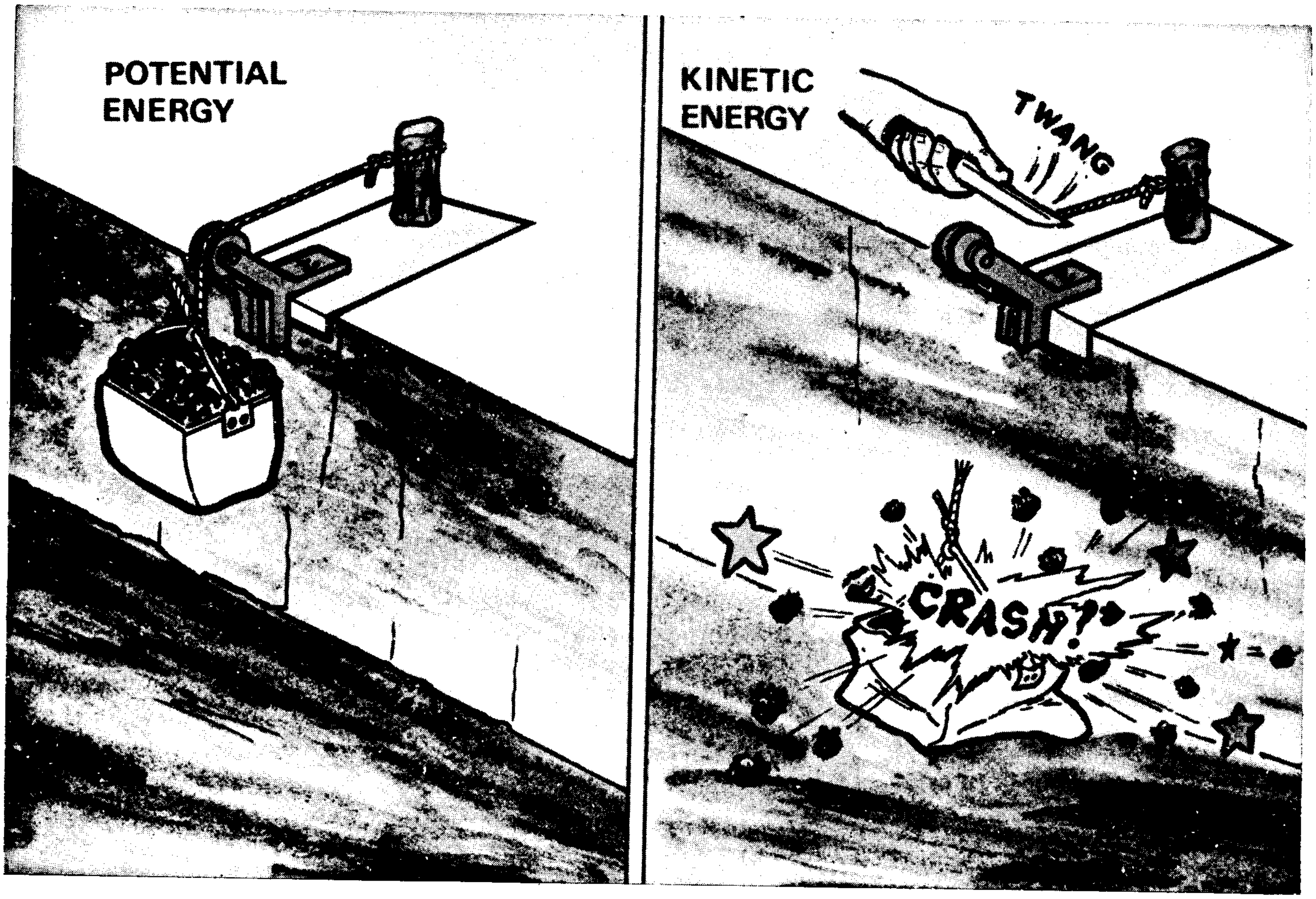


Figure I. The Two Kinds Of Energy.

direction of the ball that had been headed for the plate.

This same principle may be applied to an airplane in flight. (See Figure 3.) The force of the wind behind the plane will make it fly faster. If the force of the wind is from a direction opposite to the line of flight, the plane's speed will be slowed. If the wind is blowing in from one side or the other, the plane will be forced off course. Unless the pilot makes the proper adjustment, the direction of the flight will be changed by the force of the wind.

Force is best defined as an action which either moves an object from a state of rest, or one that changes the speed or direction of an object already in motion.

WHAT IS WORK?

Work is done when force is applied to an object and the object moves a measurable distance. A horse pulling a heavy weight is doing work when the force of his pulling actually moves the weight. (See Figure 4.)

If, on the other hand, the horse is hitched to something too heavy for him to pull, and no matter how hard he pulls, he cannot move the object, the horse is doing no work. He may be exerting a good deal of force, but unless he moves what he is hitched to, he does no work. (See Figure 5.)

Therefore, for work to be done, force must be applied to an object with the result that the object is moved a measurable distance. Work

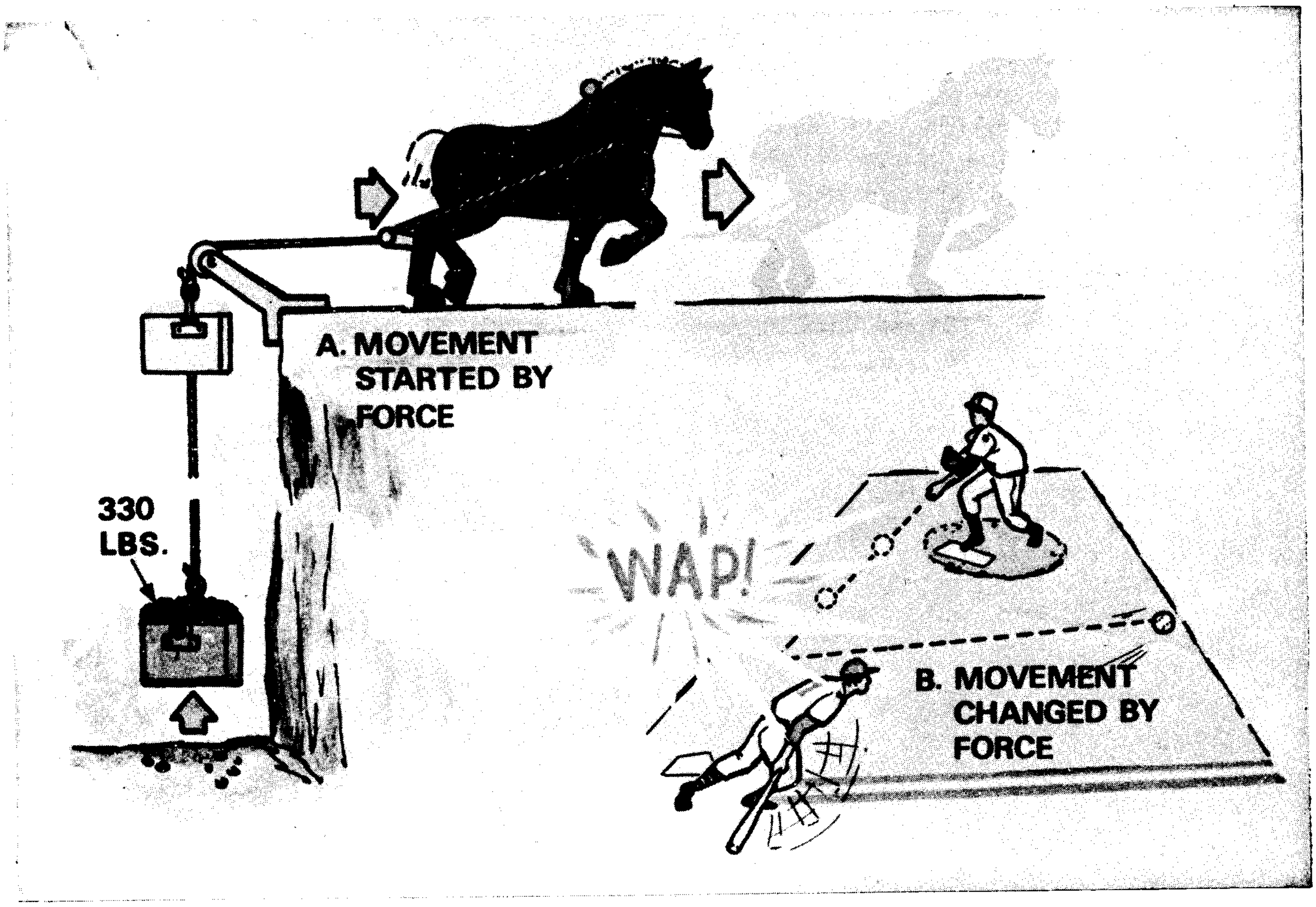


Figure 2. Force May Act In Two Ways.

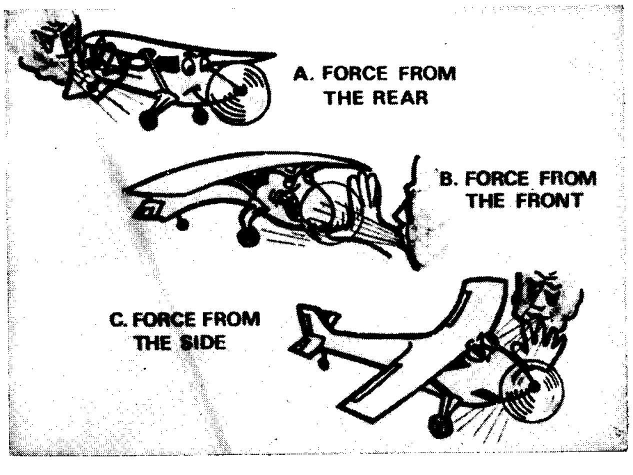


Figure 3. Movement Affected By Outside Force.

is also done when an applied force measurably changes the speed or direction of an object already in motion. If the force needed and distance to be traveled (or extent of change in speed or direction) can be measured, it is possible to determine how much work has been done or will be required.

The simple formula for calculating work is

WORK = DISTANCE x FORCE

Force is always calculated in terms of weight — ounces, pounds, tons, grams, kilograms, etc. In this book, force is measured in pounds. Similarly, distance, although it may be measured in inches, yards, or meters, is for the purposes of this book, always measured in terms of feet.

Substituting feet for distance and pounds for force, we find that work is expressed as foot pounds. Thus in the example shown below (See Figure 4.) the work the horse has done in exerting 330 pounds of force (the force required to move the weight) over a distance of 100 feet (the distance the weight was moved) can be calculated as follows.

WORK = DISTANCE (100 feet)
x FORCE (330 pounds)

WORK = 100 (feet) x 330 (pounds)

WORK = 33000 foot pounds

In this example we have calculated only straight line work, the kind of work that is done by pushing or pulling.

Another kind of work is that which is done through rotary motion, such as when a crank is turned or when a series of gears are engaged. In the example we have been discussing, for instance, a winch could have been used instead of the horse to lift the weight. (See Figure 6.) Since both the force required (330 pounds) and the distance traveled (100 feet) are identical, the work done by the winch (33000 foot pounds) is the same as that done by the horse. What is different is that the motion employed in doing the work is rotary rather than straight line. The effect of the rotary motion is to develop what is called torque.

WHAT IS TORQUE?

The force required to turn a shaft or drum against a load is called torque. In the example

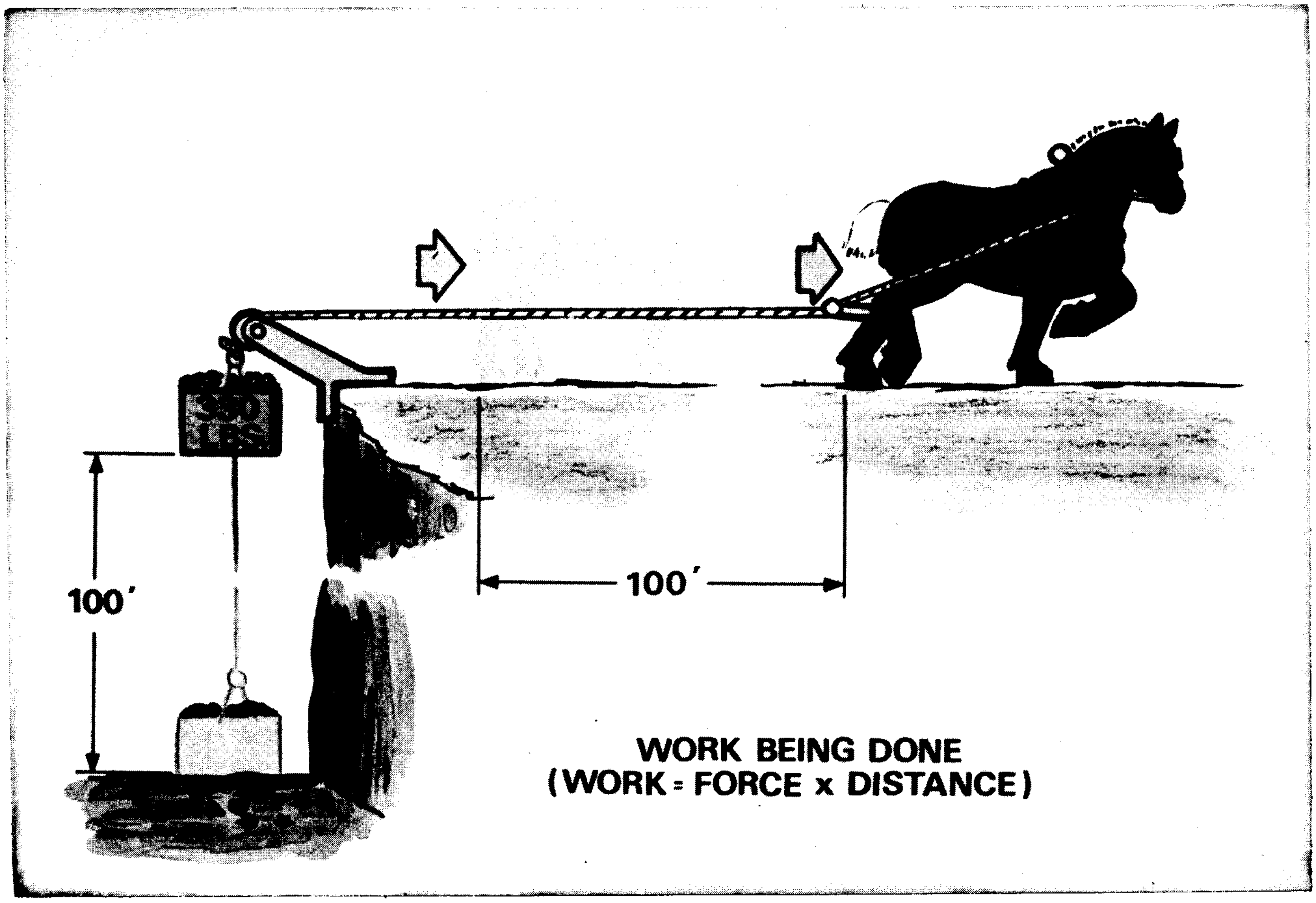


Figure 4. "Work" Requires Motion.

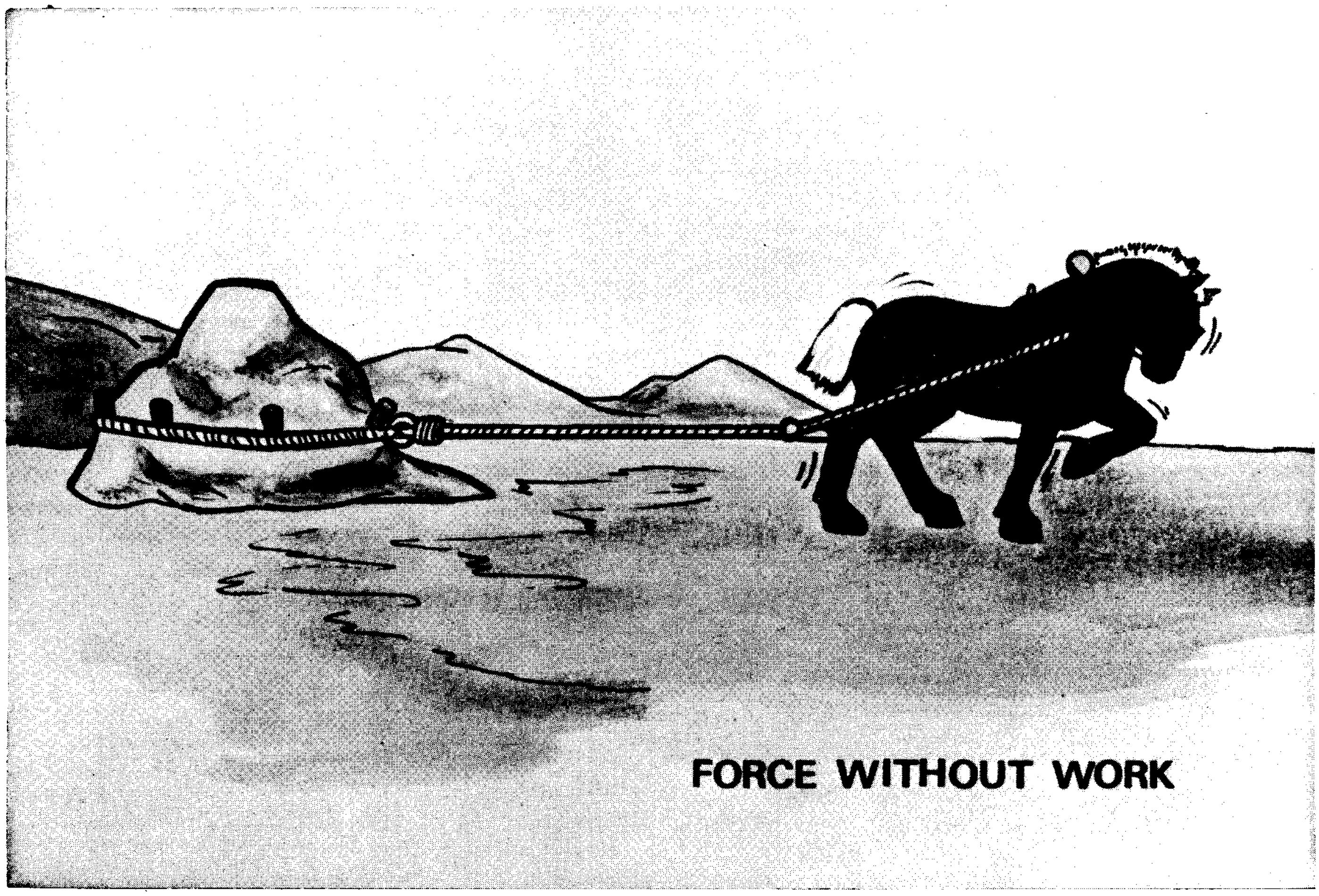


Figure 5. Without Motion There Is No "Work".

shown (See Figure 7.), torque is required to wind the hoisting cable on the drum. If the turning is stopped, the weight pulling against the drum will tend to make the cable unwind unless the drum is held. This is also torque. Consequently, torque is best described as a force which produces or tends to produce, rotation.

When we were discussing work, we noted that no matter how much force was applied, if there was no motion, there was no work. The same principle applies to torque. If it does not produce rotation, torque does no work. Thus, torque is similar to any simple straight line force in its relationship to work. Torque, however, is measured in a way which often causes confusion.

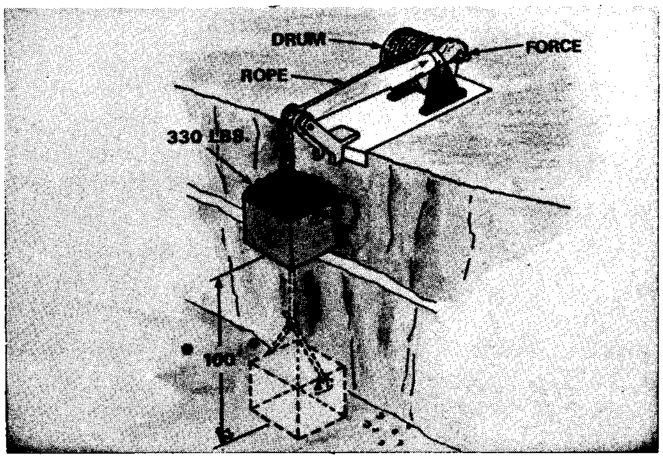


Figure 6. Work Done With Rotary Effort.

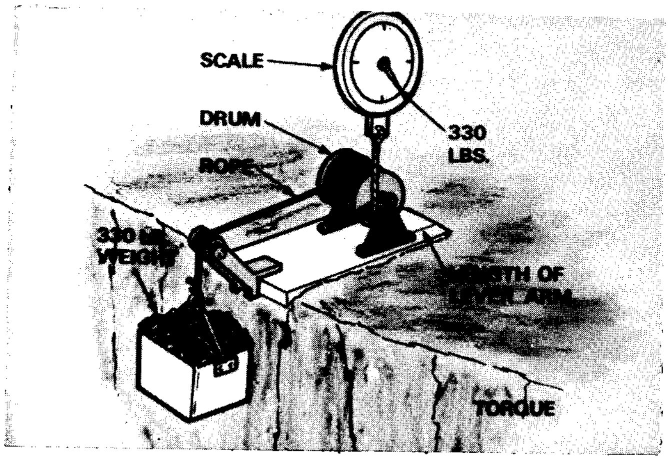


Figure 7. Relationship Of Torque And Rotation.

Like work, torque is measured in a combination of units, one of length (distance) and one of weight (force). Both torque and work are measured in terms of pounds (or ounces, grams, etc.), and feet (or inches, centimeters, etc.). What the units of measure mean, however, is different in each case.

- With work, "feet" is the distance through which the force moves (See Figure 6.); but with torque, "feet" is used as a measure of the length of the lever arm. (See Figure 7.)
- With work, "pounds" is the force that pulls on the rope to offset the weight (See Figure 6.); but with torque, "pounds" is a measure of the force applied to the lever arm that produces, or tends to produce, rotation. (See Figure 7.)

When the formulas for work and torque are compared, the differences are clear.

WORK = DISTANCE (feet) x FORCE (weight in pounds) = FOOT-POUNDS

TORQUE = FORCE AT LEVER ARM (pounds) x LENGTH OF LEVER ARM (feet) = POUND-FEET

Although there is no mathematical difference between foot-pounds and pound-feet, the differences between what the figure means as work and what it means as torque is very important. Throughout this book, work is always measured in foot-pounds; torque is always measured as pound-feet. In your references to work and torque, try to make the same distinction.

To further develop your understanding of the principles of torque, consider the three examples illustrated below. (See Figure 8.)

In the first example the length of the lever arm is one foot, the force being applied at the end of the arm is 330 pounds. Using the torque formula, the torque may be calculated as follows.

TORQUE = FORCE x LEVER-ARM LENGTH

TORQUE = 330 x 1

TORQUE = 330 POUND-FEET

In the second example the length of the arm is changed to 2 feet and the force at the end of the arm remains at 330 pounds. The calculations now look like this:

TORQUE = 330 x 2

TORQUE = 660 POUND-FEET

By doubling the length of the lever arm, the torque is doubled.

In the third example, the lever arm is left at 2 feet, but the force at the end of the arm is reduced to 165 pounds.

TORQUE = 165 x 2

TORQUE = 330 POUND-FEET

Torque is always the length of the lever arm times the force applied.

WHAT IS POWER?

So far we have discussed energy, force, work and torque. We are now ready for a discussion of power.

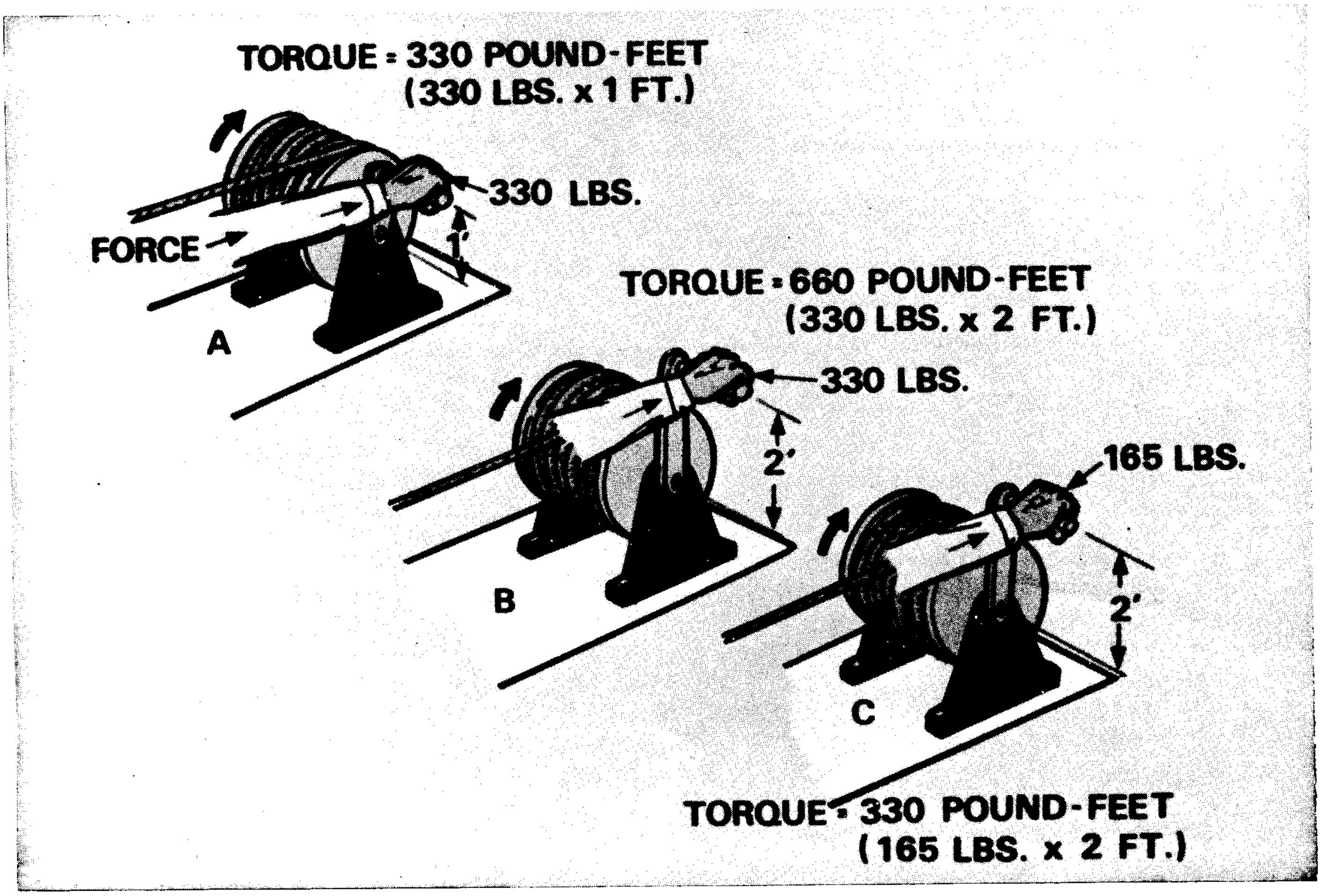


Figure 8. How Torque Is Determined.

Very simply, power is the rate or speed of doing work. To clarify what this means, let us return to the example of the horse raising the heavy weight by pulling on the rope. (See Figure 9.)

Working alone, one horse can raise the 330 pound weight, 100 feet in one minute. When a second horse is hitched up, the two horses can raise the same weight (330 pounds) the same distance (100 feet) in 30 seconds. In each instance, the same amount of work has been done. What has varied is the amount of time required to do it. In each instance, the work formula (distance x force) indicates that 33000 foot-pounds of work was accomplished. In the first instance, the work required 1.0 minute of time. In the second, the same amount of work required 0.5 minutes of time.

Since power is the rate or speed at which work is done, it is obvious that the two horses together should have produced more power than the one horse alone.

The formula for power is:

$$\text{POWER} = \frac{\text{WORK}}{\text{TIME}}$$

You may remember that work is equal to force times distance. Therefore the power formula can also be written as:

$$\text{POWER} = \frac{\text{DISTANCE (ft) x FORCE (lbs)}}{\text{TIME (minutes)}}$$

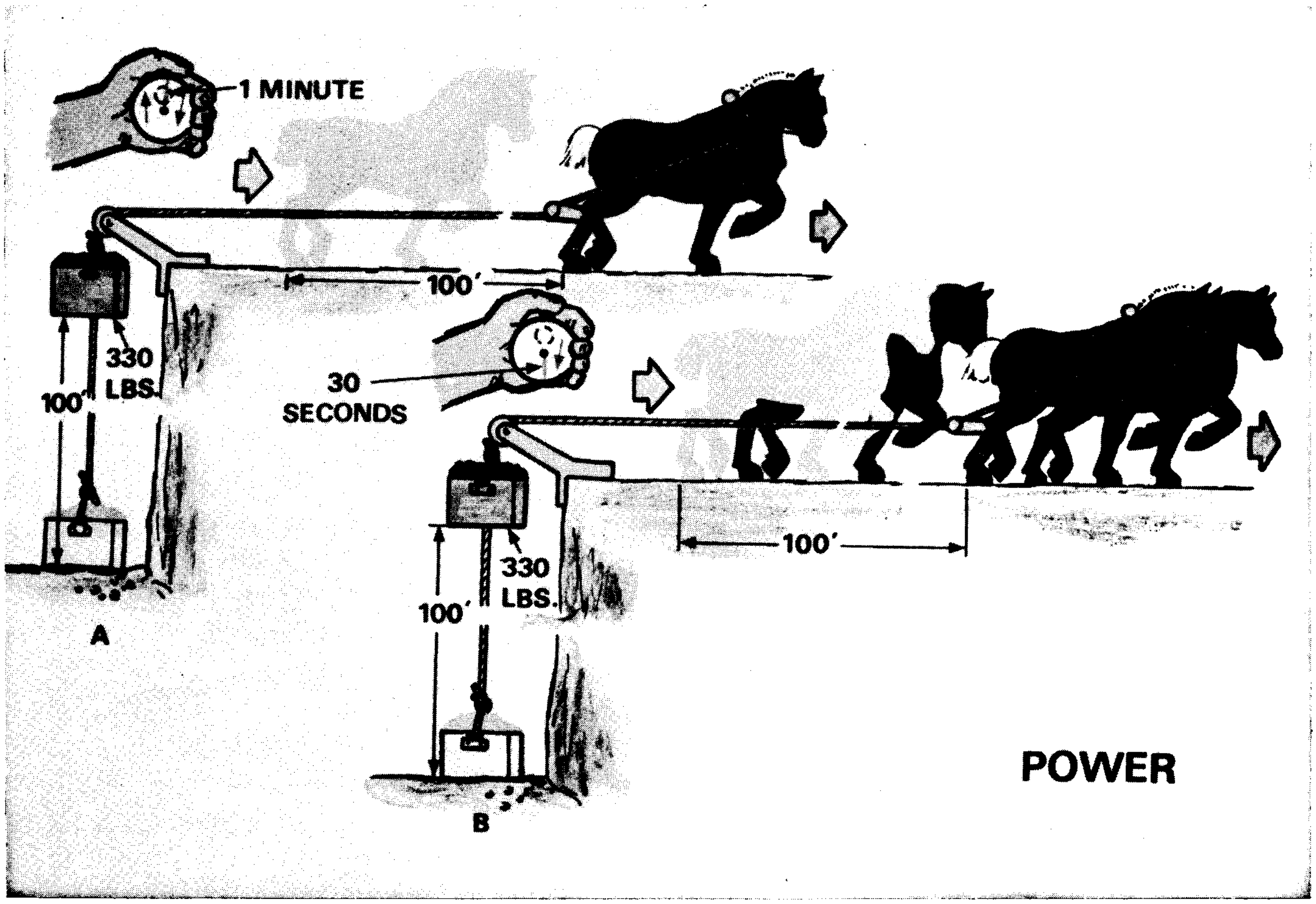


Figure 9. Power = Rate of Doing Work.

The performance of the horse in the first example above (See Figure 9.), can now be calculated this way.

$$\text{POWER} = \frac{100 \text{ feet x } 330 \text{ pounds}}{1 \text{ minute}} \text{,or}$$

POWER = 33000 foot-pounds per minute.

The calculations for two horses hitched together look like this:

$$\text{POWER} = \frac{100 \text{ feet x } 330 \text{ pounds}}{.5 \text{ minutes}} \text{, or}$$

POWER = 66000 foot-pounds per minute

Power is always expressed as foot-pounds per minute, (or as a similar combination of measure units). In the examples given, the two horses hitched together produced twice as many foot-pounds per minute as the one horse pulling alone. Hence, they produced twice as much power.

WHAT IS HORSEPOWER?

Back in 1765, when James Watt was working to develop the steam engine into a practical source of power, most heavy work was done by draft horses. When Watt needed a unit of measure to rate his engine against, it was logical that he should consider engine output in terms of the work that could be done by a horse.

Watt's calculations indicated that one horse could raise 330 pounds 100 feet in one minute. (The same figure we have been using.) From this he determined that a power output of 33000 foot-pounds per minute was equal to one horsepower. His formula for horsepower (HP) then became:

$$HP = \frac{\text{DISTANCE (ft) x FORCE (lbs)}}{\text{TIME (minutes) x 33000}}$$

The horsepower calculations for our hardworking horse working all by himself (See Figure 9.)is :

$$HP = \frac{\text{100 feet x 330 pounds}}{\text{1 minute x 33000}}, \text{ or}$$

$$HP = \frac{33000}{33000}, \text{ or}$$

$$HP = 1$$

It makes no difference to horsepower calculations whether the force applied is straight line or rotary. (See Figure 10.) What is important is that the required measurements be correctly determined and consistently applied. An object being dragged over a rough surface, for example (See Figure 10.), will require more force to move it than an object of identical weight being lifted straight up or one being slid over a polished floor. The force required to move an object is usually a combination of the object's weight and the resistance (friction, wind, grade) encountered when it is moved.

The basic formula for determining the horsepower developed by rotary motion is identical to that used in straight line applications. There are, however, some variations which apply to power developed by rotation such as in piston engines, turbines and motors. As needed, these variations will be discussed later in this manual.

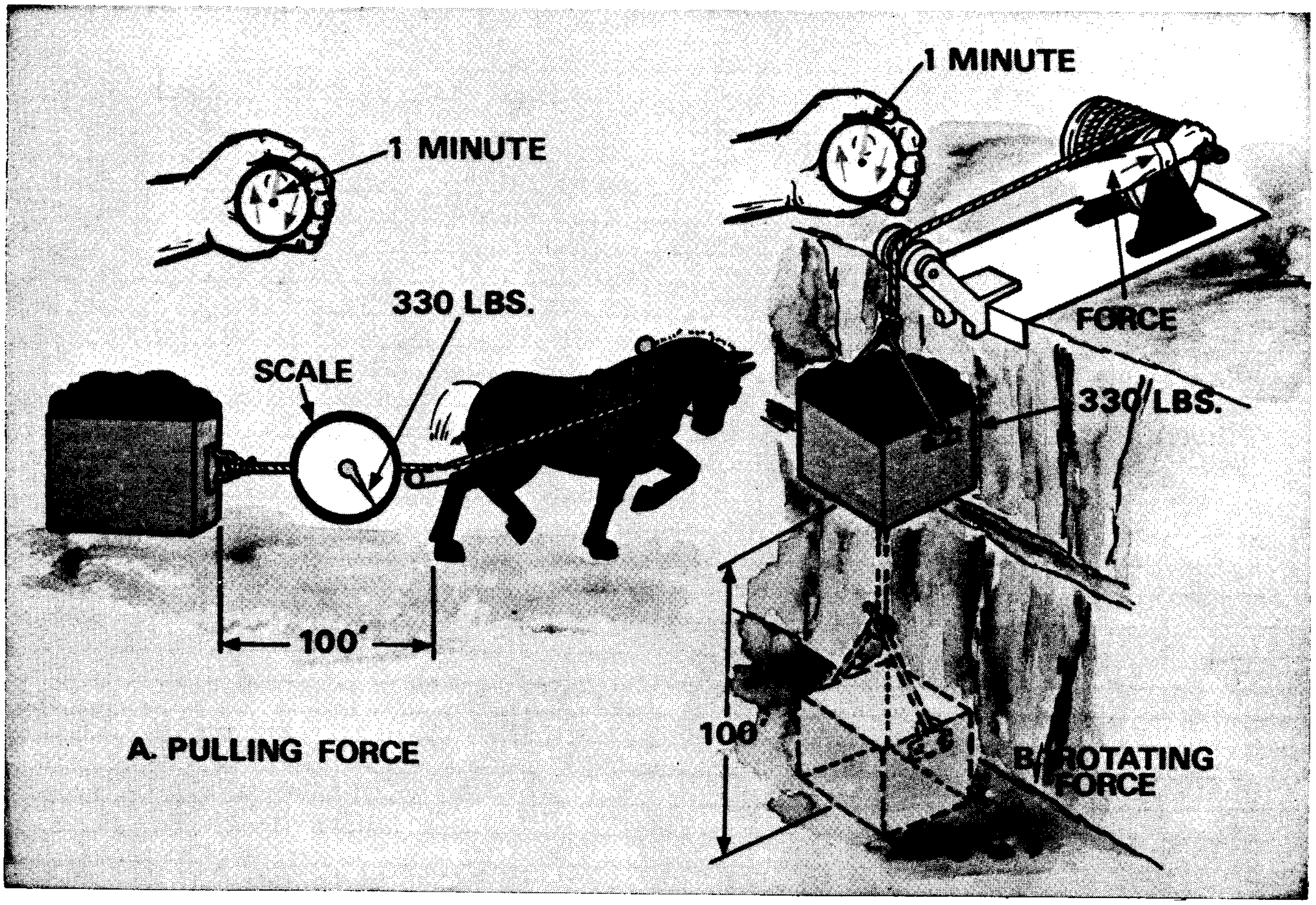


Figure 10. How Horsepower Is Measured.

NOTES

WHEN TROUBLESHOOTING, NEVER ASSUME ANYTHING; ALWAYS BE ABSOLUTELY SURE.

SECTION II

HORSEPOWER, SPEED AND TORQUE IN ENGINES

Internal combustion engines are often referred to as "motors". Although the term is commonly used, it is not absolutely correct. A better choice is engine. In this book, internal combustion engines are referred to as engines. Where they are used, the initials, I.C., stand for internal combustion.

Internal combustion engines are only one of several types of what engineers call "heat engines". Another common heat engine is the steam engine. Steam engines, of course, are external combustion engines. Although each type has its advantages and disadvantages, the great advantage of the internal combustion engine is the flexibility of design and application. Efficient I. C. engines can be made small enough to power model airplanes or large enough to drive locomotives or ships. In the United States alone, millions of I. C. engines of various sizes, capacities and configurations are used to power autos, trucks, tractors, construction machinery, pumps, boats, farm equipment, electric generators, garden tools and lawn mowers.

Each of these many applications have a different set of speed, torque and power requirements. In each case the basic design of the I. C. engine has been altered to suit the special requirements. In one power may be emphasized, in another speed, or economy.

Because of these design variations, you may hear such questions as:

- A salesman told me that this industrial engine has a high torque curve. What does this mean to me?

- My car engine develops 165 horsepower. But, why is my tractor, which has a larger engine, rated on only 76 horsepower?

To be able to answer questions like these, you will need to understand how horsepower, speed and torque are related and how horsepower, speed and torque requirements affect engine design and operation.

ENGINE HORSEPOWER AND SPEED

When we discussed horsepower in the previous section of this book, we noted that one of the factors used in determining horsepower was time. We determined that one horsepower was equal to the power required to raise 330 pounds to a height of 100 feet in one minute. If we cut the time in half, we doubled the horsepower output. Horsepower is thus directly related to speed.

Engine speed is usually measured in terms of revolutions per minute (RPM). The faster the engine turns, the higher the RPM. It might be expected, therefore, that the faster an engine turns, the more horsepower it will develop.

In general this is so. But engines cannot be run at zero RPM's nor anything close to it. After a certain upper RPM limit, they begin to use much of the extra power they develop to just keep moving. As a result, the relationship of horsepower to engine speed is not always the same.

The way horsepower output relates to engine speed shows on the horsepower curve chart which engine manufacturers prepare for each different engine design they produce. (See Figure 11.) The bottom of the chart is scaled to show engine speed in RPM. The left hand vertical scale shows horsepower. The curved line across the chart shows how the horsepower increases with engine speed. Notice that this engine reaches its maximum output (165 HP) at 4000 RPM.

ENGINE HORSEPOWER AND TORQUE

The horsepower curve alone, however, does not present the full story of engine performance. Another curve, the torque curve, is required to complete the picture. (See Figure 12.)

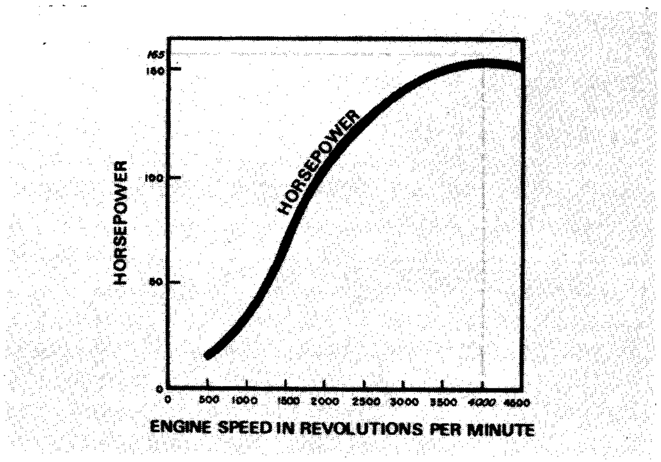


Figure 11. Horsepower Curves.

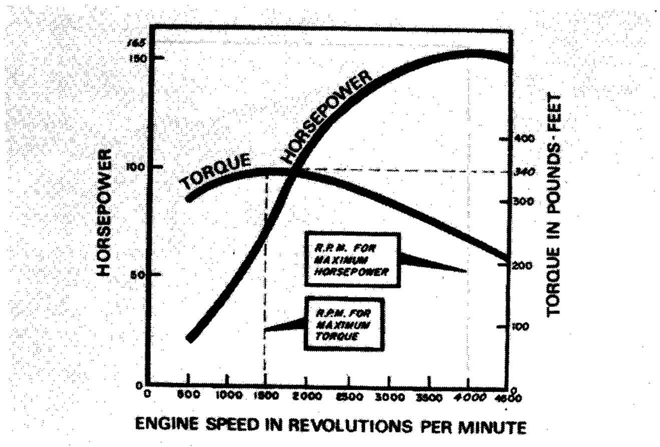


Figure 12. Torque Curves.

The torque curve shows how much torque, in pound-feet, the engine develops at different speeds. Since torque is a kind of force, — a force that produces rotation or tends to produce rotation — the torque curve shows how much turning force the engine is developing at various speeds.

You may have noticed that when an engine is running at a steady speed, it tends to sit motionless. (Except, of course, for any vibration.) But, when it is accelerated, it twists on the engine mounts, turning in a direction opposite to that of the flywheel rotation. Engine torque is what causes the engine to rotate.

A comparison of a stopped, idling and accelerating engine will make the point clear. (See Figure 13.) In the first illustration the engine is shut down. Torque is zero and the engine sits level on its mounts. When the engine is run with a light load — as it would be at idling speed — torque develops, tilting the engine to the left. As the engine speed is increased, torque is increased, and the engine twists further to the left.

Like horsepower, engine torque increases with engine speed. But, again like horsepower, there is a point after which increased engine speed no longer develops additional torque. The torque curve for a typical engine, however, will reach its maximum at a much lower RPM than will the horsepower curve. (See Figure 12.) In the illustration shown, torque peaks out at 1500 RPM; horsepower does not begin to decline until 4000 RPM is reached.

Maximum torque is developed at the point where the engine is operating at top efficiency. Just where this point is in the speed range of the engine depends on features of its design. At very low speeds — 200 to 300 RPM — most spark-ignition engines develop only enough torque to keep running. The net torque — the torque beyond that which is required to keep the engine turning over — is practically zero. If a load is applied, the engine will stall out.

As engine speed increases, however, the net torque rises rapidly until the engine reaches the peak of its efficiency. This comes when the engine is taking in an ideally balanced fuel-air charge, is able to burn the fuel most effectively, and will force out the greatest percentage of the exhaust gases. Maximum torque is developed at the engines most efficient operating speed.

Once the peak of efficiency is passed, torque drops off even though engine speed continues to increase. There are two basic reasons for this decline in torque at higher engine speeds.

1. As engine speed increases, internal friction increases rapidly.

Internal friction is the friction that develops between the moving parts inside an engine — between the piston and the cylinder walls,

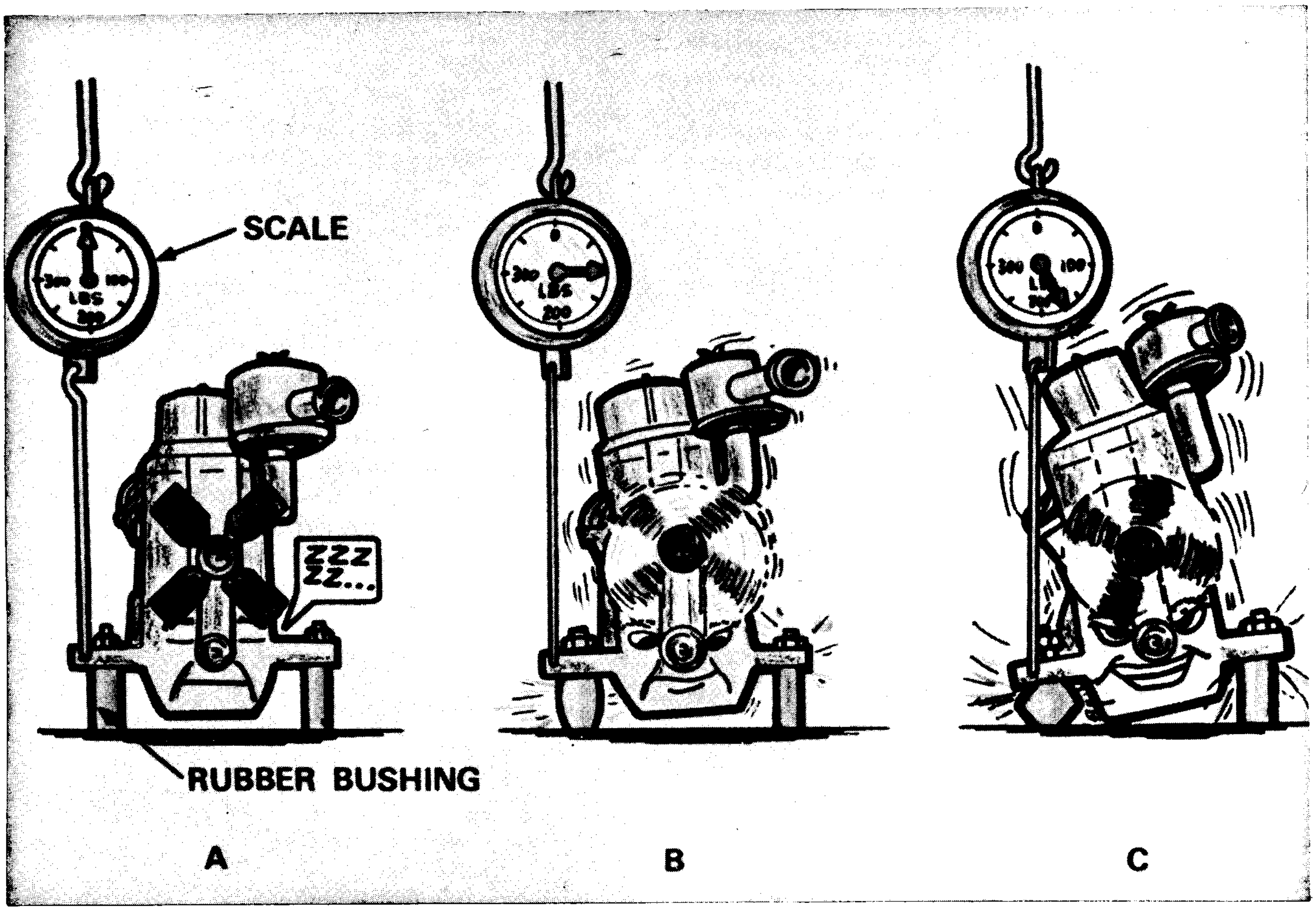


Figure 13. How Torque Develops.

for example. Although good lubricating practices and correct operation will keep friction to a minimum, it cannot be eliminated completely. At high speeds, internal friction is absorbing much of the torque that might otherwise go to the flywheel.

2. As engine speed increases, intake and exhaust breathing becomes less efficient.

An I. C. engine can operate at peak only if it can take in an adequate supply of air and fuel, and only if the exhaust gases from the burned fuel can be completely removed from the cylinder after each power stroke. Since the amount of air and fuel which can be drawn into the combustion chamber through a standard carburetor is to some extent limited by how much time the intake stroke allows, it is obvious that if the stroke is too fast, not enough air and fuel will get into the cylinder. Too rapid an exhaust stroke will not allow time for the chamber to be cleared. At high speeds, therefore, the size of the air-fuel charge drops and the percentage of unexhausted gases remaining in the combustion chamber increases. The result is a loss of power and a decrease in torque.

The comparison of how much air-fuel mixture is drawn into the combustion chamber during a given intake stroke with how much the chamber is capable of holding is called volumetric efficiency. Once the best operating speed is reached, volumetric efficiency begins to decline, and consequently, so does torque.

Low volumetric efficiency can be partially overcome by use of a supercharger or turbocharger, or by use of a multi-barrel carburetor.

Both superchargers and turbochargers improve volumetric efficiency by using a fan to force air into the intake manifold of the engine. (See Figure 14.) On the supercharger, the fan is driven by a gear within the engine. On a turbocharger, the fan is powered by the flow of exhaust gases coming from the engine.

Superchargers or turbochargers can be used on either spark-ignition or diesel type engines.

Multiple-barrel carburetors (See Figure 15.) are often used on engines where there is a sudden demand for power. Under these conditions the standard single-barrel carburetor provides too much restriction to air flow for the fast acceleration needed in the engine. Consequently, manufacturers also make available both two-barrel and four-barrel carburetors. As the air-fuel demand becomes greater (when the engine runs under heavier loads), the extra barrels open up to supply the additional air-fuel mixture that is required. The engine can then maintain its power at higher speeds.

Practically all of the smaller industrial and tractor spark-ignition type engines are equipped with single-barrel carburetors because they are less costly and provide better fuel economy. Occasionally, a two-barreled carburetor may be used, but very rarely will a four-barrel carburetor be used. Two- and four-barrel carburetors are more common on automobiles and highway trucks.

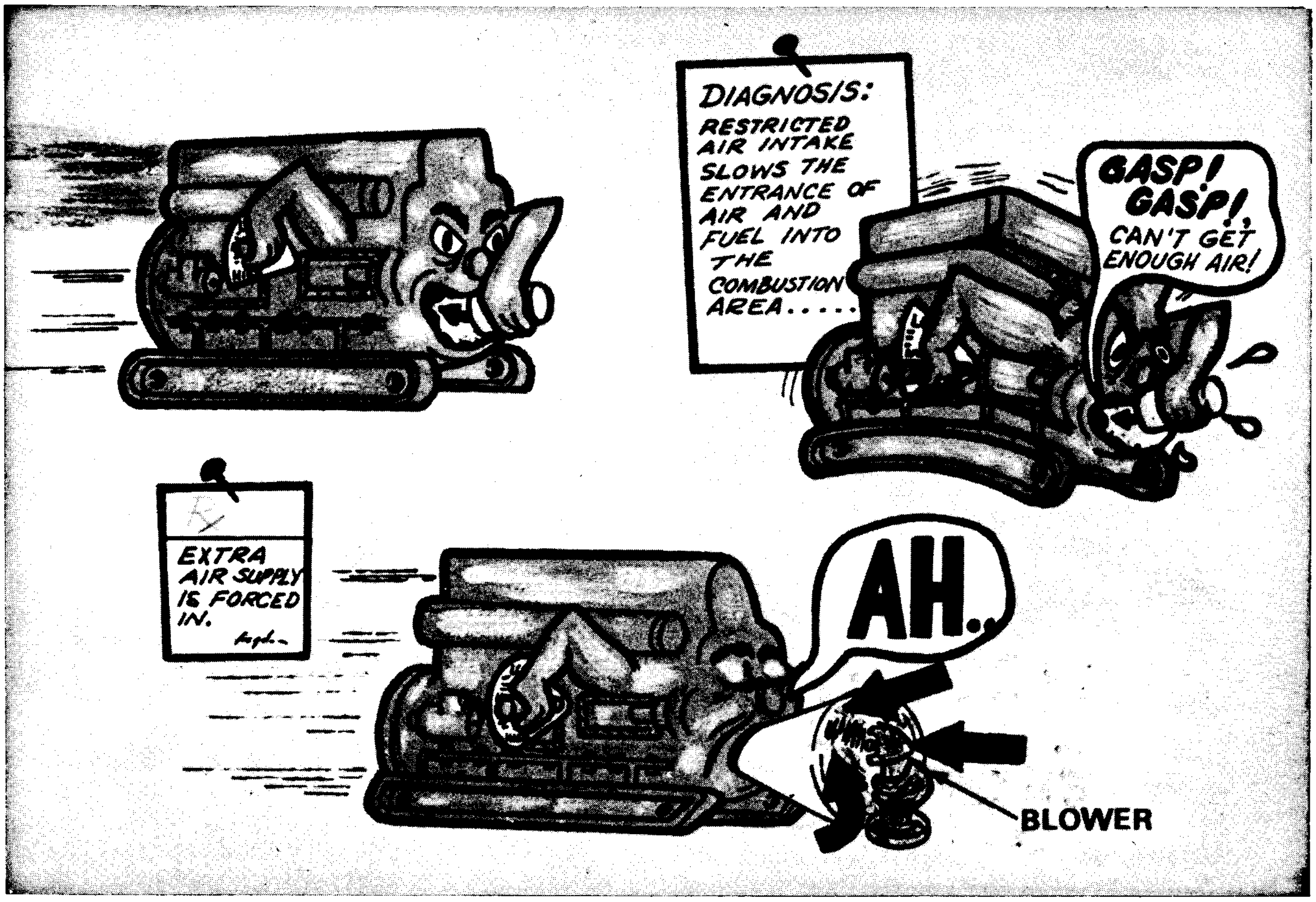


Figure 14. Horsepower, Torque and Intake Air.

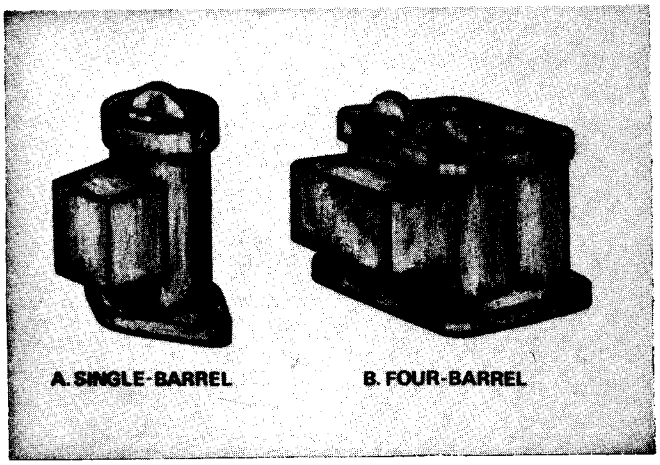


Figure 15. Features Of Carburetor Design.

POWER CURVES AND "TORQUE RESERVE"

Most manufacturer's power curves call for a rated operating speed which is somewhat higher than the speed at which peak torque is produced. The reason is simple. When an engine is suddenly loaded, operating speed drops immediately. By rating operating speed higher than peak torque speed, a "torque reserve" is created. As engine speed drops under load, it slips back toward peak torque speed and, thus, torque increases. If the load is too great, and the "torque reserve" is insufficient, engine speed will continue to drop until the engine stalls.

To make sure the "torque reserve" is large enough for most applications, engine manufacturers usually rate their engine's top operating speed at 200-500 RPM higher than peak torque speed. Where heavy loading is to be expected – such as on farm tractors – the rated operating speed may be 800-1000 RPM higher than peak torque.

In this section we have tried to make clear the differences between horsepower and torque, and to explain some of the basic terms used in discussing engine theory. The principles we have outlined above apply to all I. C. engines, regardless of size, power or number of cylinders.

Torque and horsepower are confusing terms and the relationship between them is often misunderstood. In selecting an engine for a particular application, both the horsepower and the torque ratings should be considered. How the two relate to one another can be important in determining if an engine is capable of doing the work for which it was intended.

NOTES

SECTION III

PRINCIPLES OF OPERATION

This section will cover the principles of operation of a two stroke cycle engine.

A. GENERAL

It is often misconceived that an automobile engine must work much harder to accomplish its purpose than a small, one cylinder engine. (See Figure 16.) According to the Briggs & Stratton Corporation, a comparison between an automobile engine and a 3 to 5 HP, single cylinder, air-cooled engine, has proven that if the single cylinder engine was run at 3/4 to full throttle for eight hours per day for a 30 day period, it would be equivalent to approximately 20,000 miles of wear on the automobile engine. At this rate, it is safe to assume that many small engines being used for commercial purposes are logging over 100,000 miles of wear in a 6 month mowing season. Given proper care an automotive engine run for 20,000 miles has had a great deal of servicing. It has had an oil check each week, the oil has been drained and replaced numerous times, and new oil and air filters have been installed. The points, plugs, and condensers have been changed at least twice and grease jobs have been performed regularly. In this multi-cylindered engine, if one of the six or eight cylinders is not producing the power that it was designed to produce, the other cylinders attempt to compensate for the power loss. The one cylinder engine, of course, has no helpers and is required to carry the full workload. It is evident, therefore, that even more than the automotive engine, a small engine requires regular preventive maintenance.

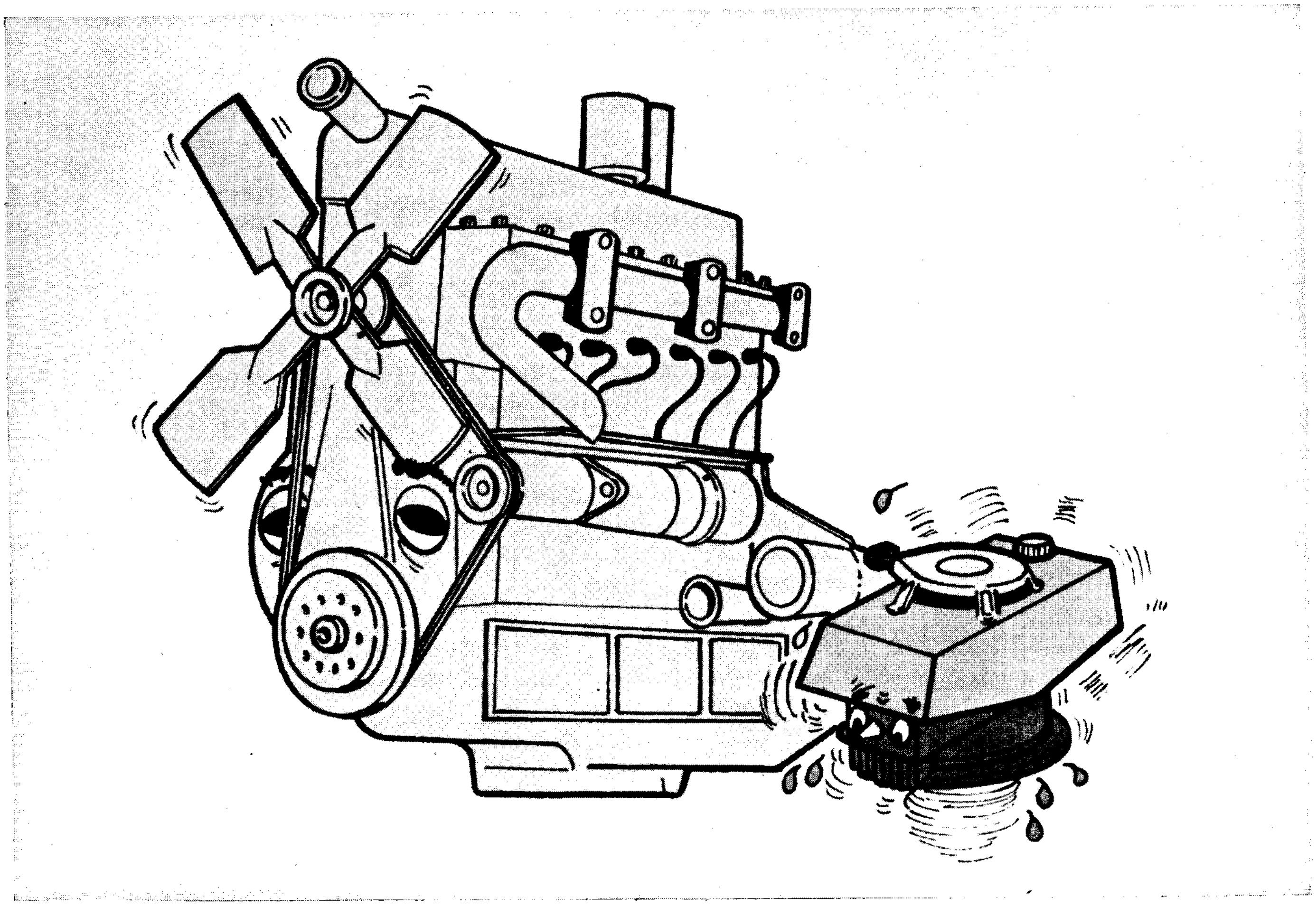


Figure 16. Which Works Harder?

The complete preventive maintenance program suggested however, is too often the exception rather than the rule. The theory, in the mind of the average individual, appears to be that the piece of equipment representing the greater dollar investment deserves the greater attention. The fallacy of this theory appears when we consider that a man must work an equal amount of time for each dollar invested in a $100.00 dollar lawn mower, as he must for each dollar in his $3,000.00 automobile. This all simply goes to illustrate that your lawn mower is just as deserving of a complete program of preventive maintenance as any other piece of mechanical equipment that you own. You can expect to receive maximum life and reliability from your lawn mower, only if you conscientiously apply such a program.

B. 2-CYCLE VS 4-CYCLE

Whether you are the owner of a low horsepower, air-cooled, one-cylinder engine, or are considering making such a purchase in the future, you may be interested in some of the basic differences between a two stroke cycle and a four stroke cycle engine of equal horsepower.

Consider the following comparison:

DESIGN CHARACTERISTICS	4-CYCLE (EQUAL HORSEPOWER) ONE CYLINDER	2-CYCLE (EQUAL HORSEPOWER) ONE CYLINDER
1. Number of major moving parts.	9 major parts to wear, maintain and replace.	3 major parts to wear, maintain and replace.
2. Lubrication Design.	Splash or pump. (The same oil is used over without filtering.)	Spray. (Used one time only - new oil induced for each revolution of the crankshaft.)
3. Number of complete crankshaft revolutions necessary to produce one power stroke.	2 revolutions. (Some moving parts make 1 extra revolution at which time only wear is produced - no power.)	1 revolution. (More usable power, faster acceleration.)
4. Versatility of operation.	Limited slope operation. (Bearings receive less lubrication when engine is tilted at an angle.)	Lubrication is not affected at any degree of angle. (This is due to lubrication design.)
5. Weight and size of engine for equal cubic inch displacement (power output).	Heavy in lbs. and bulkier in size in relation to power output.	Relatively light and small in relation to power output.
6. Ease of starting.	Two complete revolutions of the crankshaft are required to produce one ignition phase.	One complete revolution on the crankshaft produces one ignition phase. (Half the effort is required when pulling the starter cord.)

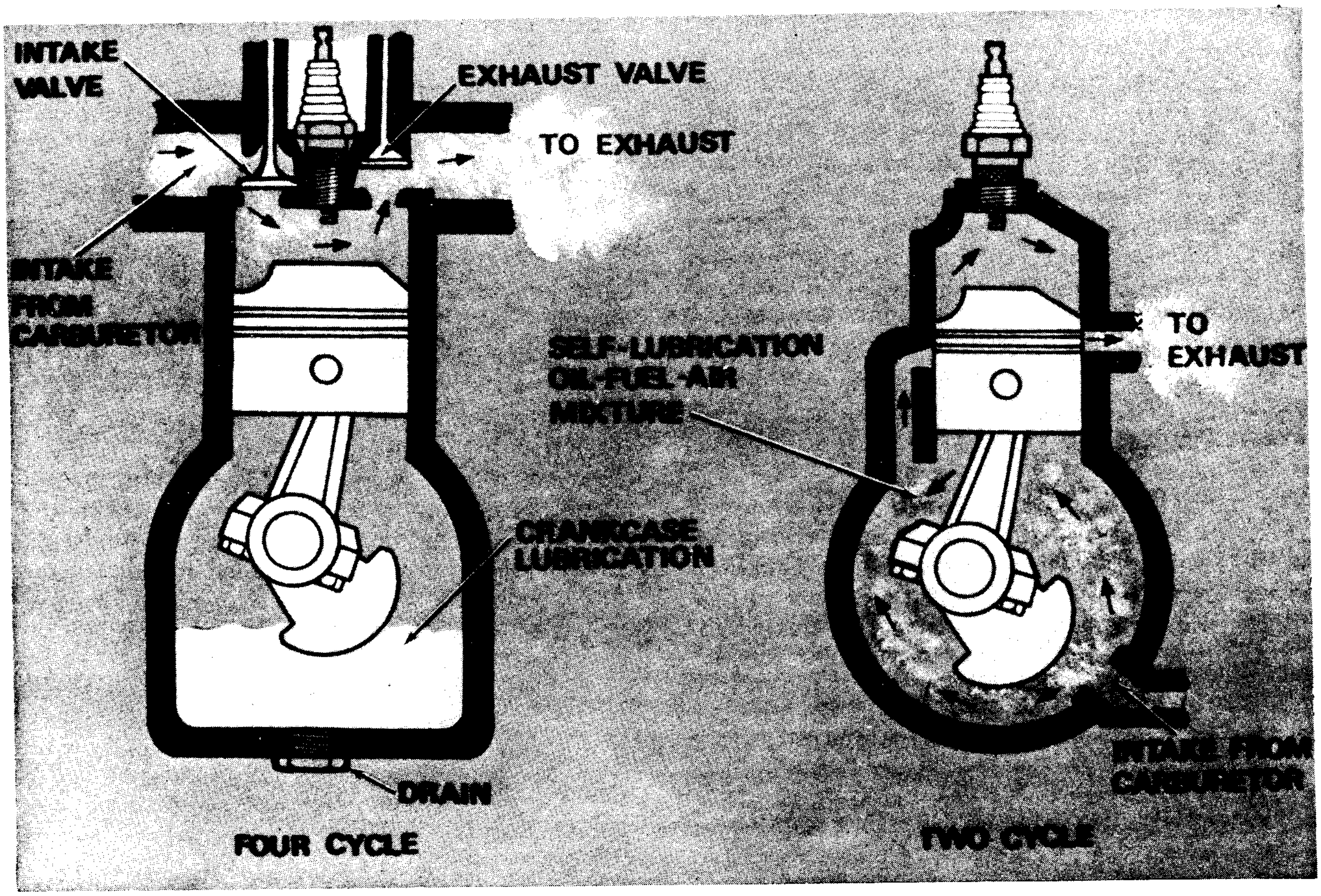


Figure 17. 2-Cycle And 4-Cycle Engines.

While several points have been shown where a 2-cycle engine is superior to a 4-cycle, it should be pointed out that a 4-cycle engine will give better fuel economy. However, you will probably agree that fuel economy is the least important of the specifications listed above, for lawn mowing or snow removal equipment. (See Figure 17.)

C. THEORY

To gain an understanding of the basic theory of combustion, magnetism, carburetion, cooling, and the intake and exhaust system, each component part will be covered in detail. (See Figure 18.)

1. Piston Travel.

With each revolution of the crankshaft on a 2-cycle engine, two strokes of the piston take place – one up and one down. When the piston moves up, from bottom to top in the cylinder bore, the intake and compression phase occurs; and when the piston moves down, from top to bottom in a cylinder bore, the power and exhaust phase is produced. The 4-cycle engine requires four strokes of the piston (two up and two down), or two revolutions of the crankshaft to produce these same phases.

As any engine part moves, there is a wear factor present. Due to this wear factor, minute metal particles are constantly contaminating the lubricating oil in the crankcase of the 4-cycle engine. However, since the lubricating oil in a 2-cycle engine is mixed with the fuel and burned during combustion, the problem of operating in contaminated oil is not present.

There are only three major moving parts in a one cylinder, two stroke cycle gasoline engine. They are: the piston, the connecting rod, and the crankshaft. Aside from these three major moving parts, there is also a reed valve, which closely resembles the reed used on the mouthpiece of a saxophone. When pressures on the top and bottom side of the piston are alternated, due to the upward and downward movement of the piston, the reeds open and close. This allows air and fuel to enter the crankcase and be pumped to the cylinder bore. The compression, ignition, and exhaust phases of the engine take place in the cylinder bore. The reeds, in conjunction with the intake and exhaust ports (holes bored in the side of the cylinder walls), perform the same function as the exhaust and intake valves on a 4-cycle engine.

The intake stroke begins when the piston moves from the bottom of the cylinder, and continues until the piston reaches the top of the cylinder. (See Figure 19.) The upward movement of the piston causes a partial vacuum to be created at the bottom of the piston. The vacuum draws the reed valve open and allows fuel and air from the carburetor to enter the crankcase. On the next stroke, the fuel and air mixture will be pumped, by crankcase pressure, into the cylinder. The compression phase of this stroke begins as the top of the piston seals off the intake and exhaust ports, and continues until the piston reaches the top of the cylinder. (See Figure 20.) Near the end of the forward movement of the piston, ignition phase occurs. During ignition phase, the fuel and air which was compressed is ignited by a spark. This ignition causes the burning gases to expand and drive the piston downward. The reciprocating movement of the piston is transferred through the connecting rod to the crankshaft, producing a rotary motion. While the piston is moving downward, but before it uncovers the intake ports, the exhaust ports are opened to allow the tremendous pressure created by the burning fuel to escape.

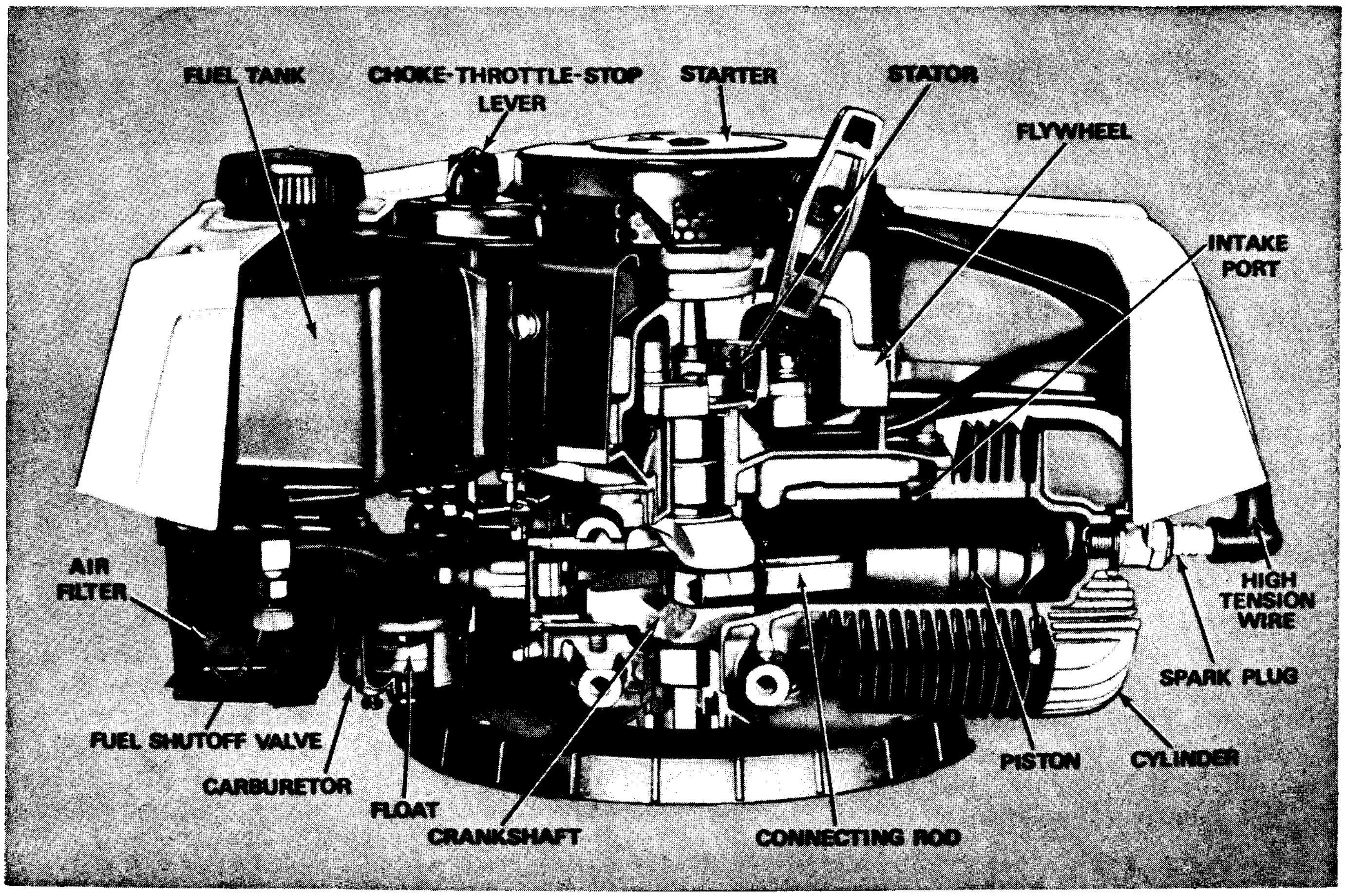


Figure 18. Jacobsen Engine Cross Section.

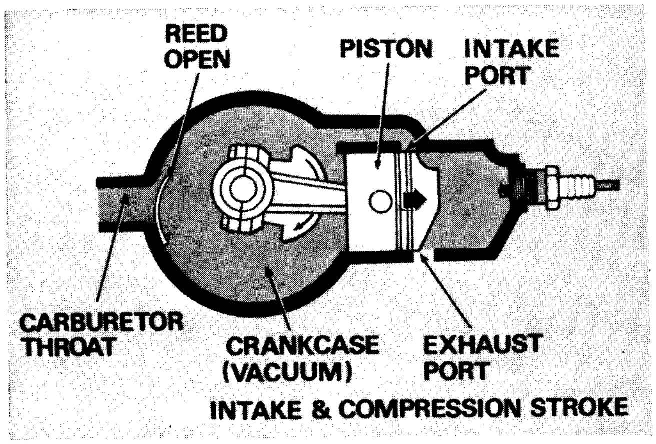


Figure 19. Intake and Compression Phase.

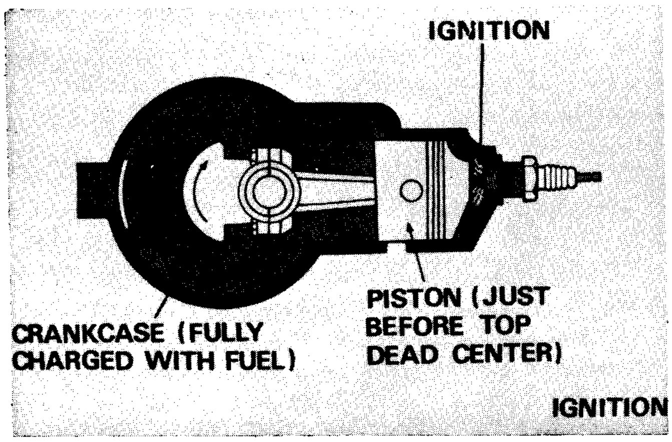


Figure 20. Ignition Phase.

(See Figure 21.) After the exhaust ports have opened, the intake ports are also exposed. At this point, the downward motion of the piston causes a pressure to develop in the crankcase, which is greater than the exhaust pressure at that piston position. As the cylinder begins to refill with pure fuel and air, the remaining exhaust gases are driven out of the cylinder thereby completing the second and final stroke of the two stroke cycle.

Carburetion is accomplished by the mixing of gas and air as they pass through the carburetor. The average mixture, under normal operating conditions, is approximately 15 pounds of air to 1 pound of gasoline by weight, (this is approximate-

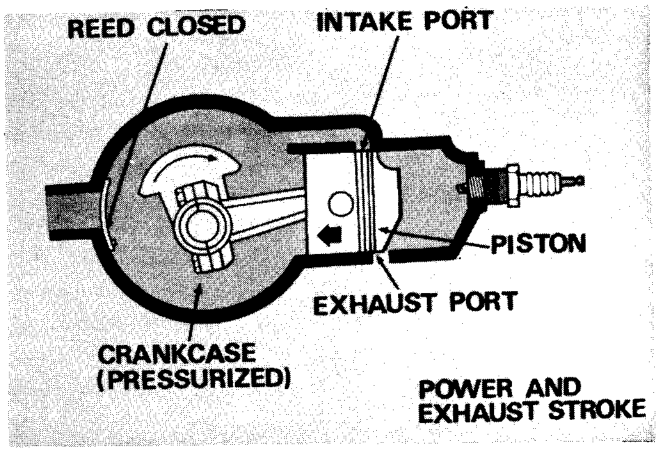


Figure 21. Power and Exhaust Phase.

ly 9,000 parts of air to 1 part gasoline by volume). An incorrect carburetor adjustment may change this ratio to as great a degree as 10 to 1, which in turn would cause the engine to "run rich". An engine that is "running rich" is characterized by lack of power, excessive smoking, and rapid carbon build up. At the other extreme, an engine "running lean" will cause the engine to get hot and possibly stall, or lack power under load conditions. In either case, it is evident that an incorrect carburetor adjustment can cause an engine to deteriorate rapidly, to be under powered, and to be incapable of handling its work load.

2. Carburetor.

The forward movement of the piston draws air through the carburetor like a pump. (See Figure 22.) The top of the piston compresses fuel and air in the cylinder, while the partial vacuum created in the crankcase draws fuel and air from the carburetor. If the engine in this illustration were to be operated at 2000 RPM, the bottom of the piston would be drawing fuel and air into the crankcase at 2,000 strokes per minute. This would yield a ratio of a set volume of air times 2,000, (the set volume would be determined by the diameter of the bore and the stroke of the piston). This set volume of air (B), moving through a large opening at the beginning of the carburetor, reaches a narrowed portion in the carburetor throat which is called a venturi (A). The function of the venturi is to cause a drop in

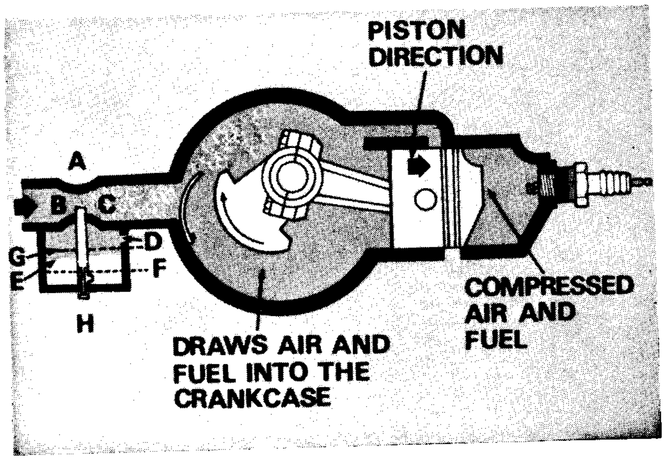


Figure 22. Carburetor Fuel And Air Mix.

atmospheric pressure. This principle of design is much the same as that of an airplane wing, or the sail on a sailboat. Fuel is drawn into the middle of the low pressure area (C), through a tube in the venturi which extends down into the float bowl housing (fuel storage area). When the set volume of air (B), is forced through the low pressure area (C), it increases in velocity (speed) so that the set volume may pass through in the same elapsed time as it passed through the original carburetor opening. The pressure drop occurs as the velocity of the air increases. This drop in pressure in the venturi, coupled with the earth's atmospheric pressure (D), (13 to 15 pounds per square inch), causes the fuel in the carburetor to be forced up through the tube in the venturi and mix with the air passing through it. If the fuel level (E), in the float bowl housing were lowered to level (F), but the pump speed of 2000 RPM, the pressure in the venturi and in the earth's atmosphere remain constant, fuel would then have to be forced a longer distance to the venturi. This would cause problems because the engine would then be running too lean on fuel for the amount of air being delivered to the carburetor, and would cause overheating of the engine, and stalling under heavy work loads. If, while using the same 2000 RPM pump speed, the fuel level were raised above the normal level in the float bowl housing to level (G), the opposite condition would occur. In this case, an excessive amount of fuel in relation to the amount of air being used would be drawn into the venturi of the carburetor due to the short distance that the fuel has to travel. This condition would cause the engine, which would then be "running rich", to smoke excessively, foul plugs, and build up with carbon rapidly. The engine would also lack power, since gasoline will not burn in a liquid form. This illustrates the necessity to maintain the correct float level in the float bowl housing, since the distance the fuel travels to reach the venturi of the carburetor should be the same in all stages of operation.

The carburetor is calibrated to limit the amount of fuel being delivered to the air in the venturi of the carburetor. This is necessary when pressure drops take place during engine acceleration from low to high throttle ranges. If an engine is operating at 3600 RPM, the pump's speed necessarily is 3600 RPM. At this rate, the volume of air moving through the venturi is greater and forces a greater drop in pressure. This drop in pressure offers less resistance to the earth's atmosphere, which can in turn deliver a greater fuel load in relation to the volume of air. Air becomes lighter and thinner in density at high velocity speeds and the fuel load would then be too great for the thin air. This will cause the engine to perform improperly as the fuel to air mixture will be too rich. This illustrates the necessity for a correct calibration of the carburetor.

3. Correct Calibration.

The carburetor calibration must meet the mixture requirements for transient conditions, i.e. conditions at which speed, load, temperature, or atmospheric pressure are abnormal or changing rapidly. Prior to the "fixed jet" carburetor calibration (that offers optimum fuel-air ratios for transient conditions), "fine-tuning" of the calibration was accomplished by mixture valves.

The fixed jet carburetor is "fine-tuned" for life during manufacture.

Since the volume of air moving through the carburetor is low and the pressure drop minor when an engine operates at a low RPM range, the carburetor is equipped with a separate system to supply fuel during low throttle range operation. Even though this feature is designed into the carburetor, excessive low speed operation of an engine causes two adverse effects: First, the engine does not do a thorough job of burning the fuel and air mixture, because at low speeds the fuel is delivered in a semiliquid state rather than in a fine vapor. This will cause excessive smoking and rapid carbon build up. Second, engines are designed to cool themselves at normal operating speeds. "Idle speed" is not considered normal, and the operating temperature of the engine will rise if the engine is allowed to idle for an extended period of time. Excessive heat will cause serious friction problems and result in high maintenance costs and a short engine life.

4. Crankcase (Pump).

The crankcase on a 2-cycle engine, as illustrated in the previous figures, operates on much the same principle as a two-way action pump. It could also, except for its location on the engine, be compared to the fuel pump on your automobile. On your automobile it is located before the carburetor, but on a small 2-cycle engine it is located after the carburetor. The function of the crankcase of a 2-cycle engine is to pump the carburetion phase, (fuel mixed with air), to the cylinder where compression and ignition take place. The efficiency of the crankcase as a pump is governed by: The effectiveness of the piston and rings as a seal on the cylinder bore, the condition of the seals in the crankshaft, the condition of the gaskets between any two pieces of metal ahead of the carburetor, and the opening and closing of the reed valve. Any air leak at a seal or gasket destroys the correct air to fuel ratio for good combustion. (See Figure 23.) The longer, faster and harder an engine runs with an air leak, the greater the affect it has upon correct air to fuel ratio. All air should pass through the carburetor and be mixed with the correct amount of fuel for that volume of air. However, if air alone is allowed to enter the engine anywhere ahead of the carburetor, the air to fuel ratio will be thinned out by adding more air to the mixture without supplying more fuel. This will starve the engine for fuel and cause a temperature increase on the metal engine parts.

5. Air Ratio.

According to the petroleum industry, the ideal air to fuel ratio should be 15 parts air to 1 part fuel by weight. Fuel and air will be combustible anywhere from as rich as 8 to 1. When an extreme air leak develops in an engine, the ratio will exceed 18 to 1 and combustion will not occur. Therefore, operating at extremes to the 15 to 1 air to fuel ratio is damaging to an internal combustion engine. From the above information, it should be easily understood that if the pump is not working at its maximum capacity, the engine will not receive the amount of fuel necessary for easy starting, and will not perform as it should under a variety of power demands.

After the operation of pumping fuel to the cylinder has been completed, the compression phase of the engine occurs. During this phase, air and fuel are squeezed into a confined area where the mixture is then ignited. (See Figure 24.)

The compression ratio of the 321 engine is 5 to 1. This means that if five cubic inches of air were in the cylinder, (with the piston at the bottom of its stroke), by the time the piston reached the

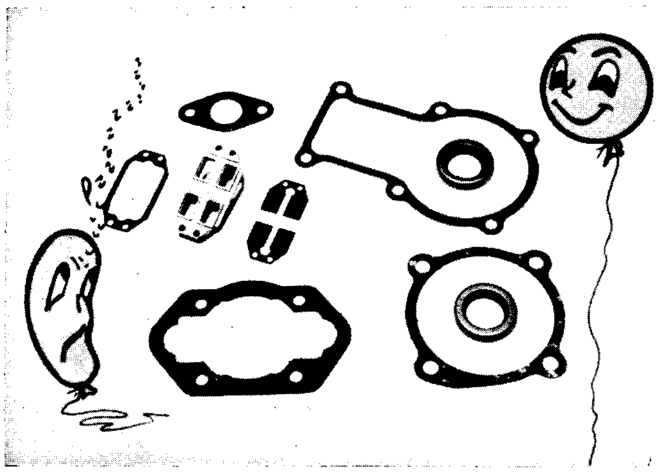


Figure 23. Air Leaks—Incorrect Air To Fuel Ratio.

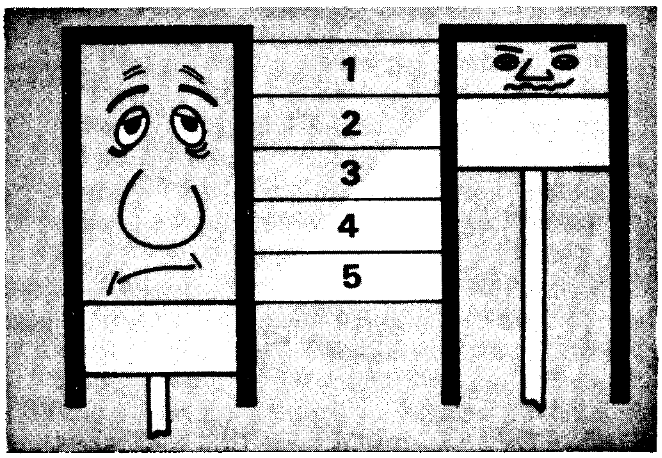


Figure 24. Compression Ratio.

top of its stroke, the five cubic inches of air would be compressed to one cubic inch by volume.

Maximum compression of an engine is dependent upon the following: Wear factor between the piston and rings and the cylinder bore, the condition of the head gasket, and the amount of carbon build up in the combustion chamber. A higher than normal compression reading indicates that such a carbon build up is present.

6. Magnetism.

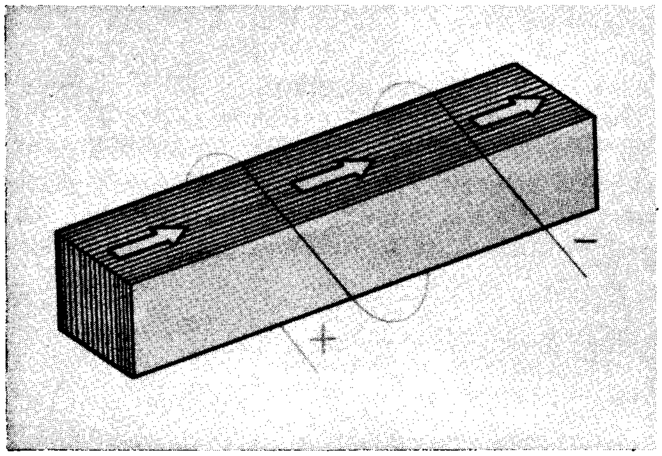


Figure 25. Basis Of A Magneto.

To gain an understanding of how spark is produced in the magneto ignition system, we must first examine the principles of magnetism, and the way in which these principles relate to electricity.

One of the most basic and useful facts relative to electricity and magnetism is that there is a close relationship between them. (See Figure 25.) Every time an electric current flows, it sets up a magnetic field. Conversely, if a magnetic field is increased, decreased or changed in direction, an electric voltage is set up in any nearby conductor.

This principle is the basis for the operation of an electric generator, and a magneto is simply a specialized type of generator. In a magneto, permanent magnets are used to produce a magnetic field in one direction through the iron core of a coil, and then act to reverse the field direction, thereby creating a voltage in the windings of the coil.

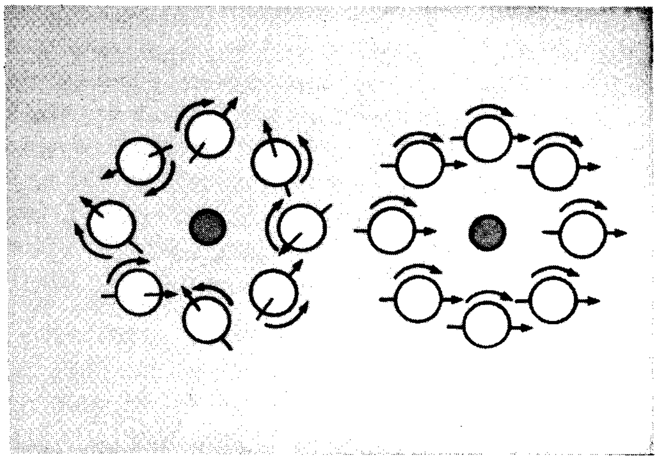


Figure 26. What Is A Magnet?

Any time a current passes through a coil of wire around a piece of iron, it turns the iron into an electro-magnet. (See Figure 26.) If the iron is hardened, it will retain a certain amount of magnetism after the current is shut off. In fact, the newer, hard alloys retain a very large portion of the magnetism and are nearly as strong as permanent magnets. Magnetizing an iron core lines up the axes of the electrons in one direction so that their separate forces act together. In a hardened piece of iron, the axes of the electrons remain lined up after the electric current stops flowing, and the piece of iron becomes a permanent magnet with established North and South poles.

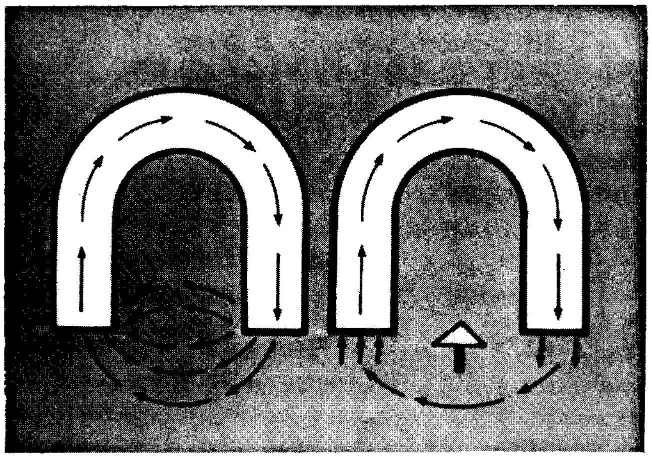


Figure 27. The Magnetic Field.

The field of a magnet is its area of magnetic influence, concentrated between its respective North and South poles, and is particularly strong within the iron core. (See Figure 27.) This principle forms the basis on which a magneto operates. The core leads the magnetic field through the path chosen by the magneto designer and concentrates itself inside the coil.

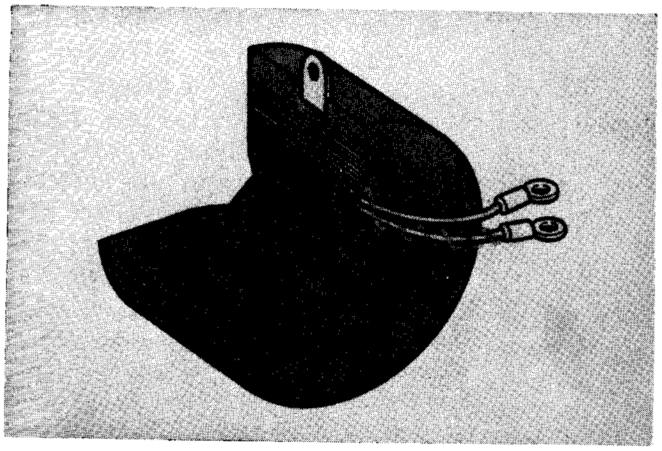


Figure 28. The Magneto Coil.

A magneto coil generates and transports electricity. (See Figure 28.) It consists of a primary and a secondary winding of wire. The primary, made up of about 175 turns of heavy wire next to the core, is connected to the frame of the magneto as ground, and at the other end to the live insulated breaker points. The secondary, of about 10,000 turns of fine wire outside of the primary, is grounded on one end with the primary and on the other end it is connected to the spark plug wire. This creates a circuit which captures the electricity produced by the magneto and delivers it to the spark plug.

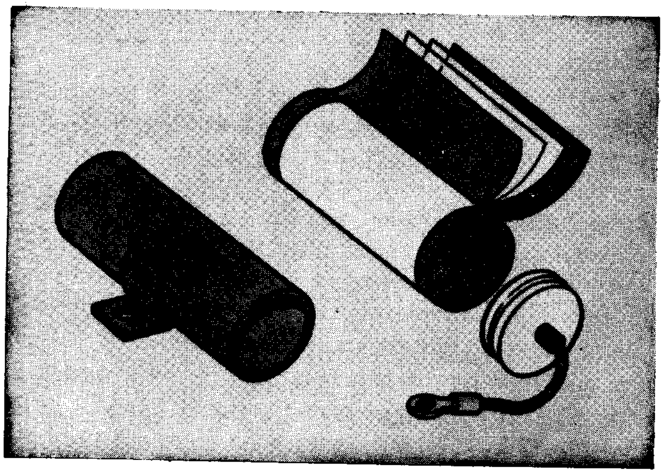


Figure 29. What Is A Condensor?

A condenser is a storage reservoir for electricity, made up of two strips of foil with paper insulation between them. (See Figure 29.) One strip is grounded – the other is connected to the live breaker point. When the points are open, the condenser paper acts as a storage reservoir or "surge tank" for electricity.

The iron core, in which magnetism is concentrated – and rapidly reversed from one direction to the other – is split up into many thin laminations. This prevents the build up of any one large electrical path for an eddy current. The slight amount of oxide between laminations provides enough insulation to prevent the circulating currents called eddy currents from traveling from one lamination to the other.

7. Magneto.

Now apply the principles of magnetism to the WICO-Flywheel magneto which is utilized on the Jacobsen 321 engine.

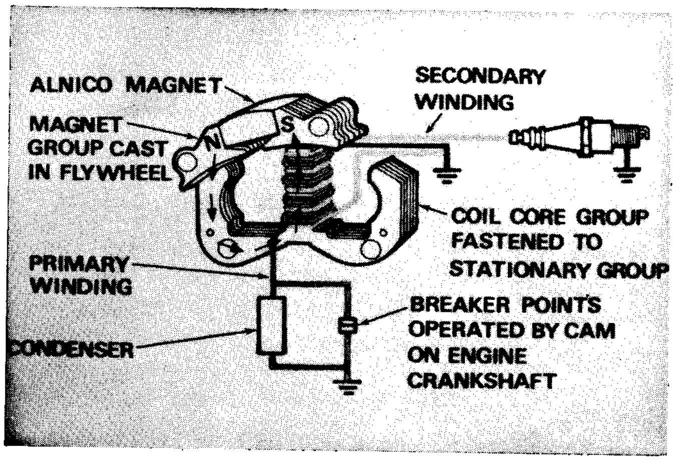


Figure 30. Magneto – Points Closed.

As the flywheel rotates, the magnet group gradually reaches a point adjacent to the coil core so that a magnetic path is completed through the coil wire. (See Figure 30.) As this path is completed the flux (illustrated by arrows) through one section of the coil core is gradually built up to a maximum value. Two legs of the coil core are fully covered by the poles of the magnetic group. At this point the breaker cam allows the points to close. Since the magnetic air gap is constant, however, there is no change of flux and, consequently, there is no current flowing in the primary.

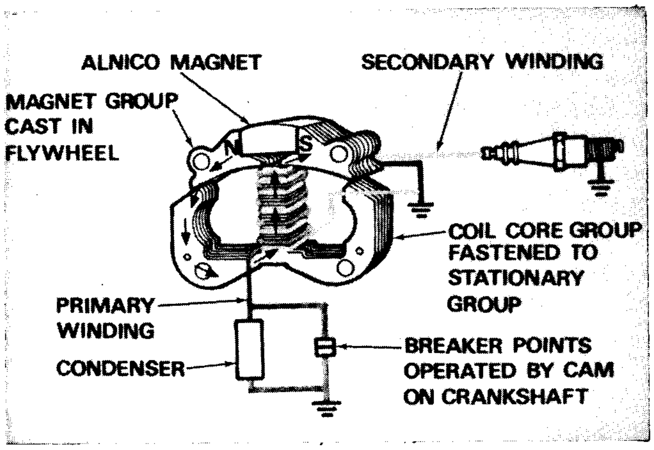


Figure 31. Magneto – Current In Closed Primary.

Turning the flywheel diminishes the area of the coil core legs covered by the magnet group, resulting in a constantly decreasing strength of the magnetic field. (See Figure 31.) This change in flux throughout the iron core causes the electrical energy to flow in the closed primary circuit. Throughout the interval before the opening of the breaker points, a change in the flux is prevented by the current in the primary.

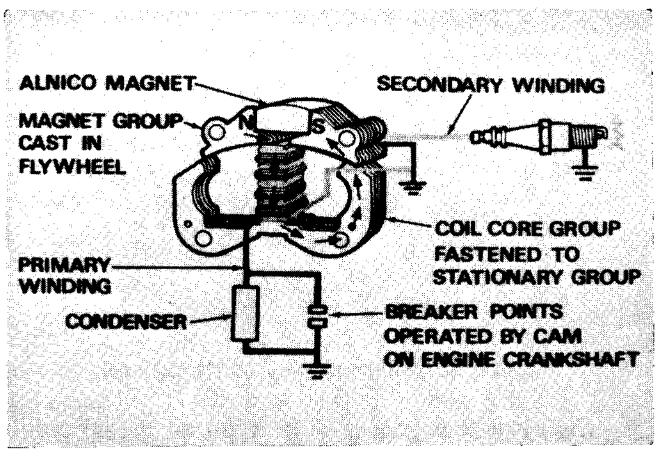


Figure 32. Magneto – Points Open.

At this point the cam opens the breaker points. (See Figure 32.) The choke effect of the coil is removed and there is a rapid change in flux. The opening of the points causes the primary voltage to rise very rapidly. This increase in voltage tends to make an arc across the points. To prevent this arcing, which is very damaging to the points and which would continue the choke action on the flux, a condenser is connected across the points. The energy which would normally be discharged across the opening gap at the breaker points rushes into the condenser.

When the point opening is large enough to make an open circuit, the energy which went into the condenser is discharged back through the primary coil to ground. This discharge back through the primary aids the rapid change and reversal of flux. This flux reversal in turn induces a high voltage in the secondary. This voltage becomes sufficient to overcome the resistance of the spark plug gap, resulting in a spark discharge. As soon as the flow of current has been established across the gap, the resistance of the gap decreases and the secondary continues to discharge the voltage oscillating downward, until there is not enough voltage to maintain the flow of current across the spark gap.

8. Spark Plugs.

With an understanding of the magneto system, we may now proceed to point out the various parts necessary to make spark available. They are: The flywheel magnet, the coil, the breaker points, the cam, and the condenser. The condition of these parts, as well as the adjustment of the points and the timing of the magneto, will determine the maximum voltage that the magneto will produce at various speeds of operation. The magneto utilized in the Jacobsen 321 engine has the potential to produce approximately 25,000 volts, which is 5/6 of the potential available in an automobile ignition system. Characteristically, the faster the magneto flywheel turns, the higher the voltage it can produce.

Although the potential of the magneto is 25,000 volts, it will only produce the amount of voltage necessary to cause a spark to jump the gap between the electrodes of the spark plug. The condition of the spark plug is the factor which determines the amount of voltage to be produced by the other components of the electrical system. As the spark plug wears, (through erosion caused by combustion of the fuel and its by-products), more voltage is required to make it "fire". (See Figure 33.) If a new spark plug in an automobile requires 5,000 volts to fire, after approximately 10,000 miles the same plug may require about 10,000 volts to fire. If, due to an incorrect point gap setting, a small engine required 10,000 volts to fire the spark plug, a slow pull on the starter cord (producing less than 10,000 volts) would not offer enough voltage to start the engine.

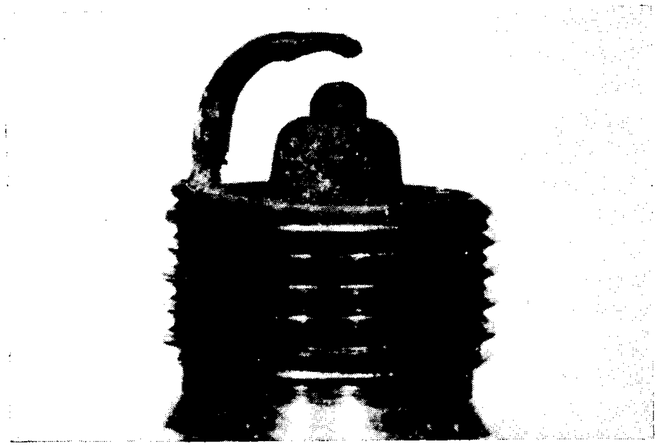


Figure 33. Eroded Spark Plug.

Quite often when a small engine is difficult to start, the spark plug is assumed to be at fault, and is subsequently replaced. This is not always a good practice since the problem often lies in the spark producing components rather than in the spark plug itself. Changing the spark plug will merely lower the voltage required to fire it from 10,000 to 5,000 volts. Continuous changing of the plug, without servicing the inside of the cylinder and exhaust ports, will eventually cause a severe carbon contamination problem. Excessive carbon deposits on the spark plug will cause the engine to be difficult to start, but a new spark plug is not always the answer to the problem.

Changing to a "hotter" spark plug range than is specified by the engine manufacturer is another common practice which should be avoided. (See Figure 34.) While this may eliminate some of the build up problems on the spark plug, other more serious problems will eventually appear. Spark plug deposits are most often caused by a weak magneto voltage output, incorrect carburetor adjustment, poor air cleaner maintenance, incorrect fuel or oil, or fuel and oil mixed in incorrect proportion. The gas to oil ratio recommended by the manufacturer of a 2-cycle engine should be followed closely. Anything other than the mixtures specified will not allow for thorough, clean burning of the fuel.

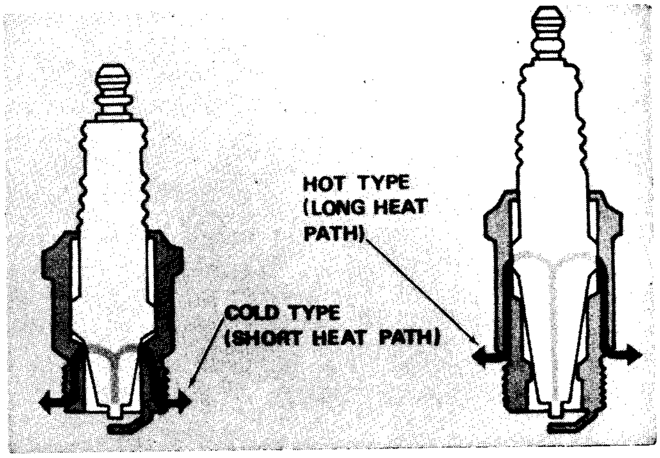


Figure 34. Spark Plug Range.

9. Ignition System.

To determine whether the ignition system of a small engine is functioning properly, the following procedures should be followed: First, examine the thin ignition ground wire to be certain that it is not grounding out the ignition system. Then check the spark plug wire for voltage leaks (cuts in covering), where the wire comes in contact with metal. Next, remove the spark plug from the cylinder head and examine the condition of the electrodes and the porcelain insulator. If it appears as though the spark plug is carbon grounded, (a direct path of carbon from the center electrode down the side of the porcelain insulator to the metal base of the plug, or a direct short from the center electrode to the ground electrode), the plug should be replaced. (See Figure 35.) If replaced, the spark plug gap should be set at .030. When reinstalling the plug in the cylinder head, take care to tighten it only enough to allow for proper heat transfer from the spark plug to the cylinder head, (finger tight, plus a maximum of 1/2 turn tighter with a wrench.) Next hold the spark plug wire approximately 3/16 of an inch away from the tip of the plug, and pull the starter cord rapidly. (See Figure 36.) An orange-blue spark should jump from the wire to the plug at point A. If it does, you have ignition. If it does not, position the wire so that it is approximately 3/16 of an inch away from the metal base of the spark plug at point B, and pull the starter cord again. If a spark will jump at the base of the spark plug, but not at the tip, it indicates that the spark plug is failing under compression and should be replaced. If a

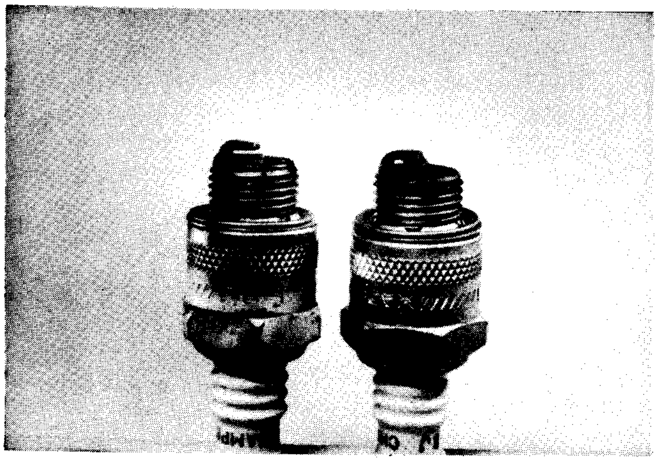


Figure 35. Carbon Grounded Spark Plug.

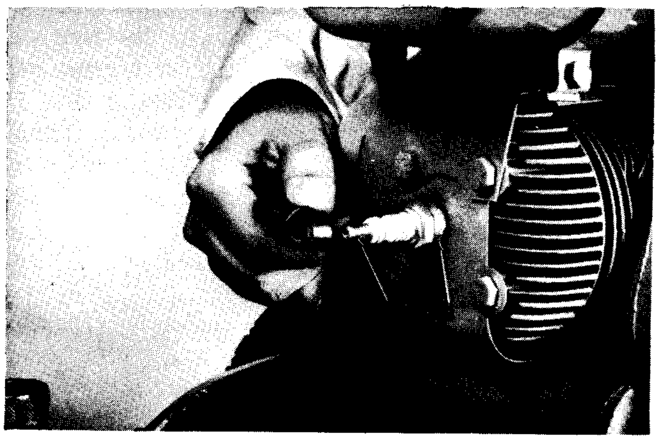


Figure 36. Ignition Test.

spark jump does not occur at either position, the problem will be found in the magneto. The procedures outlined are the only proven ways to determine where the ignition problem lies. The use of an ignition test plug will indicate whether or not the magneto is functioning, but it will not test the condition of the spark plug itself, or the potential voltage output above the test plug rating.

By examining the carbon deposit on a spark plug, it is possible to analyze the quality of burning that has taken place in the cylinder. A carbon deposit that is beige to gray-tan in color indicates thorough combustion of the fuel at proper operating temperatures.

10. Cooling System.

To appreciate the importance of keeping the cooling system clean, you need to understand the cooling principles of all air-cooled engines. The average temperature of burned gases inside the cylinder is about 3,600 degrees F. Approximately 1/3 of the heat is given off through the cooling system.

Another 1/3 is lost through the exhaust system. The remainder is used to develop power. As a result of the loss of heat through the cylinder walls to the cooling system, the temperature is reduced from 1200 degrees F. to approximately 350 degrees F. at the inside of the cylinder wall, and to 100 degrees F. at the outer edge of the cooling fins. (See Figure 37.)

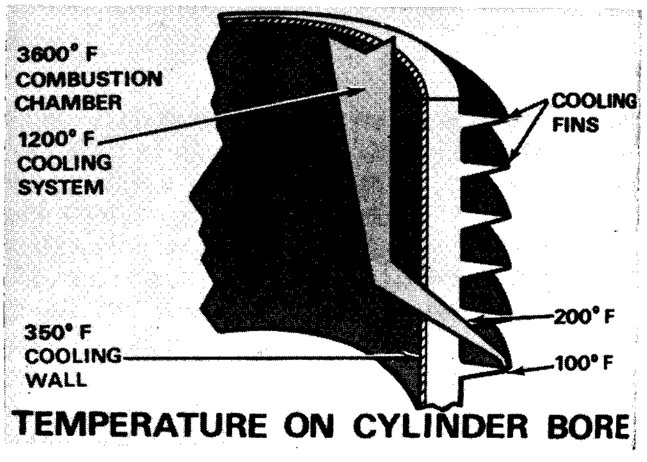


Figure 37. Temperature On Cylinder Bore.

Note that the temperature along the inner cylinder wall averages 350 degrees F. as contrasted to the burning gas temperature in the cylinder of 3,600 degrees F. The reason for the cooler temperature along the cylinder wall is a "boundary" layer of gas which has been found to lie next to it. This is a rather stagnant layer which acts as an insulating film. For this reason there is not as much heat moving through the cylinder wall as you might imagine, especially when contrasted to the intense heat developed from the burning fuel inside the cylinder.

The temperature decreases to about 200 degrees F. as the heat moves through the cylinder wall to the outer surface. This heat is given off rapidly with forced air movement over the outer wall and the cooling fins.

Heat travels through the cooling system in the following way. The heat moves from the cylinder through the cylinder walls by "conduction". The term "conduction" describes heat transfer through a solid conductor. When it reaches the outer surfaces of the cylinder, it is taken up by the air through "forced convection". The term "convection" describes heat transfer through movement of a gas – in this case air. Forced convection is accomplished by a flywheel blower forcing air past the cylinder wall and the cooling fins. It is directed around the cylinder by the cylinder baffles. This is why you should never operate an engine with the baffles removed.

The cooling fins are used to provide increased surface around the outside of the cylinder for additional cooling area. This is necessary on air-cooled engines and not on water-cooled engines because air is approximately one twenty-fifth as effective as water when used for cooling engines.

It is important to note, that if the exhaust system is in any way restricted, a portion of this 1,200 degree temperature will remain in the metals of the engine. This will cause excessive friction, which in turn will result in high maintenance costs on moving parts, and a shorter life expectancy for the entire engine. Aside from the restricted exhaust-system, dirt and grass clippings in and around the cylinder-fins will serve as an insulator and cause overheating.

11. Intake and Exhaust.

To better understand the operation of the intake and exhaust system on a small engine, it will be helpful to think of them as "modes of transportation". This term is especially relevant since, in actuality, the intake system transports fuel and air into the engine and the exhaust system transports the gaseous by-products of combustion from the engine.

The intake phase delivers fuel to the cylinder where the ignition phase takes place. The component parts necessary to complete the intake phase are the carburetor, which mixes fuel and air, and the crankcase, which acts as a pump. If either of these components is not functioning properly, such as improper mixture of fuel and air, or the crankcase not pumping at full capacity, the engine's performance will be poor, or it may not run at all.

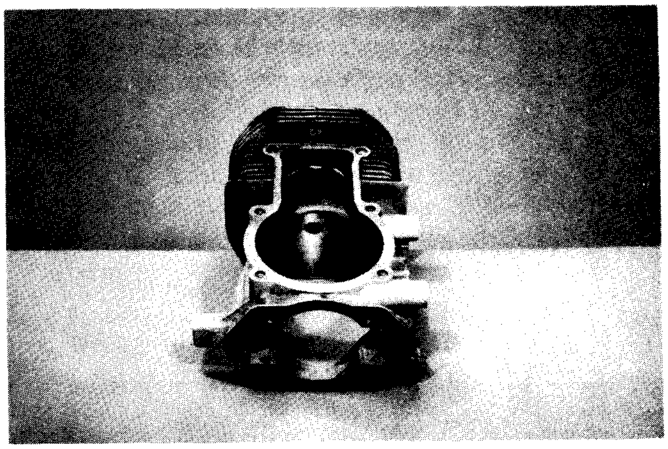


Figure 37A. Restricted Exhaust Ports.

The function of the exhaust phase is to remove the by-products of combustion from the engine. The effectiveness of this phase is controlled by the cleanliness of the exhaust port and muffler system. Any restriction in these areas will cause excessive back pressure to develop in the cylinder which, in turn, will limit the ability of the intake system to adequately supply the engine with needed fuel. If a small engine is caused to operate with too rich a fuel mixture, excessive carbon build up will cause such a restriction. This condition will be evident by a very quiet running engine which will not accelerate properly.

If a small engine will fire, even one time, it indicates that the carburetion, compression, and ignition phases are functioning. However, if a small engine fires once but will not continue to run, the problem, more than likely, will be found in the intake system, (crankcase and intake ports), or the exhaust system, (exhaust ports and muffler assembly). If this occurs, the engine should be checked for lack of fuel, an incorrect carburetor adjustment, an air leak in the crankcase, or a clogged exhaust system.

12. Ideal Fuel Mixture Requirements.

Each engine manufacturer has his own program of testing to determine the best fuel mixture for his engine. For this reason, the mixture that is proper for one make of engine may not be desirable for another.

After extensive testing with various types of lubricants and gasolines, Jacobsen Manufacturing has determined that the proper mixture of fuel for the 2-cycle 321 engine is as follows: With each gallon (U.S.), of fresh, regular grade gasoline, (80 octane minimum), mix 1 quarter of a pint, (4 ounces liquid measure), of Jacobsen 2-cycle engine oil, (available at Jacobsen dealers), or SAE 30 non-detergent, MM, or SB rated oil. A mixture of any other type or proportion is not recommended by the manufacturer for the 321 engine. Using fuel of an incorrect type or proportion could cause engine overheating, pre-ignition, sticking rings, excessive carbon build up, and fouled spark plugs.

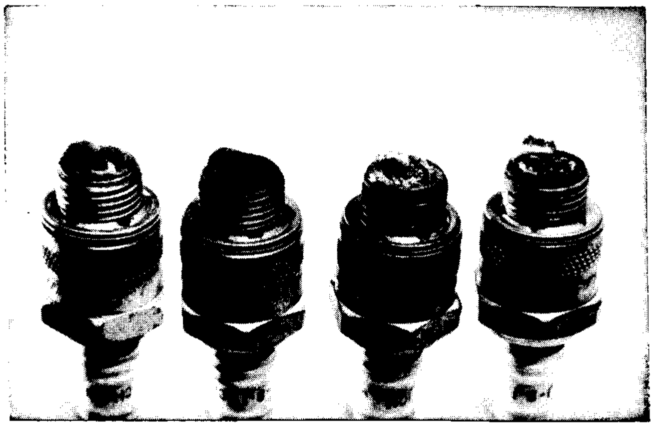


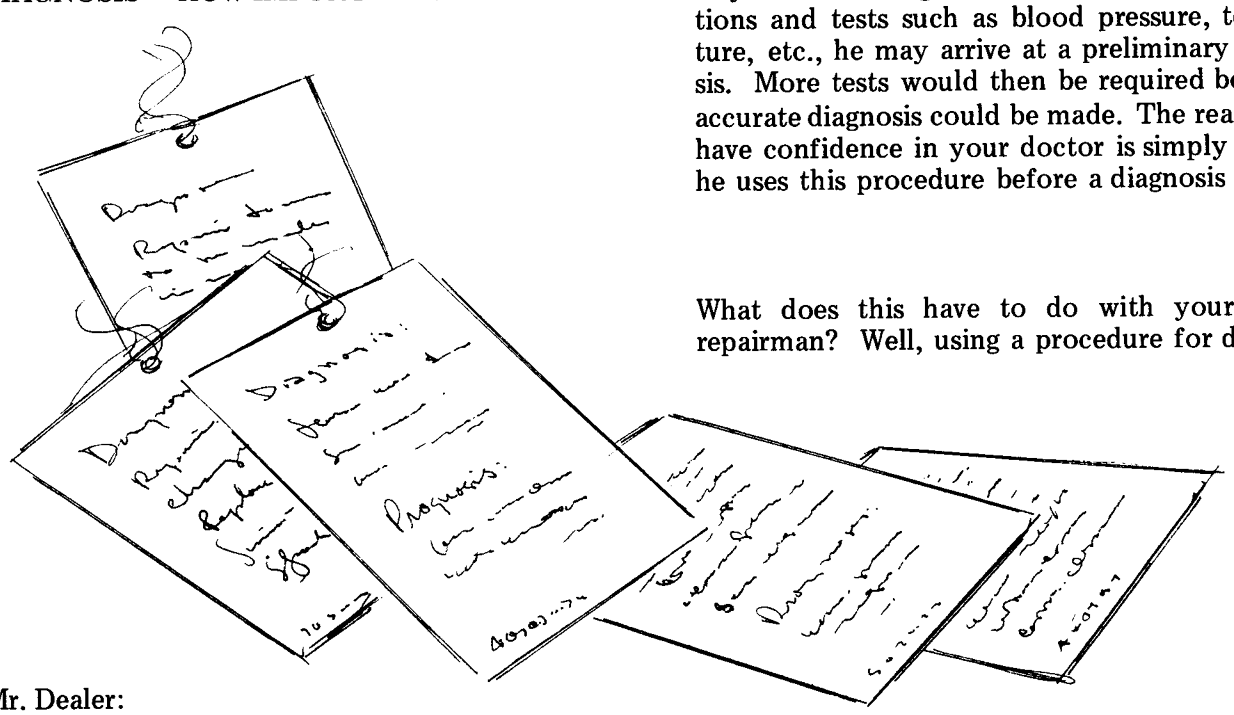
Figure 38. Spark Plug Comparison.

The spark plugs illustrated in Figure 38 were used in four of Jacobsen's 321 test engines. All four engines were run the same length of time. The same maintenance and adjustment procedures were used on all four engines with one exception. The spark plug on the left was removed from the test engine that used the oil recommended by the engine manufacturer while the other three spark plugs came from engines using different kinds of available engine oil. Not all oils will cause this type of deposit problem, but this should illustrate the importance of using the oil recommended by the engine manufacturer.

13. Carbon Build-Up.

The following are the most common causes for excessive carbon build-up in a small engine: Incorrect engine operating temperatures, dirt particles in the air, additives in the gasoline and oil which are not thoroughly burned and expelled from the engine, low octane gasoline, incorrect oil, improper proportions of oil to gas, incorrect carburetor adjustment, dirty air cleaner, weak ignition output, the wrong spark plug heat range, or idling for extended periods of time at a very low RPM.

DIAGNOSIS – HOW IMPORTANT?

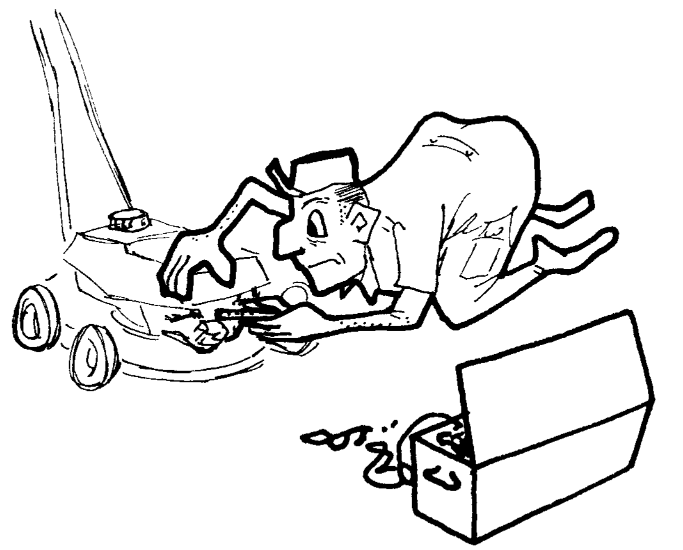


Mr. Dealer:

I'm sure at one time or another you've found yourself sick enough to warrant a visit to your family physician. If without an examination, he suggested a major operation, you would certainly question his ability. Fortunately, that's not the way he does things. With the use of a few questions and tests such as blood pressure, temperature, etc., he may arrive at a preliminary diagnosis. More tests would then be required before an accurate diagnosis could be made. The reason you have confidence in your doctor is simply because he uses this procedure before a diagnosis is given.

What does this have to do with your service repairman? Well, using a procedure for diagnosis before jumping into a quick decision on engine problems will give your customers confidence in your ability. Replacing a dirty air cleaner or a carbon grounded spark plug could be only a temporary solution; but knowing how to troubleshoot what caused the problem could change the total diagnosis. Your talent to diagnose problems must be learned and then practiced continually on every repair job, whether large or small. The more often you attempt a careful diagnosis, the more skillful you will become.

Remember, a good repairman always requests complete information regarding the engine's behavior. Although a small engine doesn't talk, different sounds during use may give the repairman a clue as to where the problem may be located. The owner might have observed a different sound after a longer running time or when running up hill. By following a set procedure to diagnose trouble, you will find repairs can be



accomplished faster and more accurately. Remember, customers that are confident in your ability will come back again and again.

Your doctor never writes a prescription when he isn't completely sure of his diagnosis. Don't prescribe for an engine unless you are sure you fully understand the problem.

Your customer is paying for a quality job. Don't you think his problems deserve a thorough and accurate diagnosis?

SECTION IV

TROUBLESHOOTING

A. GENERAL

This section will cover the methods to be used when troubleshooting the Jacobsen 321, 2-cycle engine. If you have not read and understood Section III, we suggest that you do so before attempting to diagnose engine problems.

To be an effective troubleshooter, first learn the principles of operation, and the function of all major parts in the engine. Second learn how one component part may affect the operation of the other components in the system. Third, never assume that any particular phase of the engine is operating correctly, check each operating phase in proper sequence. Oftentimes, when a small engine stops running, there is a problem with more than one phase of operation. Simply locating and replacing a defective part, may cause a faulty engine to appear as though it is functioning properly. (See Figure 39.) However, the problem may be only temporarily overcome. For example, replacing a fouled spark plug may appear to correct a faulty ignition system. But unless the problem causing spark plug fouling is corrected, within a short time, the same situation will occur again. Simply changing parts is a costly and slow way to diagnose engine problems.

By carefully studying and applying the basic principles set forth in this manual, the proper method for troubleshooting problem engines will become second nature to you. If you use the Jacobsen method for troubleshooting, the 321 engine may be analyzed for problems, in most cases, in approximately 5 minutes.

Before troubleshooting the 321 engine, check the proper procedure for starting a 2-cycle engine. Many hard starting engines are caused by the operator not following instructions.

HOW TO START A 2-CYCLE ENGINE

The proper way to start a 2-cycle engine is as follows: When the engine is cold (same as outside temperature), open the fuel shut-off valve, place the choke lever in the "choke" position and set

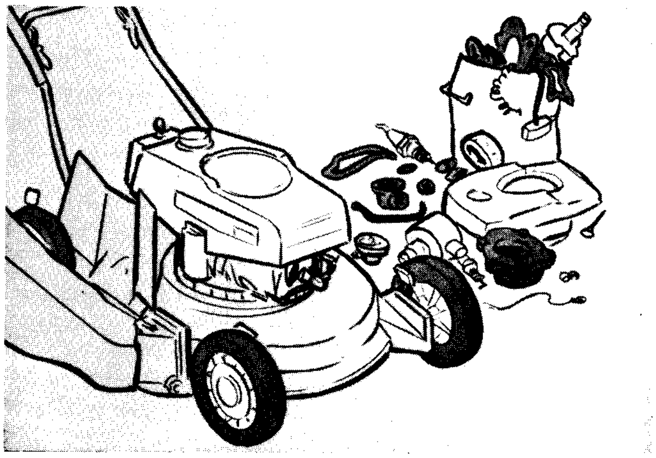


Figure 39. Replacement Is Not Always The Answer.

the throttle at the middle position. Since the crankcase of a 2-cycle engine works on the same principle as a pump, and a pump always functions better after it has been primed, you must likewise prime your engine before attempting to start it. (See Figure 40.) To prime the engine, pull the starter cord, slowly, to its full length. (Please note: On snow removal equipment, prime two or three pulls.) You are now ready to start the engine. Pull the starter cord fast and with a steady motion. Once the engine has started, place the choke lever in a

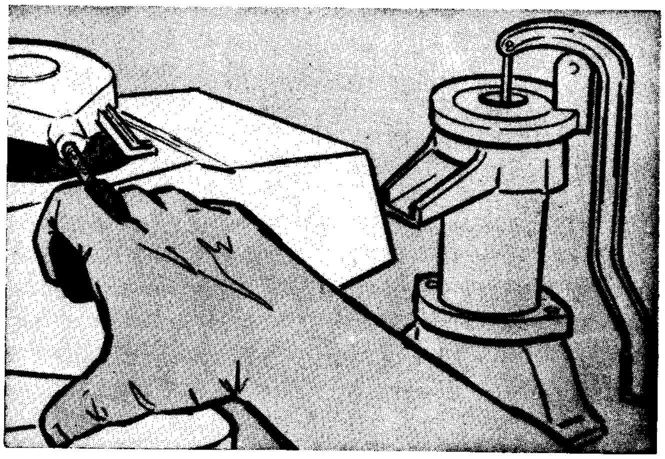


Figure 40. Starting The Engine.

"half-choke" position — wait approximately 15 seconds, then place the choke lever in the full open position. If the engine fails to start in 5 or 6 pulls, there is either a problem with the engine and it should be serviced by a qualified trouble-shooter, or the correct starting procedure was not followed, causing the operator to flood the engine.

The following step by step procedure should be followed if your engine will not start.

B. IGNITION SYSTEM

First, examine the thin ignition ground wire to be certain that it is not grounding out the ignition system. Then, check the spark plug wire for voltage leaks, (cuts in the rubber covering), at any point that it comes into contact with metal.

Next, remove the spark plug from the cylinder head and examine the condition of the electrodes and the porcelain insulator. If it appears as though the spark plug is carbon grounded, (a direct path of carbon from the center electrode, down the side of the porcelain insulator to the metal base of the plug, or a direct short from the center electrode to the ground electrode), the plug should be replaced. (See Figure 41.) When reinstalling the plug in the cylinder head, take care to tighten it only enough to allow for proper heat transfer from the spark plug to the cylinder head, (finger tight, plus a maximum of 1/2 turn tighter with a wrench). Now, hold the spark plug wire approximately 3/16 of an inch from the tip of the plug at point A and pull the starter cord rapidly. (See Figure 42.) An orange-blue spark should jump from the wire to the plug, indicating ignition is present. If it does not, position the wire so that it is approximately 3/16 of an inch away from the metal base at point B of the spark plug, and pull the starter cord again. If a spark will jump at the base of the plug but not at the tip, it indicates that the spark plug is failing under compression and should be replaced. If a spark jump does not occur at either position, the problem will be found in the magneto. The use of an ignition test plug will indicate if the magneto is functioning; it will not test the condition of the spark plug itself, or the potential voltage output above the test plug range.

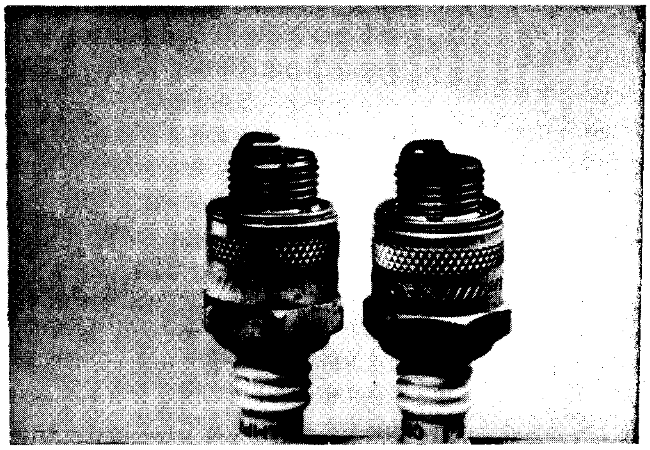


Figure 41. Carbon Grounded Spark Plugs.

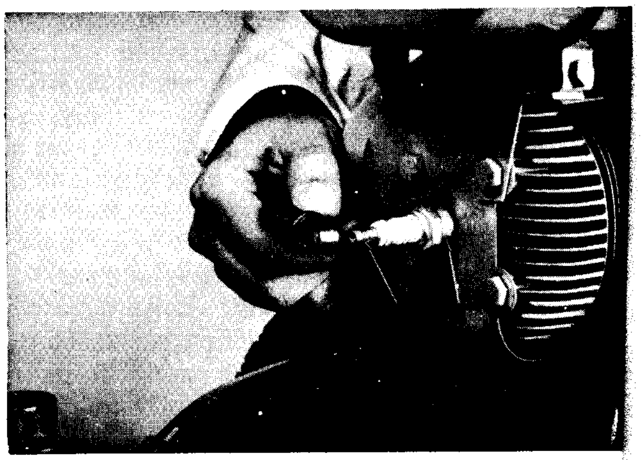


Figure 42. Ignition Test.

C. COMPRESSION

If the engine fails to start after examining and repairing the ignition system, check for adequate compression. This may be accomplished by simply pulling the starter cord. You should feel a resistance to the pull. If the engine turns over too easily, check for either a hissing sound around the head gasket, or a possible loose spark plug. A hissing sound will indicate that either the head bolts are loose, or that the gasket is worn and should be replaced.

If internal wear is suspected, remove the spark plug and squirt a small amount of oil into the cylinder through the spark plug hole. Replace the plug and attempt to start the engine. If, after a few pulls, the engine will start, it is probably in need of an internal overhaul.

D. FUEL SYSTEM

To troubleshoot the fuel system, first remove the fuel tank cap. Check to be sure the cap is air vented, since atmospheric pressure must be allowed to enter the fuel tank or a vacuum will develop and shut off the fuel flow. Check the fuel supply and fill the tank if it is below 1/4 full. Drain and replace the fuel if it was not properly drained after last season. Next, hold in the drain button (A) at the bottom of the carburetor for approximately 20 seconds to allow fuel to flow steadily out of the drain. (See Figure 43.) If fuel does not flow freely, check for a fuel restriction in the shut-off valve on the tank, or the hose leading from the tank. If no problems are noted, check the needle and seat assembly or the float inside the carburetor for malfunctions. At this point, remove the high-speed adjustment needle (B) from the carburetor, by turning it counterclockwise, and allow fuel to flow from the hole for five seconds. If it does not flow steadily, the lower section of the float bowl housing is probably in need of cleaning. Replace the high-speed adjusting needle and tighten it until it gently bottoms. Then unscrew it one full turn. At this point, attempt to start the engine by following the procedure outlined on page 33. If the engine will not start, refer to the section entitled, Carburetor Disassembly And Cleaning on page 60.

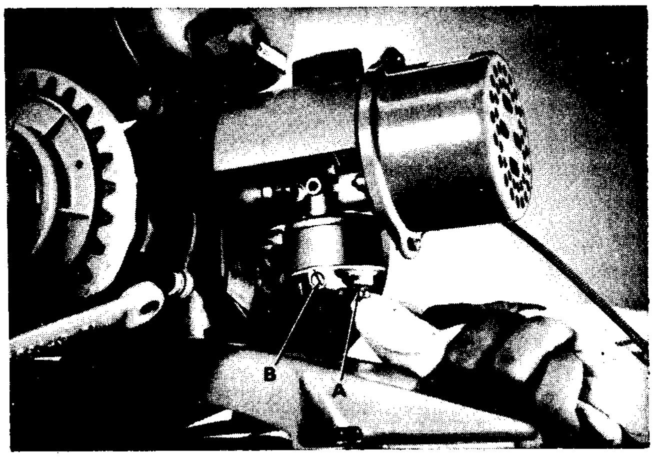


Figure 43. Fuel Check.

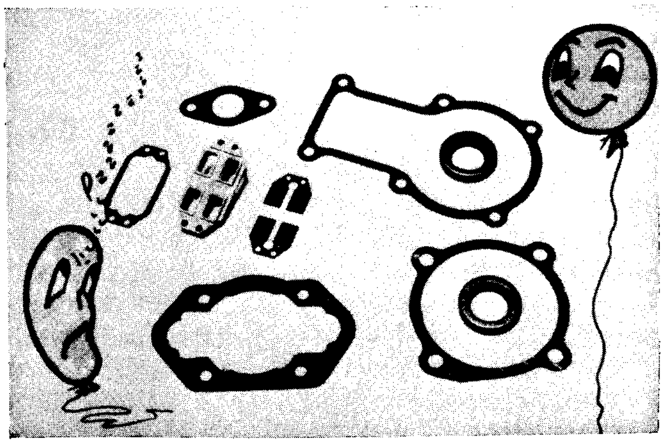


Figure 44. Air Leaks - Incorrect Air to Fuel Ratio.

E. CRANKCASE SEALS AND GASKETS

To thoroughly troubleshoot your engine, the crankcase must also be examined. Bad seals, leaking gaskets, or a leaking reed plate may cause hard starting and possibly, even if it has been running for an indefinite period of time, stalling of the engine. (See Figure 44.) Allowing the engine to cool, and setting the carburetor to "choke", will probably make it possible to restart the engine. However, worn seals, leaking gaskets, or leaking reeds will cause stalling of the engine again, after the restart. To determine if an air leak in the crankcase has developed around the seals, start the engine and allow it to run at as low an RPM throttle setting as possible. On a horizontal crankshaft engine such as is used on a reel mower, examine the seal on the power takeoff side, (side with a pulley or sprocket). Squirt a small amount of oil around the inner lip and the outer shell of the seal. (See Figure 45.) If it is leaking, you will detect a definite change in the rhythm of the engine, and a noticeable increase in exhaust smoke. For obvious reasons, it is not possible to check the power takeoff seal on a rotary mower in the same manner as explained above. However, you may remove the cutter blade and adapter, and examine them for a raw fuel film. If a raw fuel film rather than an exhaust film is seen, seal leakage is indicated. If you are not certain which type of film is present, the installation of a new seal is recommended.

When troubleshooting a horizontal engine with a gear reduction case, specific seal installation should be noted. (See Figure 46.)

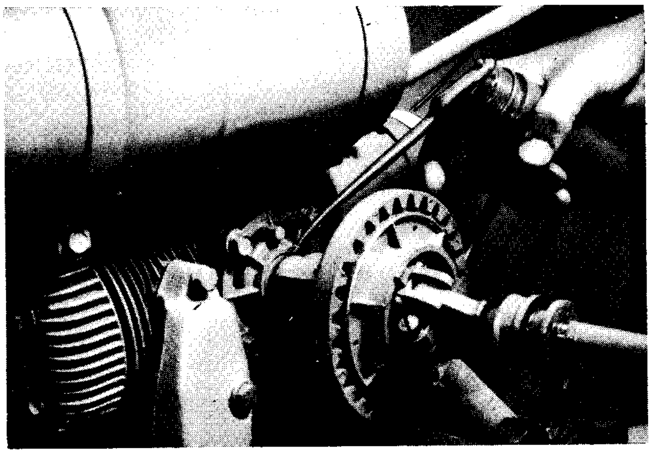


Figure 45. Crankcase Seal Test.

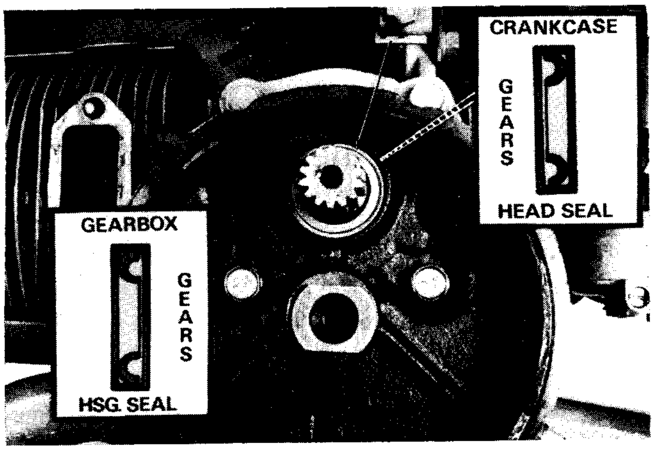


Figure 46. Gear Reduction Case Seal.

The normal rule for seal installation requires the lip of the seal be toward the side with the greater pressure, which is the gear box on the 321 engine. If these seals are not properly installed, the seal will be drawn in and the oil from the gear case will be forced into the engine.

The ignition seal, located under the flywheel assembly on both the horizontal and vertical crankshaft engine may be checked in the following manner: Remove the flywheel and the plate, which covers points, and the coil and condenser assembly. If there is evidence of an oil film, (regardless how small), in the assembly, an air leak is indicated and the seal must be replaced. An air leak in this area will totally destroy the ignition system. In troubleshooting, all gasket surfaces must be checked for air leaks. No gasket should ever be reused. Once a gasket has been compressed its ability to seal properly has been greatly reduced. To check these gasket surfaces, thoroughly clean the engine as this must be a visual check. Start the engine and set the throttle to a fast RPM and visually check all gasket surfaces, (starting at the carburetor gaskets and continuing forward to the cylinder head). The gasket must be replaced if any evidence of fuel bubbling in these areas is noted.

To test the engine for leaking reeds, remove the air cleaner element from the engine. (See Figure 47.) With the engine running, or by using rapid pulls on the starter cord, hold a clean piece of paper approximately one inch from the carburetor throat. If there is any evidence of fuel spotting on the paper, the reeds are not seating. Allowing the engine to operate under this condition will result in fuel starvation, inadequate lubrication, and overheating of the engine.

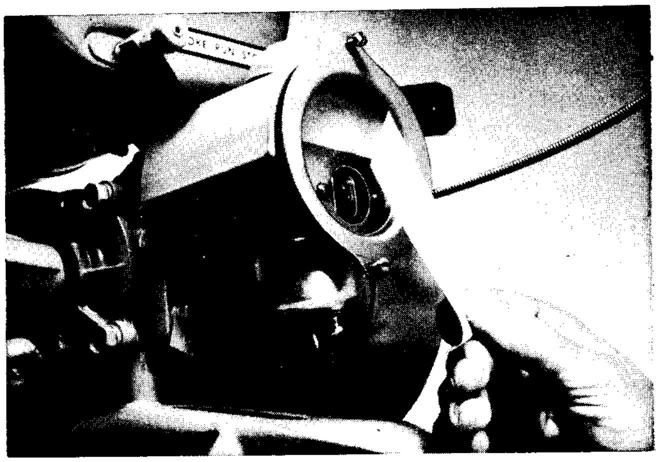


Figure 47. Leaking Reed Test.

F. EXHAUST PORTS AND MUFFLER

An accumulation of carbon in either exhaust ports or muffler will reduce power output. This condition is identifiable by slow acceleration and an overly quiet sounding exhaust. To clean carbon from horizontal engine, remove muffler and scrape all carbon from inside muffler. Use a screwdriver, small knife, or similar tool to clean carbon from exhaust ports. (See Figure 48.) Be sure piston is at bottom dead center when scraping ports, or damage to the piston may result.

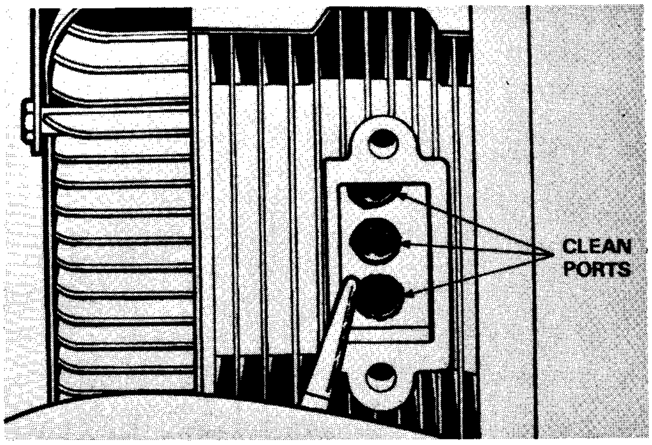


Figure 48. Exhaust Ports - Horizontal Engine.

To clean carbon from vertical engine, remove spark plug wire from plug, and remove rotary blade and muffler. (See Figure 49.) Use a screwdriver, small knife, or similar tool to clean carbon from exhaust ports and carbon areas of muffler. Be sure piston is at bottom dead center when scraping ports or damage to the piston may result.

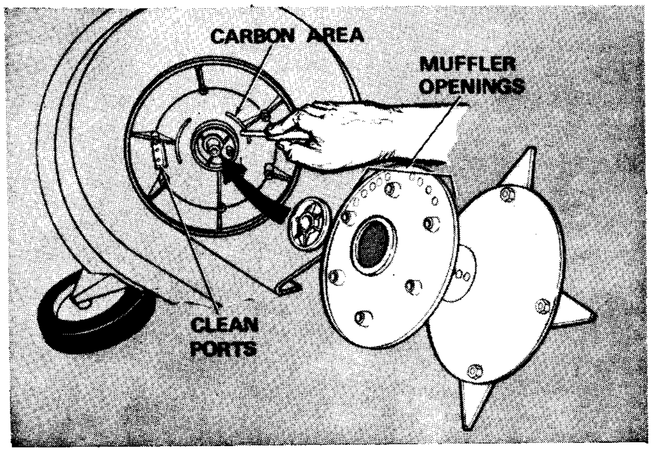


Figure 49. Exhaust Ports - Vertical Engine.

When further disassembly is required to clean out carbon from engine, remove cylinder head. Scrape carbon from cylinder head, clean off top of piston and also clean carbon deposits from intake ports. To reach ports rotate crankshaft until piston reaches bottom dead center. Refer to Overhaul – Section VI for disassembly procedure.

G. AIR CLEANER

Four types of air cleaners are used on Jacobsen engines: An aluminum foil, a paper filter, oil bath and polyurethane foam. All are subject to clogging and restricting the flow of air to the carburetor. An inadequate supply of air will prevent the engine from producing maximum power and also cause the excessive fuel in the mixture to burn improperly. Carbon will build up at a fast rate in the cylinder and add to inefficient operation of the engine. To properly clean the air cleaner, remove from engine and disassemble. (See Figure 50.)

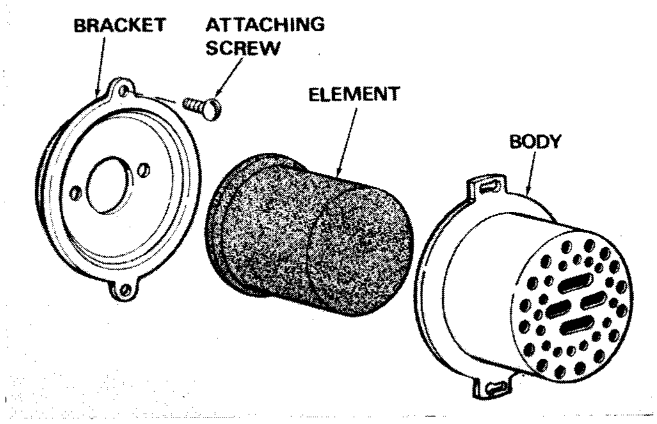


Figure 50. Air Cleaner Disassembly.

FOIL TYPE CLEANER

Wash and rinse thoroughly in gasoline or other solvent. Shake off gasoline or solvent and immerse in clean SAE 30 oil. Allow excess oil to drain off before installing.

PAPER FILTER

Brush or wipe outside of cleaner. Tap gently to loosen dirt from inside of filter. Do not oil or wash filter. Filter can also be cleaned by gently blowing compressed air from the inside. If, after extended use, filter is too dirty to clean properly, replace with a new filter, (normally once each season).

OIL BATH TYPE CLEANER

Remove cover from oil reservoir and dump out old oil. Wash cleaner in gasoline or other solvent. Dry cleaner thoroughly. Refill to level indicated by arrow with same grade of oil used for engine lubrication.

FOAM TYPE

The polyurethane foam type air filter is removed for cleaning. The filter should be washed and rinsed thoroughly in kerosene or like solvent. Re-oil with approximately 2 tablespoons of clean SAE 30 oil. Compress to distribute oil evenly throughout filter.

NOTE:

A plugged air filter element will cause hard starting, loss of power and excessive spark plug fouling. (See Figure 51.)

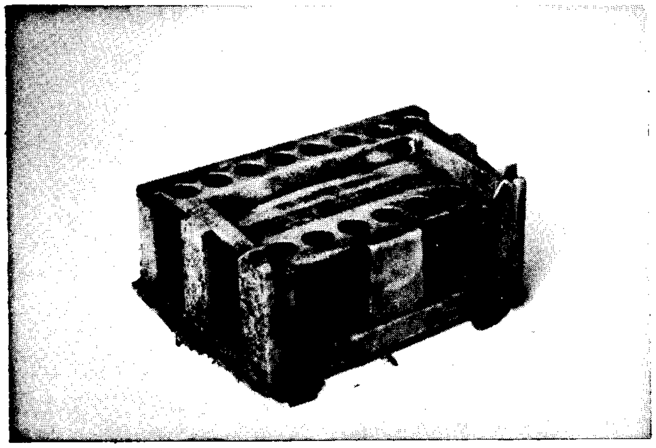


Figure 51. Plugged Air Cleaner.

If the engine will not accelerate or lacks power, remove the air cleaner and accelerate again. If the engine functions properly with the air cleaner removed, servicing or replacement of the air cleaner element is required.

Clean filter every 25 hours of operation and at the beginning of every season. Under severe dust, service as often as conditions warrant.

If a dry cannister type filter is used, replacement is required at the beginning of each season.

H. PISTON AND RINGS

The life of the piston and rings is dependent upon proper air cleaner maintenance. (See Figure 52.)

The piston on the right in Figure 52 has been in service for 2,000 hours. The piston on the left has only 100 hours of service. The poor condition of the piston and ring on the left can be directly attributed to either an improperly installed or improperly serviced air cleaner.

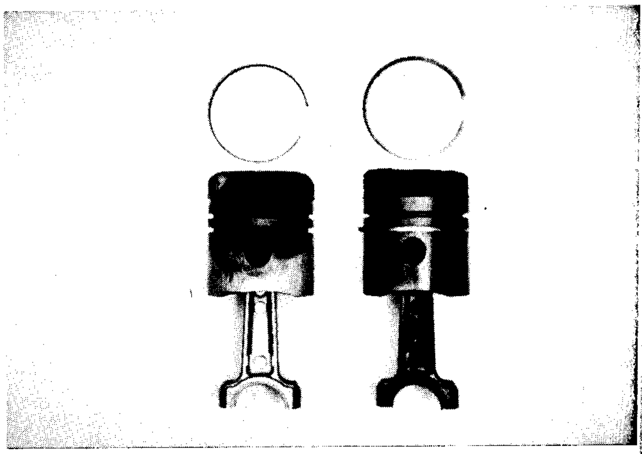


Figure 52. Piston Comparison.

The piston rod assemblies shown in Figure 53 are examples of carelessness. The piston on the right has a needle bearing (A) imbedded in the piston. Someone neglected to check for all twenty-eight when disassembling the engine. The piston (B) on the left shows galling. If replacement of the piston is ignored, it can cause the engine to overheat or difficult starting.

The piston in Figure 54 is an example of proper combustion. This piston has seen 1000 hours of service. A comparison with the piston on the left in Figure 52, a piston with only 100 hours of service gives you an idea of the difference proper maintenance can mean to your engine.

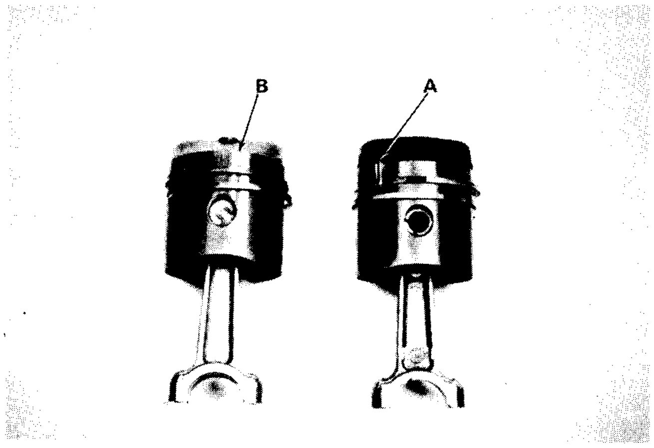


Figure 53. Piston Comparison.

Figure 54. Proper Combustion.

J. FUELS AND LUBRICANTS

Proper mixture of good REGULAR GRADE GASOLINE, and non-detergent oil is necessary to obtain top performance and trouble-free operation of 2-cycle engines. Do not use low octane gasoline. This will cause engine overheating, pre-ignition, sticking rings, excessive carbon in exhaust ports, and fouling of the spark plug.

The oil mixed with gasoline lubricates all moving parts of the engine as the fuel-air mixture is drawn into the crankcase and cylinder. Always mix the fuel according to the instructions for the engine. All units prior to the 321 engine use 1/2 pint of oil to one gallon of regular gas. The 321

Figure 55. Jacobsen Recommended Fuel-Oil Mixture.

engine fuel mixture is 1/4 pint of oil to one gallon of regular gasoline. Use SAE 30 oil, non-detergent; MM or SB if it is necessary to use other than Jacobsen Engine Oil. (See Figure 55.)

Note: Use 1/4 pint of oil to one gallon of gasoline on 321 engine only.

This is to be considered a basic guide for troubleshooting. If after following this step by step procedure the engine will not start, refer to the master troubleshooting chart on pages 40 and 41.

MASTER TROUBLESHOOTING CHART FOR 321 ENGINE

Trouble	Causes	Remedy
Engine will not start.	Fuel level too low.	Must be at least 1/4 full.
	Water in fuel.	Drain and fill with fresh gasoline & oil mix. See page 30.
	Last season's fuel.	Clean carburetor. Drain and fill with fresh gasoline & oil mix. See page 79.
	Fuel flow restricted.	See page 64.
	Weak or no spark.	See pages 25, 34, 69.
	No compression resistance felt when pulling starter.	See page 34.
	Crankcase pump leaks.	See pages 23, 35, 58.
Engine lacks power.	Throttle linkage not positioned correctly.	Adjust throttle linkage. See page 76.
	Engine not operating at specified RPM.	See page 37.
	Carburetor set incorrectly.	See page 75.
	Governor set incorrectly.	See page 52.
	Exhaust system clogged.	See pages 29, 36.
	Float level too low.	See page 67.
	Dirty air cleaner.	Clean and reoil. See page 37.
Engine slows down and gradually stops.	Gas cap vent plugged.	Unplug vent hole on inside and outside of cap. See page 35.
	Carburetor set incorrectly.	See page 75.
	Crankcase air leak.	See pages 23, 35, 58.
Engine surges up and down, from high to low speed.	Governor linkage bent or binding.	Straighten or loosen linkage. See page 52.
	Throttle plate binding in carburetor throat.	See page 61.
	Air leak in crankcase.	See pages 23, 35, 58.

MASTER TROUBLESHOOTING CHART FOR 321 ENGINE (Contd.)

Trouble	Causes	Remedy
Carburetor leaks gas, and sometimes floods engine.	Needle valve and seat sticking in open position.	See page 66.
	Float level too high.	See page 66.
	Carburetor float set incorrectly.	See page 67.
Engine stops abruptly.	Wrong fuel (no oil).	Drain system and fill with gasoline and oil mix. See page 30.
	Overheated.	Clean cylinder fins and check for air leaks. See pages 23, 28, 35.
	Warped, galled or burned piston.	Replace piston, hone cylinder. See page 38.
Ignition misfire while engine is running.	Rings not seating in cylinder bore.	Common with new or rebuilt engine. See page 57.
	Loose carbon in cylinder.	Remove carbon, try different brand of gasoline or oil or both. See page 30.
	Water in fuel.	Drain fuel and fill with gasoline & oil mix. See page 30.
	Ignition out of time.	See page 69.
	Points incorrectly adjusted.	See page 70.
	Loose ignition wires.	Secure all leads. See page 69.
	Bad condenser or coil.	See pages 45, 69.
Engine smokes excessively	Too much or wrong kind of oil mixed with gasoline.	Drain system. Fill with proper fuel mix. See page 30.
	Carburetor incorrectly adjusted.	See page 74.
	Leaky seal in gear reduction box (Estate, Lawn King or Manor).	See page 35.

NOTES

A GOOD TROUBLESHOOTER NEVER WORKS IN A HELTER-SKELTER FASHION; HE WILL DEVELOP THOROUGH, SYSTEMATIC HABITS.

SECTION V

SERVICE DATA

A. GENERAL

This section will cover the factory recommended specifications, tolerances and clearances, torque data, magneto test data and special tools necessary to service the Jacobsen 2-cycle engine.

The following data is applicable to all Jacobsen 321 engines.

B. TOLERANCES AND CLEARANCES

When servicing the Jacobsen 321 engine, refer to the following table for specific tolerance and clearance information.

TABLE 1. TOLERANCES AND CLEARANCES FOR THE J-321 ENGINE

Cylinder Bore	2.1265 2.1260	Spark Plug Gap	.030
Piston Skirt Diameter	2.1227 2.1220	Magneto Point Gap	.020
Piston Ring Width	.0925 .0935	Ignition Timing in Degrees B.T.D.C.	22° (Full Retard)
Piston Pin Diameter	.5001 .4999	Piston Skirt to Cylinder Clearance	.0033 .0045
Piston Pin Bore in Piston	.5001 .4998	Maximum Wear Tolerance on Cylinder Bore	.002
Piston Pin Bore in Rod	.5008 .5015	Maximum Out of Round Tolerance	.001
Crankpin Diameter	.7505 .7500	Piston Ring End Gap (Maximum Allowable Ring End Gap .070)	.005 .013
Crankpin Width	.568 .563	Piston Ring to Land Side Clearance	.0015 .0035
Connecting Rod Bore	.9819 * .9824	Piston Pin Clearance in Rod	.0007 .0016
Connecting Rod Width Crankpin End	.558 .550	Connecting Rod Crankpin Side Clearance	.005 .018

* Needle Bearing Used.

C. RPM SETTINGS

Proper speed adjustment is essential for engine protection and to obtain the best performance from your Jacobsen 321 engine. Refer to the following table for proper settings.

NOTE:
Use a Tachometer when checking maximum RPM settings. (See Figure 56.)

TABLE 2. SPEED SETTINGS

	Idle Speed RPM	Top Speed RPM
18" Pacer (52C18, 42D18, 42E18)	1300 to 1600	Up to 3500
18" Pacer (11814)	1500 to 1800	Up to 3600
21" Lawn Queen (2C21, 2D21, 2E21)	1300 to 1600	Up to 3500
21" Lawn Queen (12113)	1500 to 1750	Up to 3600
21" Manor (28F21, 28G21)	1300 to 1600	Up to 3500
21" Manor (22114, 32121-7B1)	1500 to 1750	3200 to 3600
22" Greensmower (9A22, 9B22)	1500 to 1800	Up to 3400
22" Greensmower (62203, 62208)	1500 to 1750	3400 to 3800
24" Estate (8A24, 8B24)	1300 to 1600	Up to 3800
26" Estate (8A26, 8B26, 8C26, 8D26)	1300 to 1600	Up to 3800
26" Estate R.R. (22601, 22605-7B1)	1500 to 1750	3400 to 3800
26" Estate F.R. (22611, 22615-7B1)	1500 to 1750	3400 to 3800
26" Lawn King (12A26, 12B26)	1300 to 1600	Up to 3200
26" Lawn King (12601)	1500 to 1800	Up to 3800
9" Edge-R-Trim (32A9, 32B9, 32C9)	1500 to 2000	3000 to 3300
9" Edge-R-Trim (50012)	1500 to 1750	3200 to 3600
10" Trimo (3110 - 8610, 86A, 86B)	1500 to 2000	3400 to 3600
10" Trimo (50035)		3500 to 3700
18" Turbo-Cut (3418, 34B18, 34C18, 34D18)	1300 to 1800	3400 to 3500
18" Turbo-Cut (7518, 75A18, 75B18)	1500 to 2000	3400 to 3500
18" Turbo Cone (117-18)	1500 to 1600	3200 to 3400
18" Turbo-Vac (31819) *	1500 to 1800	3200 to 3400
18" Turbo-Vac (31819)	2400 to 2600	3200 to 3400
18" 4-Blade Rotary (31809)	2400 to 2600	3200 to 3400
20" Commercial (32028)	2400 to 2600	3200 to 3400
20" Commercial Rotary (32028) *	1500 to 1600	3200 to 3400
20" Robust (32031)	1500 to 1700	3200 to 3400
20" Scepter (8020, 80A20)	1500 to 1800	3000 to 3200
21" 4-Blade Rotary (32114)	2400 to 2600	3200 to 3400
21" 4-Blade Rotary S.P. (42114, 42118, 42119)	2400 to 2600	3200 to 3400
21" Turbo-Cut (3921, 39B21, 39C21)	1500 to 1800	3200 to 3400
21" Turbo Cone (119-21)	1500 to 1600	3200 to 3400
21" Turbo-Cut (3521, 35C21, 35D21, 35E21, 35F21)	1500 to 1800	Up to 3500
21" Turbo Cone (121-21)	1500 to 1600	3200 to 3400
22" Scepter (80A22)	1500 to 1800	3000 to 3200
24" Rotary S.P. (40A24)	1900 to 2100	Up to 3000
20" Snow Jet (9620, 96A20)	1500 to 1800	3600 to 3800
20" Snow Jet (52002, 52003)	1700 to 1900	3600 to 3800

* Speed Control On Handle.

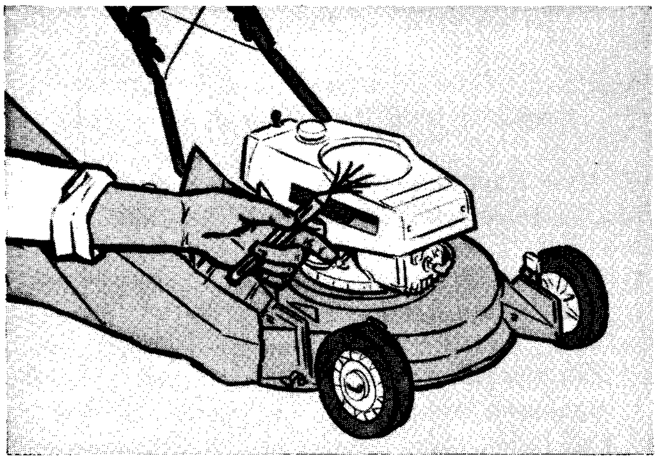


Figure 56. Checking RPM With Tachometer.

D. SPECIFICATIONS

Bore	2-1/8 in.
Stroke	1-3/4 in.
Piston Displacement	6.2 Cu. in. 101 CC
Compression Ratio	5.0 - 1
Cylinder Head Compression	75 - 85 PSI
Recommended Spark Plug	
Rotary	J-17-LM
Reel	UJ-12

E. TORQUE DATA

The following table will be used whenever disassembly or reassembly of the Jacobsen 321 engine is necessary. Strict compliance to the torque data should be observed.

TABLE 3. TORQUE DATA
FOR THE J-321 ENGINE

COMPONENT	Size	Inch-Pounds Torque	COMPONENT	Size	Inch-Pounds Torque
Spark Plug	14mm	180-200	Gear Box Cover Screws	1/4-20	60-80
Cylinder Head Bolts or Nuts	5/16-18	150-180	Engine Mounting Bolts	5/16-18	235-260
Crankcase Head Bolts	5/16-18	80-100	Starter Mounting Screws	1/4-28	20-25
Backplate Screws	1/4-20	60-80	Muffler Mounting Nuts & Bolts (Rotary Engines)	1/4-20	60-80
Connecting Rod Screws	10-32	40-50	Muffler Mounting Nuts & Bolts (Reel Mower Engines)	5/16-18	80-100
Carburetor Adapter Screws	1/4-20	60-80	Exhaust Manifold (Reel Mower Engines)	5/16-18	80-100
Stator Plate Screws	1/4-20	60-80	Flywheel Nut	7/16-20	300-360
Fan Housing Screws	1/4-20	60-80			

F. SPECIAL TOOLS

The Jacobsen 321 engine can be disassembled and reassembled with standard shop tools. However, several tools are recommended for particular functions of repair. The following special tool kit is available at your Jacobsen dealer. (See Figure 57.)

1. Flywheel Knockoff Nut - Threads on the crankshaft to facilitate the flywheel removal.
2. Flywheel Wrench - Holds the flywheel when removing the starter ratchet or the flywheel nut.
3. Oil Seal Spreaders - Used on crankshaft to protect the oil seal when removing or installing backplate or crankcase head.
4. Vibration Tachometer (Vibra-Tac) - Used to check RPM setting of engine.
5. Ignition Spark Tester - Used to test the magneto output.
6. Ring Compressor - Used to compress rings when installing piston in cylinder.

G. COIL TEST DATA
(Standard Breaker Type)
Type - Wico x 12935
Maximum Secondary - 9000
Maximum Primary - 1.1
Coil Index - 55
Minimum Coil Test - 17
Maximum Gap Index - 65

H. CONDENSER TEST DATA
(Standard Breaker Type)
Type - Wico x 11000
Tester - Graham
Capacity - .16-.23 (Microfarads)

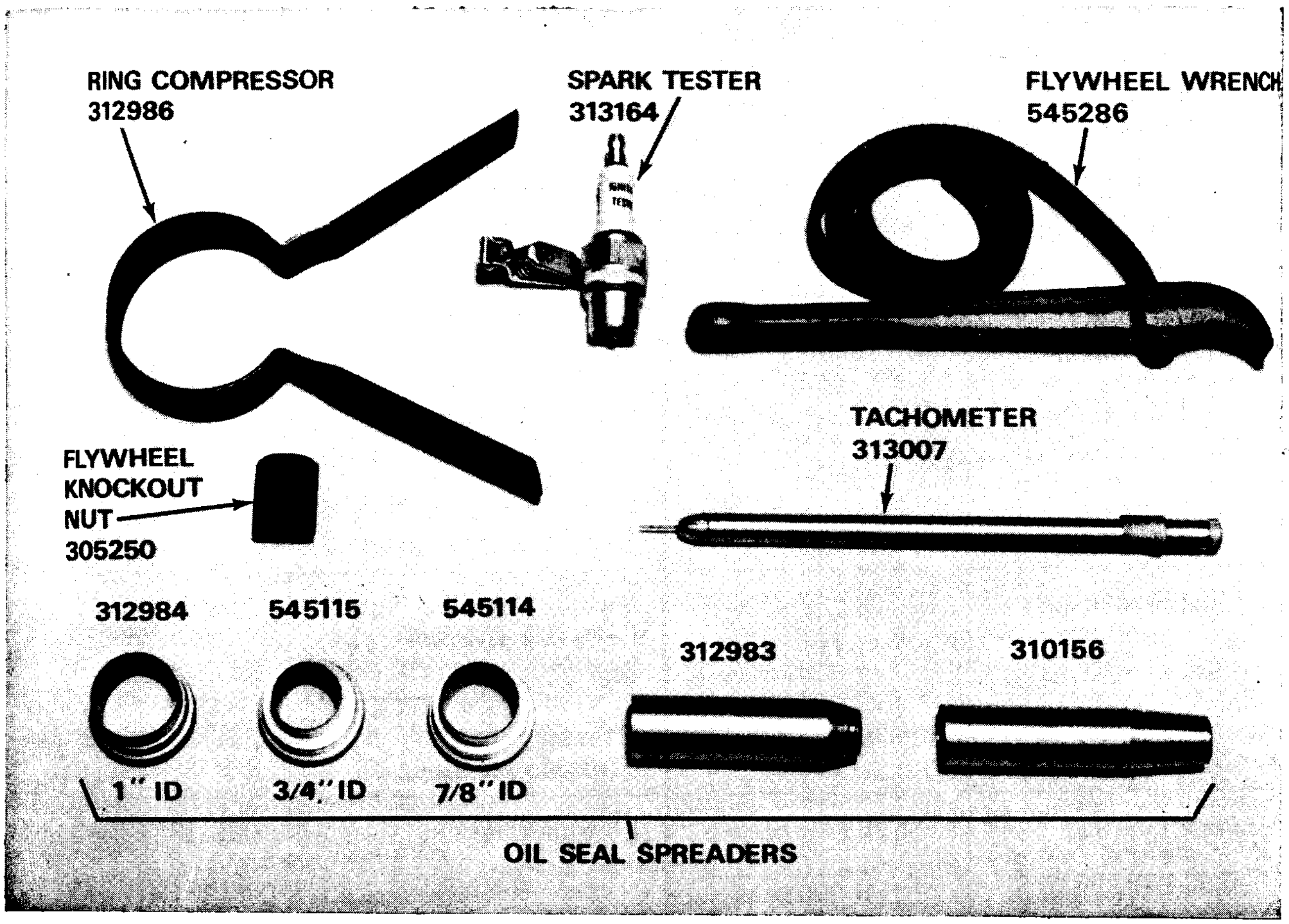


Figure 57. Special Tool Kit. Part No. 500321.

I. MAGNETO TEST DATA
(Breakerless)
Type - CD Magneto
Tester - Simpson Model 260 V.O.M. or Equivalent

USE TEST PLUG — Before starting to check out the CD system, make sure a spark is or is not present. Use a test spark plug (suggest Wico test plug No. 14281) and crank engine. If spark is there, look for something other than ignition as cause of trouble. If there is no spark, follow procedure outlined.

J. TEST INSTRUMENT

Set voltage selector switch to DC +. Be sure test equipment is in good condition and if test equipment is battery powered, that the battery is good. Be sure your meter is zeroed before each reading and each time you change scales. Ohmmeter readings are to be used only as indications as to whether or not a part is good or bad and should be used as a guide to substitute parts as indicated in step No. 4.

Before taking readings remove two (2) stator hold down bolts and lift unit off engine. At this time determine if unit is an early production or a late production CD magneto. Note the position of terminal (D) on the charging coil and electronics group. Early production units have the D terminal located left of center. (See Figure 58. - View A.) Use Test A. Late production terminal (D) is located slightly right of center of coil. (See View B.) Use Test B.

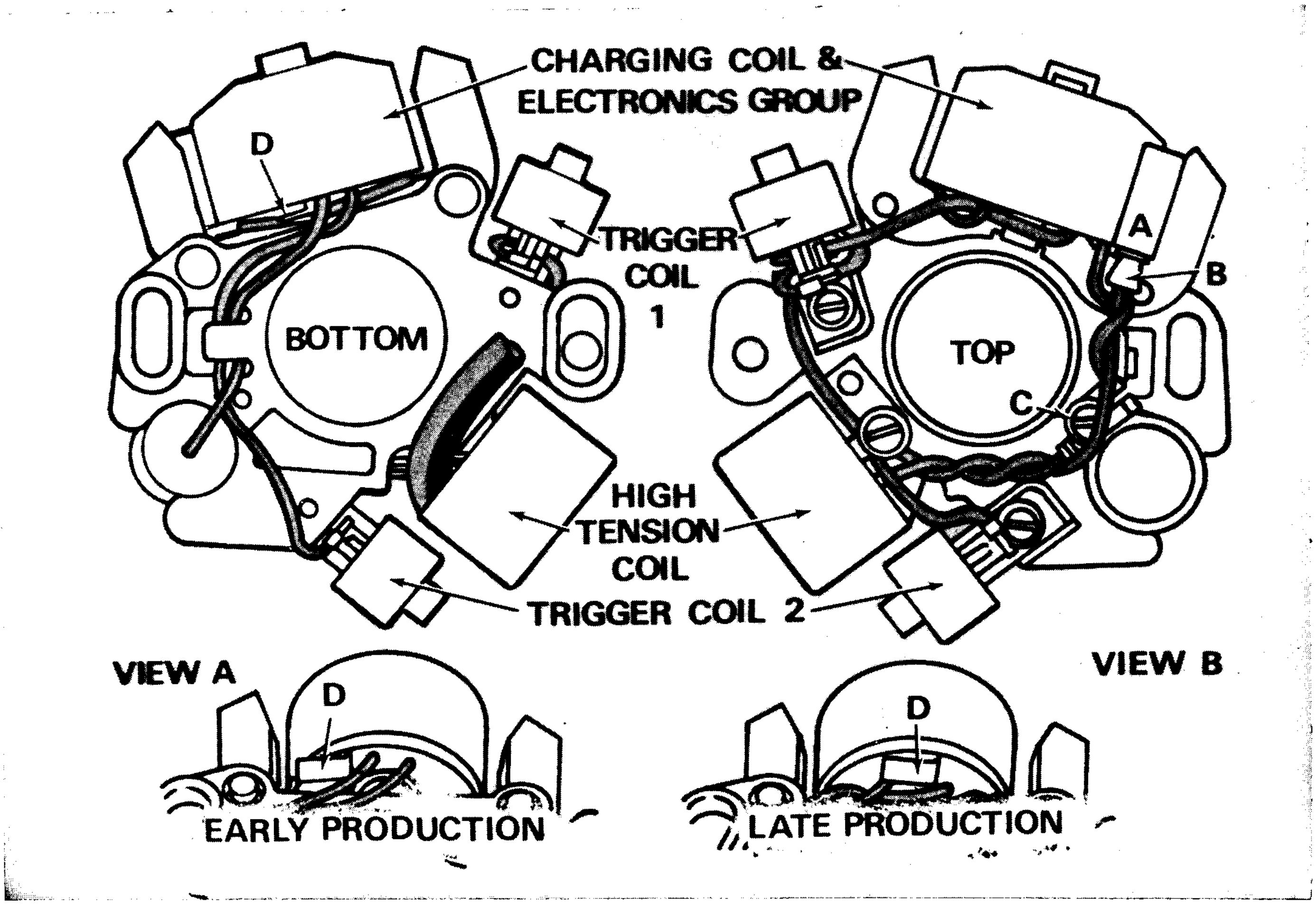


Figure 58. CD Breakerless Magneto Test.

TO CHECK TRIGGER COILS EARLY AND LATE PRODUCTION

STEP 1 — Set meter to R X 1 scale — adjust to zero.
(a) Disconnect both leads from each trigger coil.
(b) Read resistance across each coil. Resistance should be 15 ohms to 25 ohms.
(c) If both trigger coils check to spec, check the connecting lead for continuity and good co nections to the trigger and terminals.

TO CHECK CHARGING COIL AND ELECTRONICS GROUP

	TEST A . EARLY PRODUCTION	TEST B . LATE PRODUCTION
STEP 2 —	(a) Remove plug-in terminal "B" from charging coil tower "A". Remove "Engine Stop" lead from terminal "D". Set meter at R X 1 — adjust to zero.	(a) Same as TEST A.
	(b) Connect red (positive) meter lead to female terminal in coil tower "A".	(b) Same as TEST A.
	(c) Connect black (negative) meter lead to terminal "D".	(c) Same as TEST A.
	(d) Meter should read 5 to 25 ohms.	(d) Meter should read 1 Megohm to infinity.
	(e) Reverse the connections.	(e) Same as TEST A.
	(f) Meter should read infinity.	(f) Meter should read 1 Megohm to infinity.
	(g) Set meter at R X 100 scale — adjust to zero.	(g) Same as TEST A.
	(h) Connect the red (positive) meter lead to terminal "D".	(h) Same as TEST A.
	(i) Connect the black (negative) meter lead to ground Screw "C".	(i) Same as TEST A.
	(j) Meter should read infinity.	(j) Meter should read 560 to 760 ohms.
	(k) Reverse the connections.	(k) Same as TEST A.
	(l) Meter should read 1500 to 2200 ohms.	(l) Meter should read slightly lower than rea ing on line (j) above.

(Above checks are for charging winding circuit.)

STEP 3 — To test high tension coil:

(a) Set meter at R X 1 scale — adjust to zero.

(b) Connect red (positive) meter lead to terminal "B".

(c) Connect black (negative) meter lead to ground screw "C".

(d) Meter should read .1 — .5 ohms. Set meter at R X 100 scale — adjust to zero.

(e) Reconnect red (positive) meter lead to high tension lead.

(f) Reconnect black (negative) meter lead to ground screw "C".

(g) Meter should read 900 to 1100 ohms.

STEP 4 — If all readings appear normal and unit still does not run, a method of substituting new parts for the old ones, one at a time, can be used. It would be suggested that the order to follow would be:

(a) Substitute high tension lead.

(b) Substitute high tension coil.

(c) Substitute charging coil and electronics group.

(d) Substitute trigger coil 1.

(e) Substitute trigger coil 2.

(f) Substitute flywheel last.

NOTES

LIKE A DOCTOR, A GOOD MECHANIC IS ALWAYS INTERESTED IN THE "HISTORY OF HIS "PATIENT".

SECTION VI

ENGINE OVERHAUL

A. GENERAL

This section will cover the complete overhaul of the Jacobsen 321 engine. As the basic interior components are identical, the procedure used is fundamentally the same for both the horizontal and the vertical engines. (See Figure 59.) This manual will present the overhaul procedure as it applies to the horizontal crankshaft engine. Any deviation from this procedure required for the vertical crankshaft design will be explained in depth.

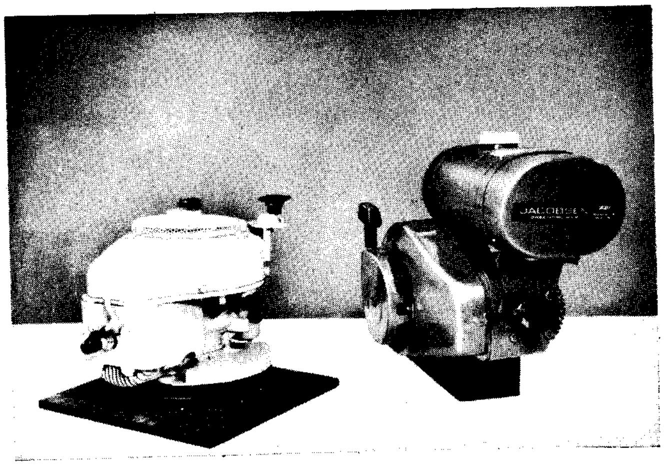


Figure 59. Vertical and Horizontal Engines.

The overhaul will be a step by step pictorial view of the teardown of the 321 engine. The disassembly and inspection of minor components will be covered in sub-section B. (ENGINE TEARDOWN). Major components i.e., carburetor, magneto and starter will be covered in sub-section C. (MAJOR COMPONENTS).

All external shrouding i.e., gas tank cowling, air cleaner, etc. must be removed before the engine overhaul can be accomplished. Remove all shrouding at this point and your engine should look like the one shown in Figure 60.

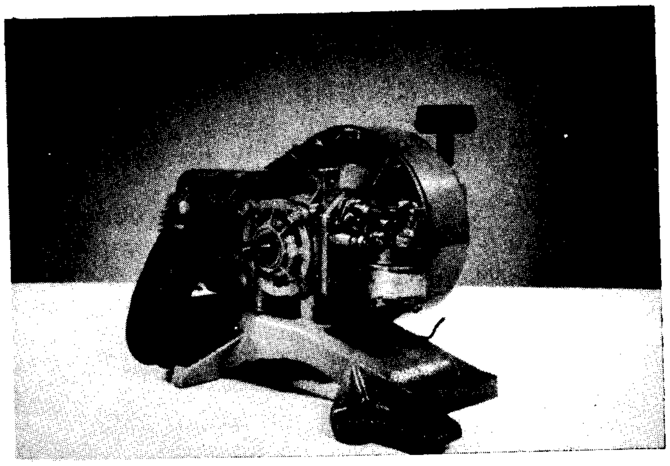


Figure 60. 321 Horizontal Engine – Shrouding Removed.

B. ENGINE TEARDOWN & INSPECTION

1. Governor, Carburetor & Reed Adapter.

   a. Disconnect the governor and the throttle linkage. (See Figure 61.)

      1. Grasp the brass retaining button (A), pull upward and remove.

      2. Lift the notched nylon throttle link to a vertical position and disconnect at (B).

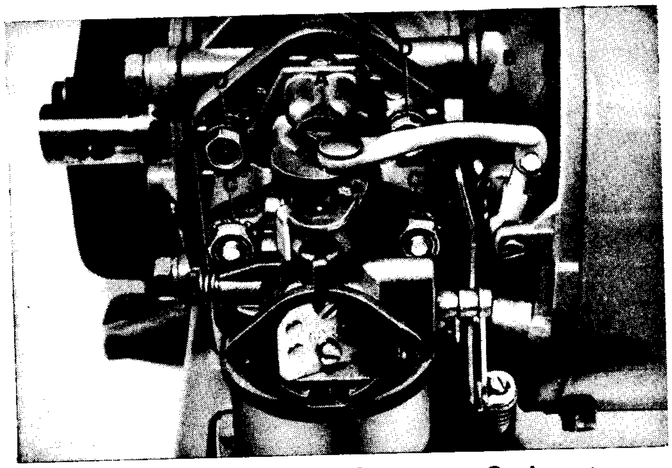


Figure 61. Removal of Governor, Carburetor and Reed Adapter.

b. Unscrew the carburetor mounting nuts (C), and remove the carburetor from the engine.

c. Remove the four hex head mounting screws (D) with a thin walled 3/8" socket, and lift the reed adapter assembly from the engine.

2. Reed Adapter Inspection.

a. Inspect for proper seating of reeds (A) on the die cast portion of the assembly (B). No clearance should be noted if the reeds are seated properly. (See Figure 62.)

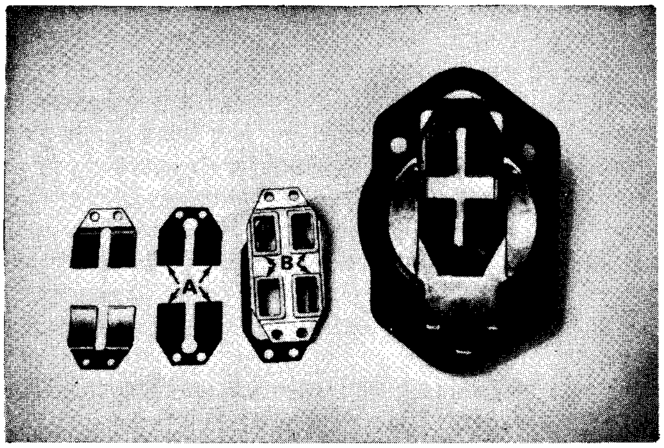


Figure 62. Reed Adapter Inspection.

Improper sealing could be caused by bent reeds, foreign matter in the reed assembly or reeds that have been installed upside down. If reeds are bent, replacement is required. Do not attempt to straighten them, as during manufacture the reeds have been kinked to create a pressure side.

NOTE:

When installing new reeds, the pressure side must always face downward. Positioned in this manner, the reeds seal against the ridges of the four cutout portions of the die cast piece.

b. Examine the bottom of the die cast piece for excessive warpage. Any leakage between the die cast piece, the gasket and the reed housing assembly will cause crankcase pumping pressure. This result in an insufficient amount of and air being supplied to the en

The governor and throttle linkage attache the backplate of the engine can now be remo (See Figure 63.) Using a 3/8" socket, re screw (A), and disconnect the remaining gove and throttle linkage from the backplate of engine. Then remove screw (B) and lift off governor vane.

NOTE:

Removal of the governor vane is sugg to avoid possible damage during flyw removal.

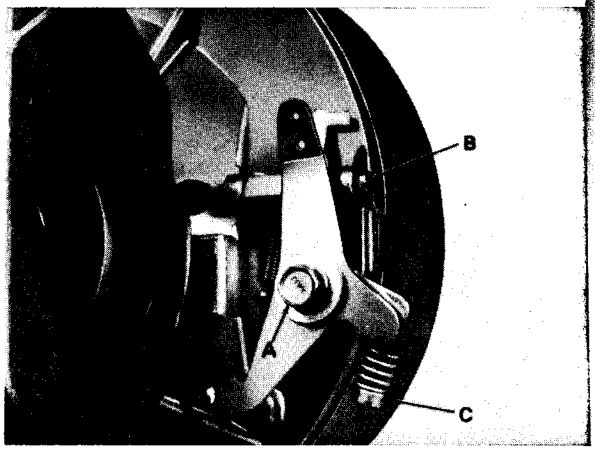


Figure 63. Governor and Throttle Linkage Removal.

The Jacobsen 321 engines, with positive gover control, have an adjusting screw (C) on the le that links the positive control to the govern Turning the adjusting screw from one end of threads to the other will allow an increase or crease of about 400 engine RPM. When adju ment is required, always use a Tachometer check and set engine speeds. (See Table 2 Section V, page 44.)

3. Flywheel.

Using a 3/8" socket, remove the four h head cap screws that attach the flywhe starter cowling to the engine. On a horizo tal engine the flywheel starter cowling removed after the exhaust manifold.

Removal of the flywheel can be accomplished using a strap wrench. (See Service Data – Section V, page 46.)

a. Secure the flywheel with the strap wrench. (See Figure 64.)

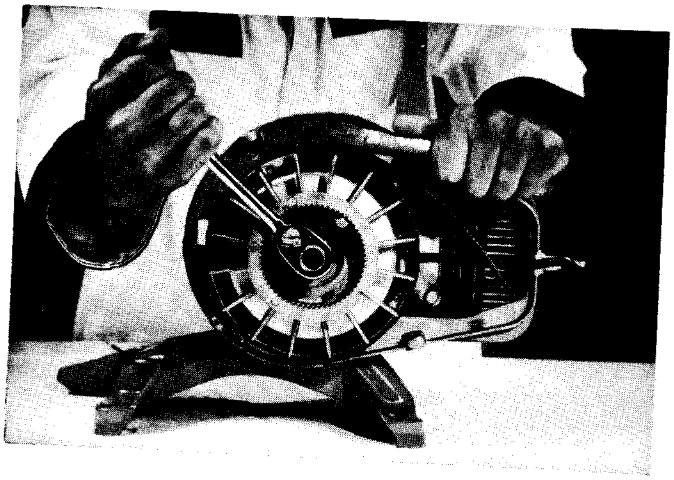


Figure 64. Using the Strap Wrench.

b. With a 11/16" socket, remove the flywheel nut, cupped washer, and the starter cup by turning the nut counterclockwise.

c. Assemble the flywheel knock off nut.

d. Strike the flywheel knock off nut (A) sharply with a hammer. (See Figure 65.)

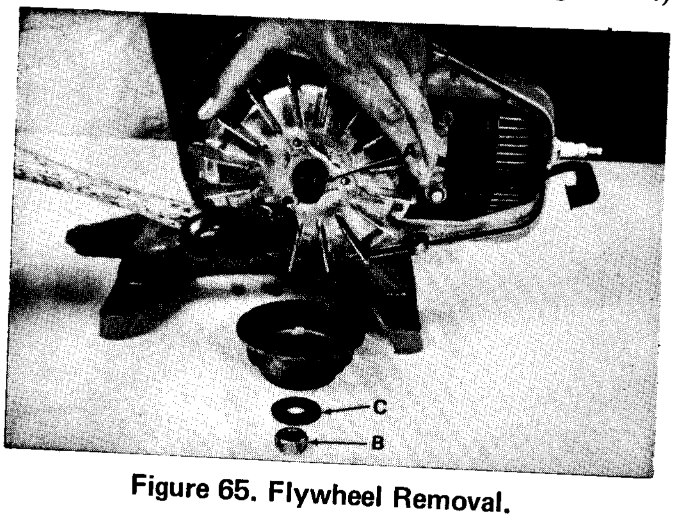


Figure 65. Flywheel Removal.

The strap wrench and knock off nut required for the flywheel removal are available in a special tools kit from any Jacobsen dealer.

NOTE:

NEVER use the original flywheel nut (B) as a knock off nut, as damage to the crankshaft threads will occur.

When reinstalling the cupped washer (C) on the engine, the high portion at the center must be facing toward the nut (outside of the engine).

e. Check the inside of the flywheel for scraping caused by incorrect positioning of the stator plate on top of the crankshaft seal.

f. Magnetic strength of the flywheel should now be tested. (See Figure 66.) Place a 1/2" socket on the magnet and shake as indicated. Replace the flywheel if the socket will not hold to the flywheel.

NOTE:

Dropping the flywheel or hammering on it could cause loss of magnetic strength.

Figure 66. Flywheel Magnetic Strength Test.

4. Stator Assembly.

a. Remove the metal cover and the dust shield (A) from the stator assembly. (See Figure 67.)

Before removing the stator assembly, special attention should be given to the placement of the spark plug wire (B), and the ignition short out wire (C). (See Figure 67.) Incorrect placement of these wires at reassembly will cause cutting by the rotation of the flywheel. Ignition failure will then occur. Also check for evidence of a fuel film surrounding the crankshaft seal. If evident, seal replacement is mandatory.

b. Using a 3/8" socket, remove the 2 screws, lockwashers and flat washers (D).

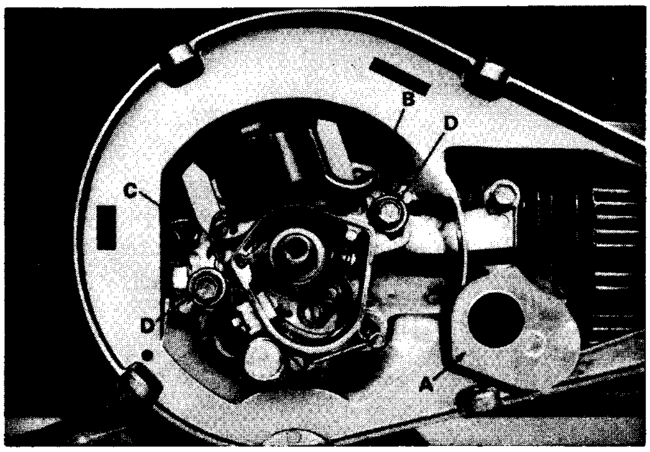


Figure 67. Stator Assembly Removal.

c. Remove the pull connector from the spark plug wire. Lift the stator assembly from the engine and pull the wire through the opening in the backplate.

CAUTION:

NEVER pull the spark plug wire from the coil as internal damage to the spark plug wire will result.

5. Baffle and Cylinder Head.

a. Remove the spark plug from the cylinder head.

b. With a 1/2" socket, remove the four hex head bolts (B) from the cylinder head. (See Figure 68.)

c. Remove the baffle, cylinder head and gasket from the engine.

NOTE:

When reinstalling the baffle on the eng make certain it is locked into the ret ing ears (A).

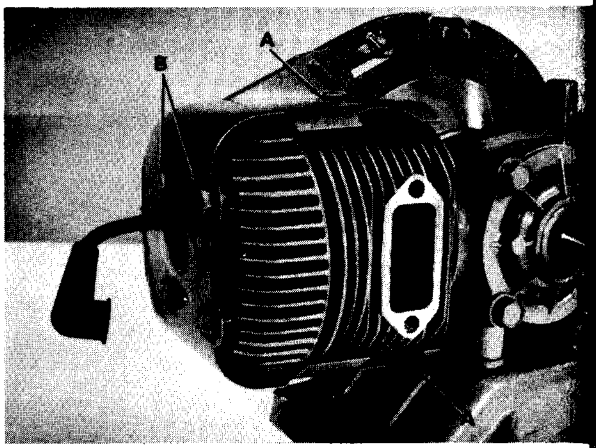


Figure 68. Baffle and Cylinder Head Remova

CAUTION:

NEVER run an air cooled engine with the air baffle in place as overheating will result.

6. Piston and Rod Removal.

a. A clean cloth should be positioned un the rear of the engine before removal the rod cap (A). (See Figure 69.) T cloth will catch any of the 28 nee bearings that may drop from the conn ing rod when the cap is removed.

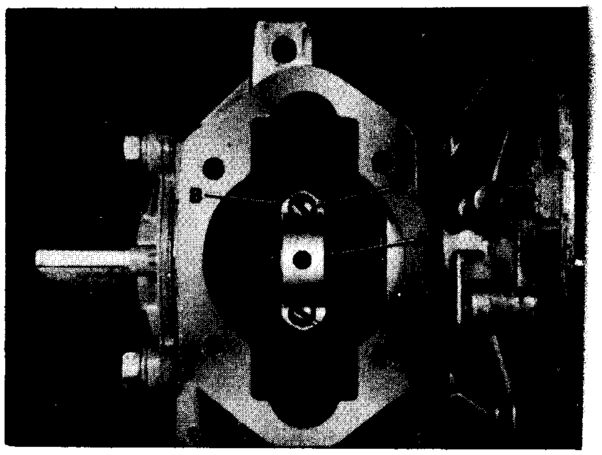


Figure 69. Rod Cap Removal.

b. Before removing the rod cap, note the metal staking (B) on the connecting rod cap. Each time the rod cap is reinstalled, the screw slots are staked to lock them in place.

NOTE:

It is recommended that the rod and cap be replaced after the cap has been removed three times. (Indicated by three staking marks.)

c. Remove the two connecting rod cap screws (C). (See Figure 69.) Push the piston and rod assembly forward, through the cylinder bore of the engine.

d. In Figure 70, locate the 28 needle bearings (A). Always double check to be certain all 28 needle bearings have been removed.

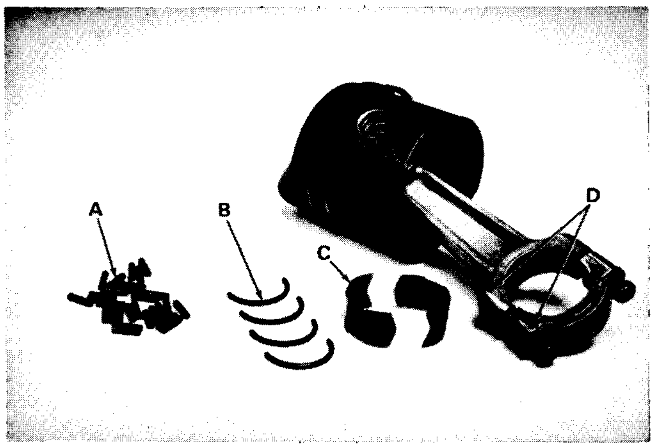


Figure 70. Needle Bearings Removed.

e. Check for the 4, half circle bearing guides (B) and the 2 interchangeable bearing liners (C).

NOTE:

Proper mating of the bearing liners (1 in the rod and 1 in the cap) must be accomplished on reinstallation.

f. The rod and rod cap must be mated on reinstallation. (See Figure 70.) Reference marks (D), on the rod and rod cap should be noted. Mismating and tightening down of the rod cap can cause serious damage to the engine. If this should occur even once, the rod must be scrapped.

7. Piston and Rod Disassembly.

a. Remove the retaining rings (A) from both sides of the piston. (See Figure 71.) Then placing a drift in the hole in the piston pin (B) gently tap the drift until the pin is removed.

Figure 71. Disassembly of Rod and Piston.

NOTE:

Inspect the piston pin bushing in the connecting rod for scoring. If damage is noted, a new rod should be installed.

b. The piston pin (A) should be inspected for wear. (See Figure 72.) If a concave surface on the piston pin is noted (when pulling your fingernail down the length of the pin), replacement is necessary. A piston pin that shows this kind of wear has either a faulty air cleaner or air cleaner maintenance has been poor.

c. Inspect the piston pin for snug fit in the piston. If it revolves or turns even slightly, replacement is required.

d. When installing the piston pin, be certain the hole in the pin faces side (B) of the piston crown. Side (C) is the exhaust side and side (B) the intake side. The

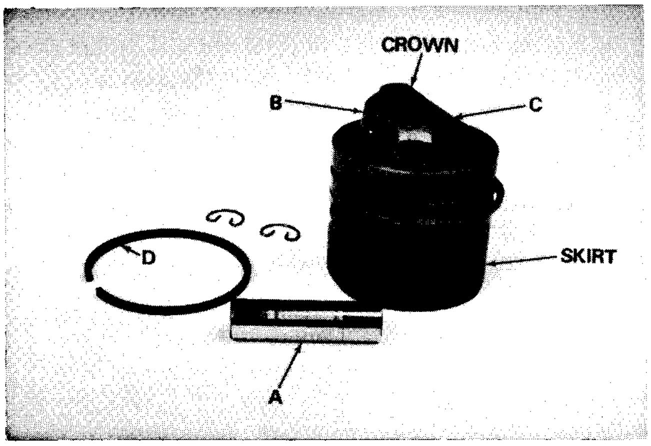


Figure 72. Piston Inspection.

hole is for cooling the piston pin and rod bushings. When properly installed, the piston crown side (B) should face the side of the engine housing the ignition system.

e. Always remove the rings (D) over the top of the piston crown. Special care should be taken not to spiral or over stretch them in the process.

NOTE:

There is a chamfer on one side of the inside diameter of each ring. (See Figure 73.) This chamfered edge must be installed toward the top of the piston crown.

f. To test the piston rings for wear, insert one of the rings approximately 1/2 inch into the cylinder bore. (See Figure 74.) Using a feeler guage, check the ring end gap. Replacement of the ring is necessary if the gap is greater than .070.

g. Sizing and inspection of the cylinder bore can be accomplished with an inside micrometer. (See Figure 75.) If the measurement is .003 or more over 2.1265, the cylinder bore should be rebored or a new short block engine should be installed. The cylinder should be rebor .020 oversize and refitted with a oversized piston.

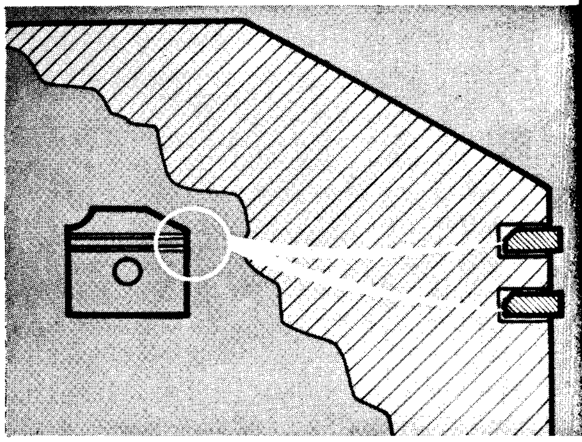


Figure 73. Piston Ring Chamfer.

Figure 74. Piston Ring Gap Test.

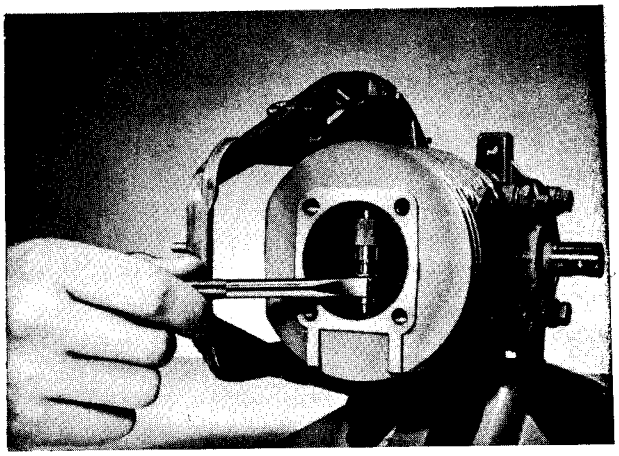


Figure 75. Cylinder Bore Sizing.

NOTE:

If new rings are installed, the cylinder bore must be deglazed. This may be accomplished through the use of a small cylinder bore hone. (See Figure 76.)

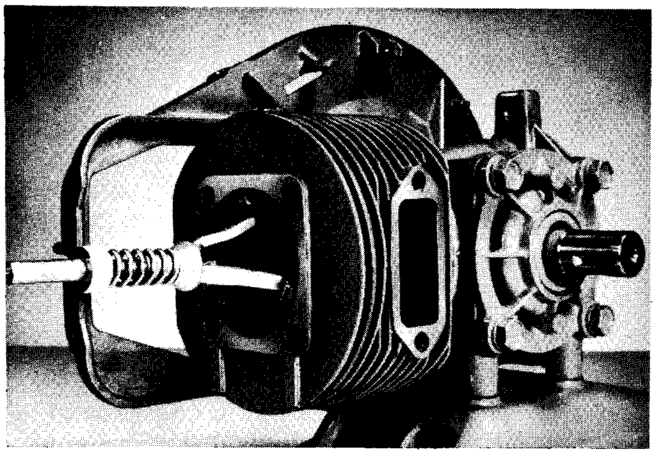


Figure 76. Cylinder Hone.

8. Installing Assembled Piston and Rod.

   a. Insert the assembled piston and rod into the cylinder from the top. The ring compressor shown in Section V — Service Data must be used to compress the rings for insertion. The piston must be positioned with the exhaust side on the same side as the exhaust ports of the cylinder. (See Figure 77.) Position the two ring end gaps on opposite sides of the piston, taking care not to line them up with the intake or exhaust ports.

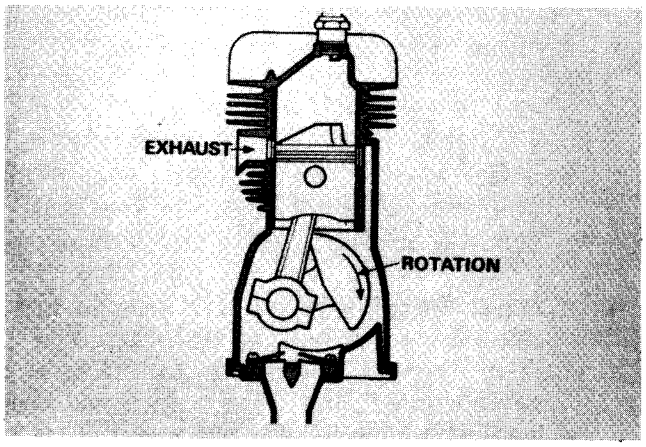


Figure 77. Piston and Rod Installation.

   b. The Jacobsen 321 engine uses a connecting rod bearing kit. It consists of two liners for the connecting rod, four crankpin needle bearing guides and 28 needle bearings. The 28 needle bearings are held together in a wax strip for easy installation. (See Figure 78.)

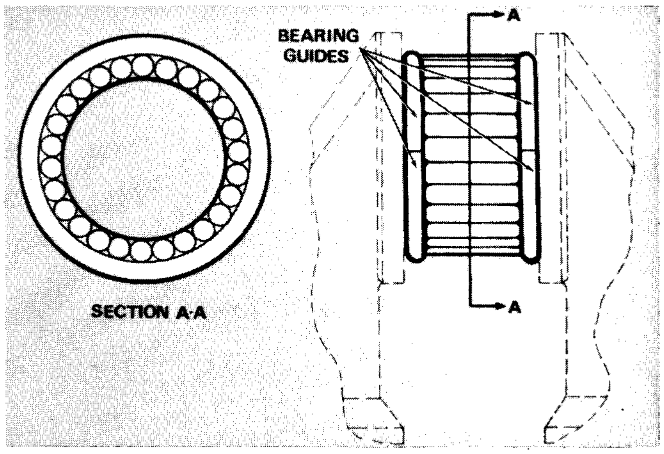


Figure 78. Needle Bearings and Bearing Guides.

   c. Before installing the connecting rod bearings, be certain the wax strip is at room temperature (70° - 80°F).

   d. Inspect the wax strip and count the needle bearings to be certain there are exactly 28. Remove the paper backing and wrap the bearings and wax strip around the center of the crankpin.

   e. With the bearings in this position, apply vaseline around the pin on either side of the needle bearings and slide the semicircular bearing guides over the ends of the bearings. There are four guides required.

   f. Next, install the liners in the connecting rod and cap. Note the 2 reference marks, 1 dot on the rod and 1 dot on the rod cap. They must be mated when reinstalling them. (See Figure 70.)

NOTE:

If the rod cap is mismated and tightened down, the rod must be scrapped or serious damage to the engine will occur.

Position the piston in the cylinder so that the rod liner fits against the needle bearings. Assemble the rod cap with liner, to the rod end and torque attaching screws to 45-50 lbs. inch.

CAUTION:

The ends of the rod liners must match and the rod cap screws must be staked. (See Figure 79.)

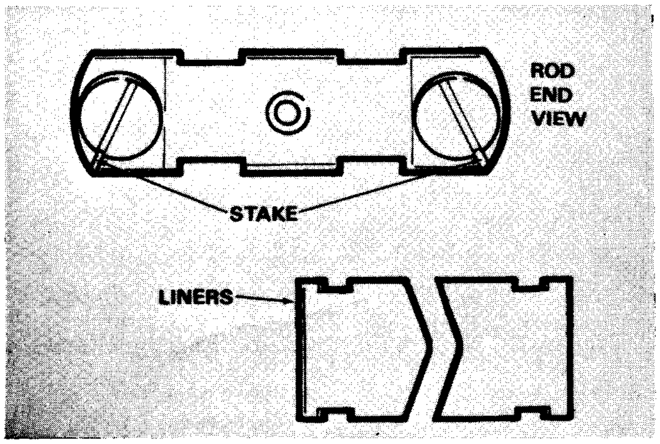


Figure 79. Staking Rod Cap Screws and Liner Match.

9. Backplate.

   a. Insert a seal spreader (A) in the backplate seal before removing the backplate from the engine. (See Figure 80.)

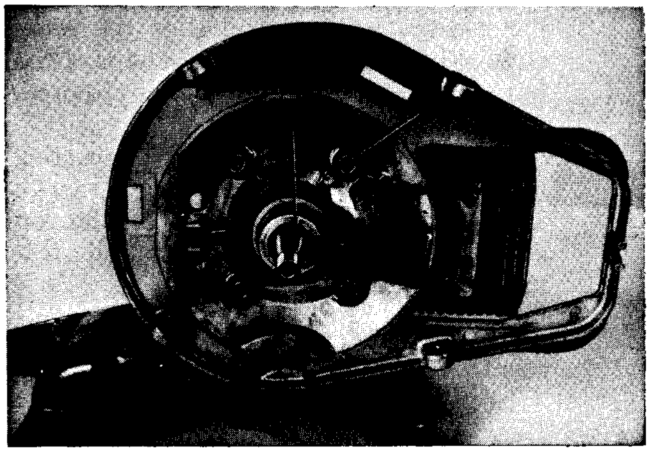


Figure 80. Seal Spreader Installed.

NOTE:

The seal spreader is available in the Jacobsen 321 engine overhaul kit. (See Section IV — Service Data, page 46.)

   b. Remove the six screws (B) that hold the backplate to the engine with a 3/8" socket.

   c. Position the backplate in an arbor press with the seal facing down. (See Figure 81.) Applying pressure to the bearing will force the seal and bearing out of the cavity.

NOTE:

Always use an arbor press to remove the seal. Damage to the seal housing could result in a crankcase air leak.

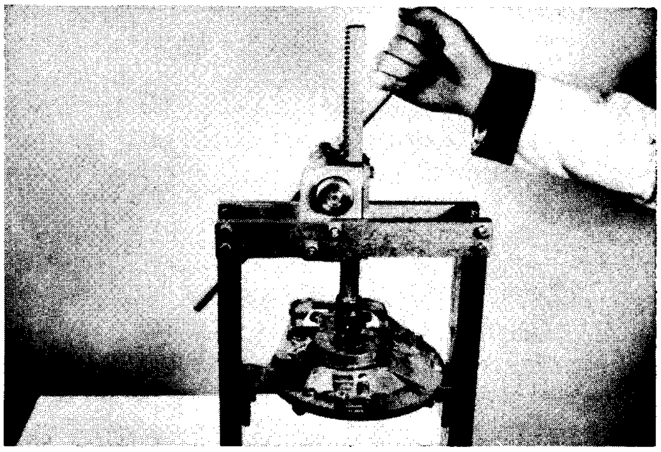


Figure 81. Backplate Seal Removal.

   d. When reinstalling the bearing, seat it to its previous depth, (approximately 3/16" from the top surface).

   e. Before installing a new seal, coat the outside of the seal housing with "Loc-Tite". (See Figure 82.) Position the backplate as illustrated and gently seat the seal until it bottoms. Do not cock the seal in the housing.

NOTE:

On early production engines, do not seat the seal too deep, as the top of the seal must act as a locater (pilot) for the magneto stator plate assembly.

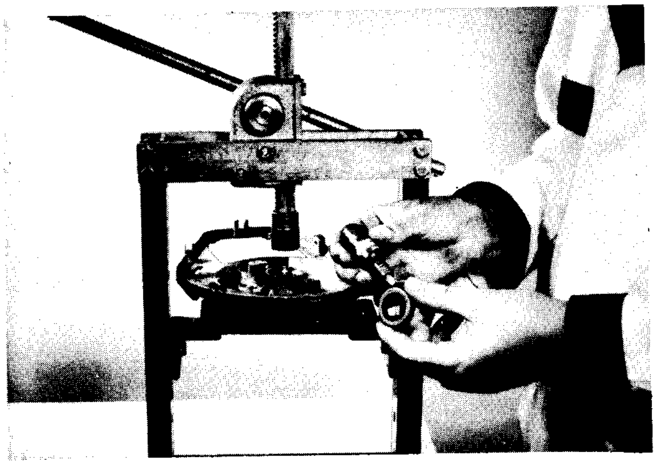


Figure 82. Installing a New Seal.

10. Crankcase Head Assembly.

a. Using a 1/2" socket, remove the four hex head cap screws that hold the crankcase head assembly to the engine. (See Figure 83.)

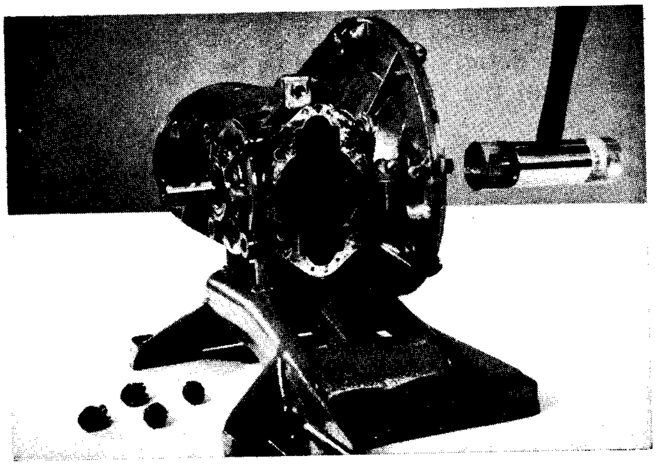


Figure 83. Crankcase Head Removal.

b. With a soft mallet, tap the crankshaft and crankcase head assembly out of the engine from the ignition side.

c. The same procedure can be used to disassemble a vertical crankshaft engine. (See Figure 84.)

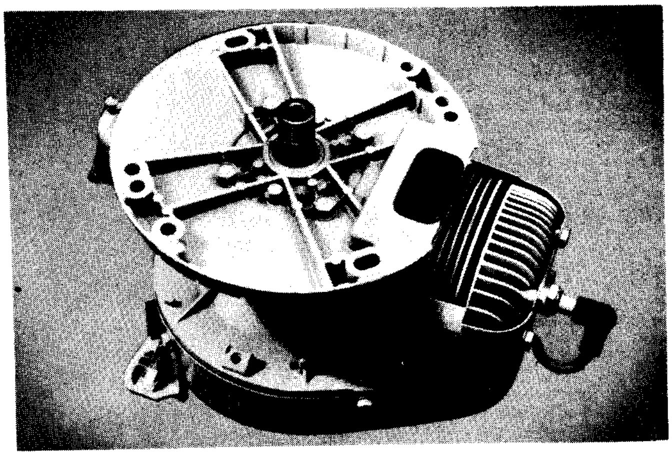


Figure 84. Vertical Crankshaft Engine.

11. Crankshaft Removal.

a. With a 5/16" socket, remove the two hex head cap screws and locking tabs (A) from the crankcase head. (See Figure 85.)

b. The outer race of the ball bearing is pressed into the crankcase head with a light press fit. By placing the crankcase head in an arbor press (See Figure 86.) and applying a light but steady pressure, taking care not to brinell the bearing, press out the bearing and crankshaft assembly.

c. If bearing replacement is necessary, remove the bearing retainer ring from the crankshaft and press the bearing off. After installing a new bearing, be certain the retainer ring is properly seated.

d. To remove the seal on the power, take off side of the engine, position it in the arbor press, and press out. Installation of a new seal will follow the same procedure outlined for backplate seal installation. (See Figure 82.) On engines with a gear reduction box, see Figure 46 for seal installation.

NOTE:

Special attention should be given to the flat spot (B) on the crankcase head. (See

Figure 85.) Position the flat spot so it faces toward the cylinder bore when reinstalled.

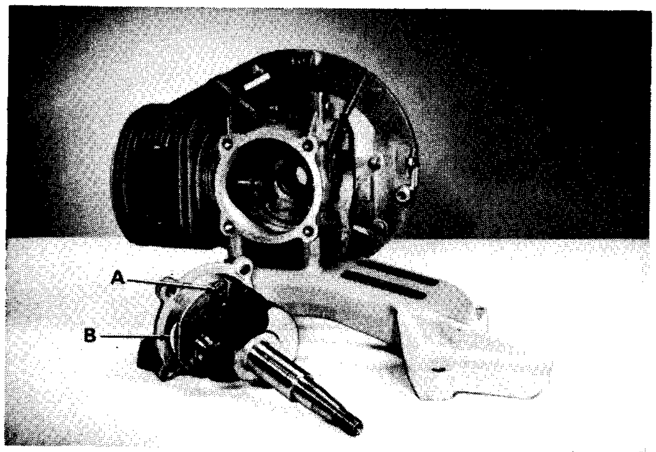


Figure 85. Crankshaft Removal.

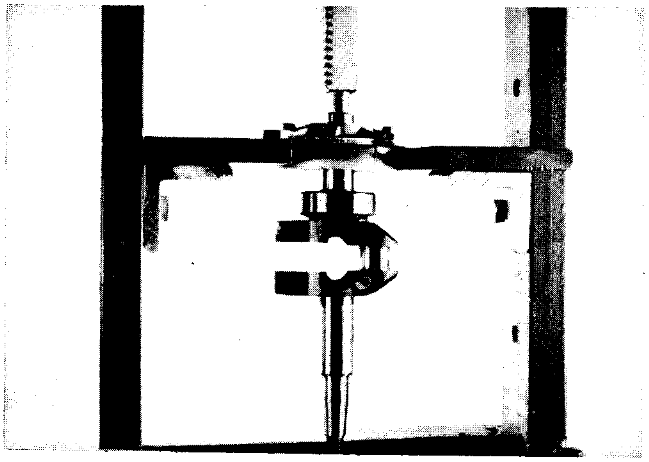


Figure 86. Bearing Removal.

If, after completing the disassembly procedure, a great deal of internal wear is evident, it is recommended that a short block engine replacement be utilized rather than resorting to the more costly and time consuming process of replacing individual parts.

C. CARBURETOR

There are three types of carburetors used on the Jacobsen 321 engine. To simplify identification before disassembly, the following illustrations have been included. (See Figure 87.)

1. Carburetor Identification.

   a. Carburetor (1) is equipped with an idle fuel adjusting needle (F) and a high-speed adjusting needle (G).

   b. Carburetor (2) does not have an idle fuel adjusting needle and is plugged at reference (D). The high-speed adjusting needle is however, the same as the one used on carburetor (1).

   c. Carburetor (3) is termed a fixed jet carburetor. Neither an idle fuel adjusting needle (D) nor a high-speed adjusting needle (E) are necessary as no external carburetor adjustments are required.

2. Carburetor Nomenclature.

   Figure 88 and 89 are illustrations that clarify nomenclature used during the disassembly and adjustment procedures. These illustrations are keyed to the legend.

3. Carburetor Inspection.

   Prior to carburetor disassembly, a complete inspection of the carburetor throttle plate and choke plate should be performed. Binding in the carburetor throat could cause poor power response, stalling at low speeds, and surging from low to high engine RPM. To determine if binding is occurring, perform the following inspection.

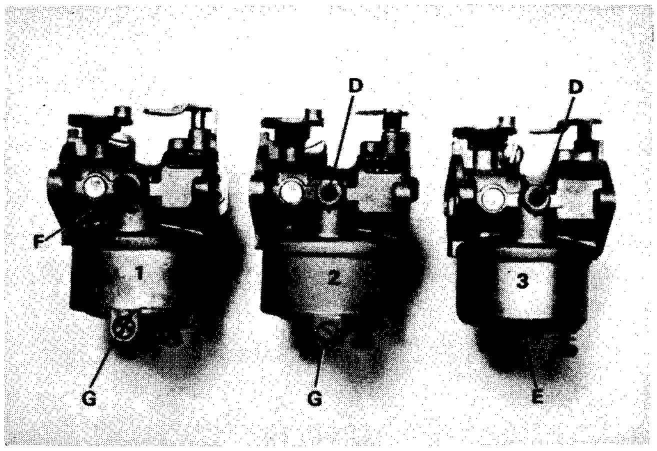
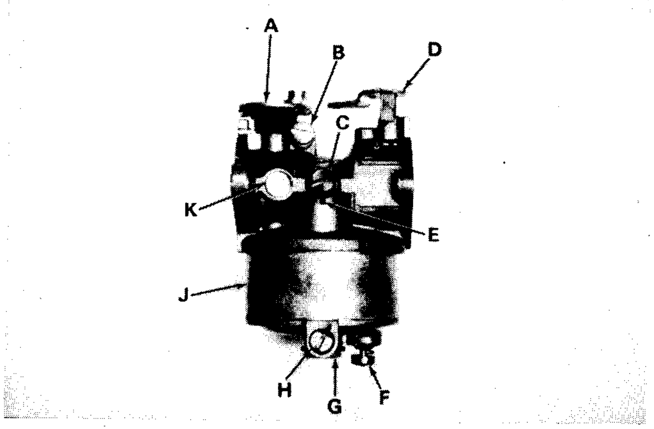
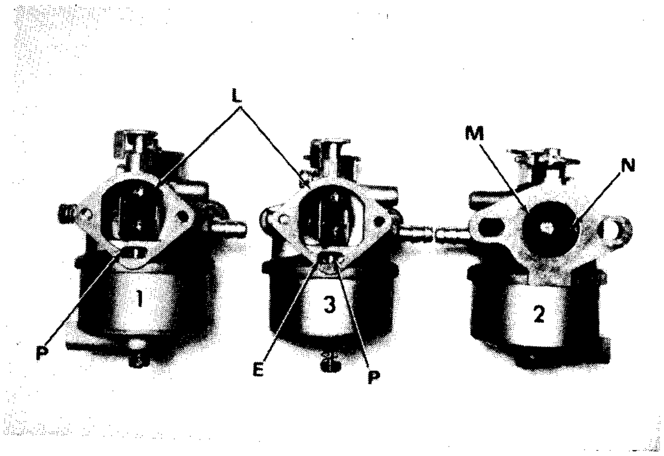


Figure 87. Carburetor Identification.



A. Throttle Plate and Throttle Shaft Assembly.
B. Idle Speed Regulating Screw.
C. Idle Fuel Regulating Screw.
D. Choke Plate and Choke Shaft Assembly.
E. Atmospheric Vent Hole.
F. Float Bowl Housing Drain Valve.
G. Float Bowl Housing Retainer Screw.
H. High-speed Adjusting Needle.
J. Float Bowl Housing.
K. Idle Chamber.

Figure 88. Carburetor Nomenclature.



L. Choke End View of Carburetors 1 and 3. (See Figure 87.)
M. Throttle Plate End View, (All Three Carburetors).
N. Primary and Secondary Idle Passages, (All Three Carburetors).
P. Main Nozzle Air Vent Hole, (All Three Carburetors.)

Note: The atmospheric vent hole, E, on carburetor 3 is located next to the main metering nozzle pressure regulating hole, P. (See Figure 87.)

Figure 89. Carburetor Nomenclature.

a. Turn the throttle shaft disc (A) until the throttle plate is completely closed. (See Figure 90.)

b. The primary idle fuel passage (C) and the secondary idle fuel passage (B) are located in the carburetor throat. (See Figure 90.) If the throttle plate is not binding, only the primary idle fuel passage (C) should be visible.

c. If both passages are visible, backout screw (B) (Figure 88.) until it is not making contact with the stop on the throttle shaft disc (A) in Figure 90.

d. If the throttle plate is still incorrectly positioned, both passages will be visible. The throttle plate, which has beveled edges, must be positioned in such a manner that binding between the throttle plate and the carburetor throat will not occur.

e. To obtain proper throttle plate positioning, hold the carburetor in its normal operating position and loosen screw (D). (See Figure 90.)

NOTE:

With the carburetor held in its normal operating position (See Figure 90.), the throttle plate will pitch in on the right and out on the left in the carburetor throat, as you are looking at the throttle plate.

f. Position the throttle plate so the stamped "W" is at approximately 9 o'clock in the carburetor throat and turn the throttle shaft disc plate (A) until the throttle plate is closed. Only one hole should then be visible, (hole C which is the primary).

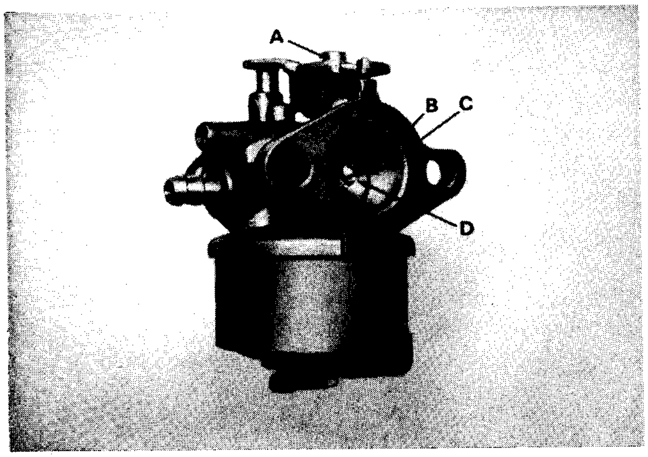


Figure 90. Carburetor Throttle Plate Inspection.

g. Hold the throttle plate in this position and retighten screw (D). Check for binding.

h. If binding is still noticeable, loosen screw (D) and slightly reposition the throttle plate.

The choke plate must be properly installed in each carburetor, or the choke will not function. Due to the external connections of the choke mechanism, <u>the choke plates on all horizontal crankshaft engines pitch in on the right and out on the left</u>. On the vertical crankshaft engine however, <u>the choke plate pitches in on the left and out on the right</u>. This pitch reference is correct only <u>when</u> the carburetor is held in its normal operating position and you are looking at the choke.

i. Inspect the choke end of the carburetor throat. (See Figure 91.)

j. The self-regulating choke valve (C) must seal tightly against the inside surface of the choke plate to function properly. If improper sealing is noted, the choke plate must be replaced.

NOTE:

For effective cleaning of the internal passages at point (D), remove the two screws that secure the choke plate to the shaft and remove both the choke plate and shaft from the throat of the carburetor.

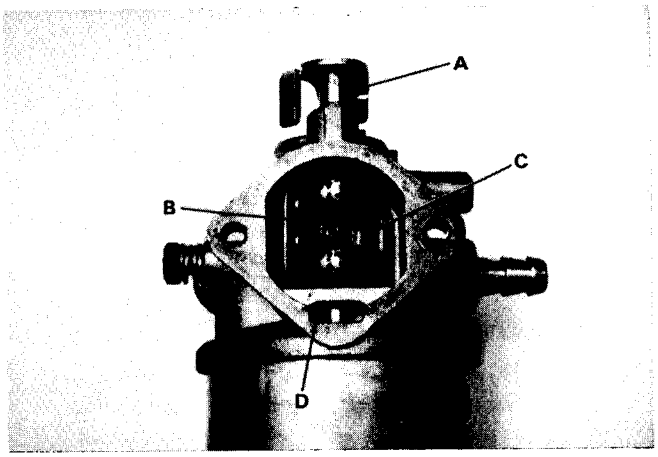


Figure 91. Carburetor Choke Plate Inspection.

4. Carburetor Disassembly & Cleaning.

   a. Remove the idle fuel regulating screw (C) and the high-speed adjustment needle (H), if your carburetor is so equipped. (See Figure 88.)

   b. With a box wrench, remove the brass retaining screw (G) at the bottom of the float bowl housing.

   c. Hold the carburetor upside down and lift the float bowl housing (J) from the body of the carburetor. Inspect the housing for clogged or contaminated passages. Care must be taken to assure that the opening that houses the high-speed adjusting needle and the area under the filtering screen in the float bowl housing, if so equipped, are thoroughly cleaned. These areas are the most common places for dirt and gum deposits to accumulate. Gum formations develop by leaving old fuel in the engine for extended periods of time. Refer to section VII on Proper Engine Storage, page 79.

d. The two 9/16" gaskets (A) located on the inside and outside of the float bowl housing must be discarded. (See Figure 92.) (Earlier vintage carburetors used three gaskets.) Replacement of these gaskets is essential each time the float bowl housing is removed. Use of old gaskets will cause a poor seal and eventually effect the final carburetor adjustment.

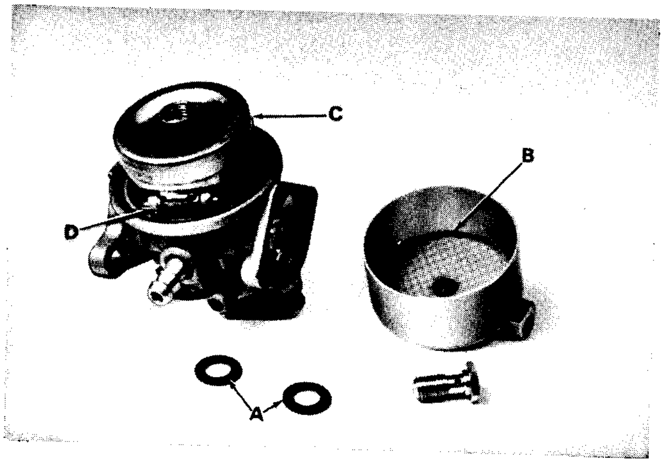


Figure 92. Float Bowl Housing Disassembly.

e. The fine screen (B) in the bowl housing must be removed to thoroughly clean the carburetor. Do not try to lift the screen from the bowl. Remove by tapping the bowl lightly on a flat surface while it is in an upside down position. Do not rap the housing a number of times in rapid succession, as this may cause damage to the screen.

NOTE:

Fixed jet carburetor float bowl housings are not equipped with screen (B).

f. Remove the hinge pin (D) and gently lift the float assembly (C) from the carburetor body.

g. Before removing the main metering nozzle (B) from the stem of the main carburetor body (A), note the screwdriver slot in the nozzle end. (See Figure 93.) Always use a screwdriver that will fit the entire diameter of the nozzle slot. Use of too small a screwdriver could raise a burr and effect the fuel flow passing through the main metering nozzle.

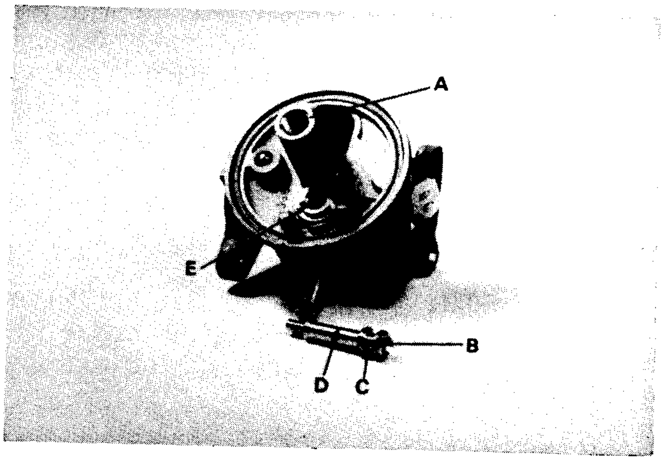


Figure 93. Main Metering Nozzle.

h. After removing the main metering nozzle (B), check to be certain the four idle fuel holes (C) and the four air bleed holes (D) are not restricted. There are six air bleed holes on the fixed jet nozzle. (See Figure 93.) Next, remove the brass seat (E) with its gasket from the carburetor.

i. At this point the carburetor may be rinsed in any pure cleaning solvent.

NOTE:

If a commercial carburetor cleaner is used, remove the throttle shaft and plate to protect the dust shield located on the throttle shaft.

j. Use an air hose to blow the excess solvent and dirt from the passages illustrated in Figure 94.

5. Fuel and Air Flow.

The passages illustrated in Figure 94 explain the fuel and air flow through the carburetor. Any restrictions in these passages can cause severe engine problems.

Fuel flows from the float bowl housing up through the main metering nozzle at point (A) and then through the main metering nozzle (M) into the venturi of the carburetor. Additional air which helps to vaporize the fuel stream into a fine mist enters at point (B) and flows through the holes in the upper section of the nozzle at (E) where it mixes internally with the fuel passing up through the main metering nozzle.

NOTE:

If points (B) in the housing, or (E) on the nozzle are restricted, the engine will "run rich". This will result in excessive smoking and rapid carbon accumulation in the cylinder bore.

Points (A) and (B) on the carburetor housing and (E) on the main metering nozzle, constitute the internal high-speed air and fuel system of the carburetor.

While the engine is idling, the fuel is forced from the float bowl housing up into the main metering nozzle to point (F). It then flows out through a horizontal drilling to point (G). From there it passes upwards through a vertical drilling to point (D).

At this point air enters through the idle air pickup (C) and mixes with the fuel coming up through the vertical drilling at point (D). The air and fuel for the idle system then passes through a horizontal drilling to the idle chamber (H). This is where the primary and secondary idle fuel passages (J) and (K) are located.

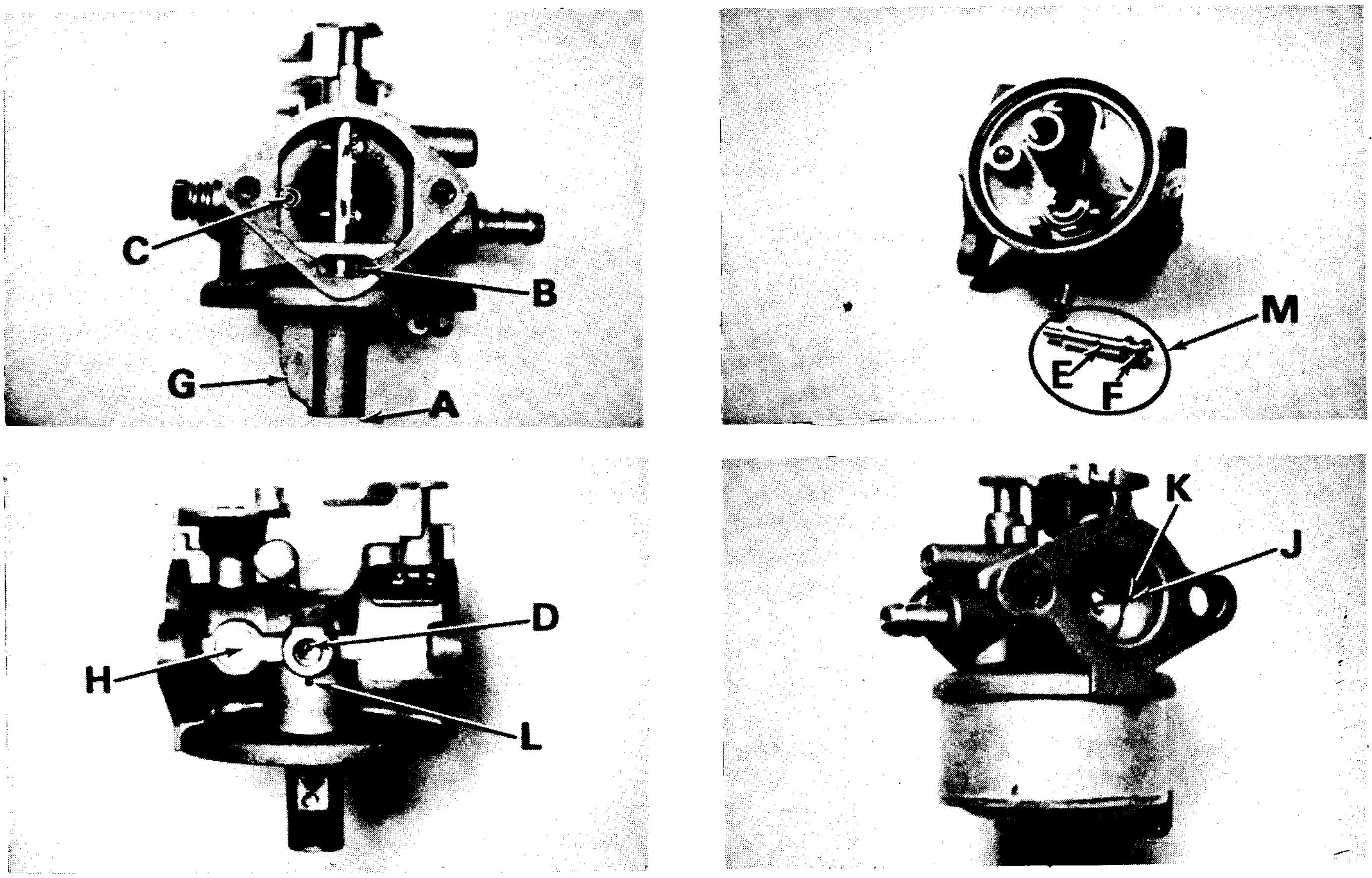
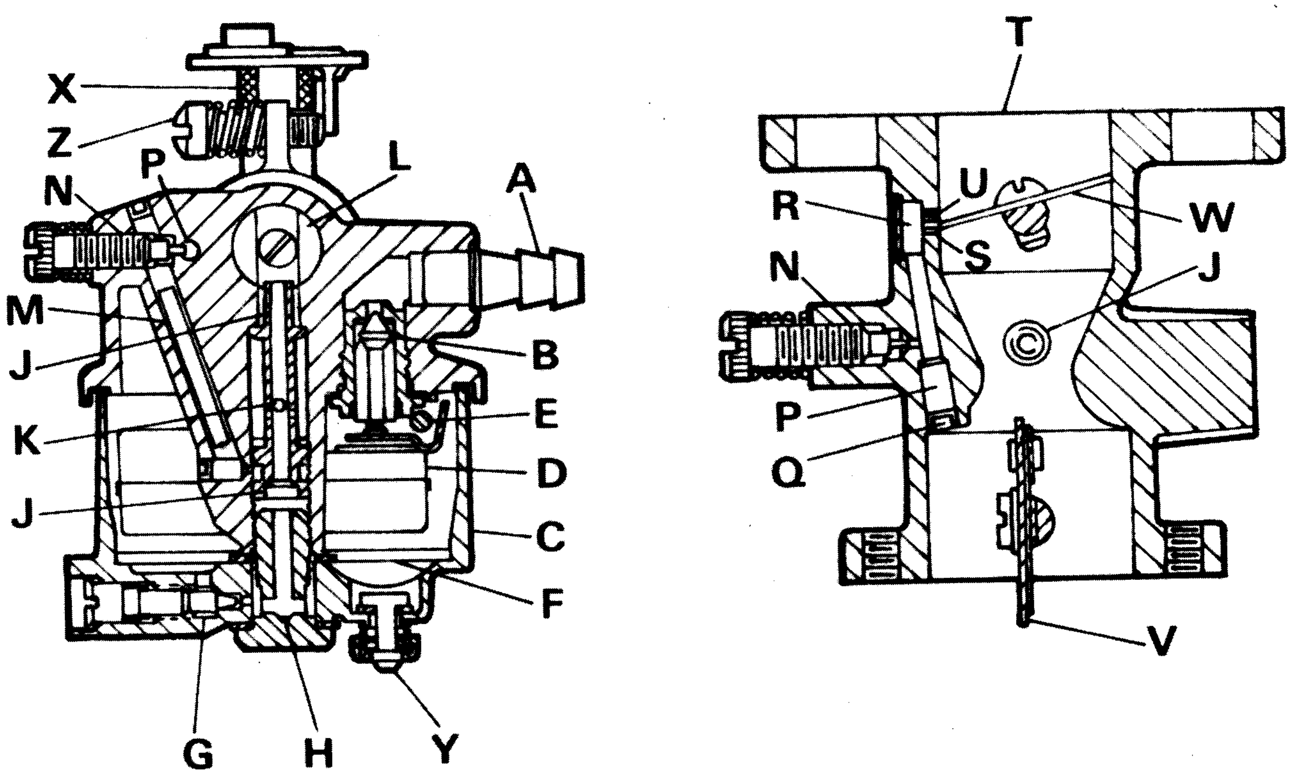


Figure 94. Fuel and Air Flow Passages.



A. Inlet Fitting	J. Main Nozzle	S. Secondary Idle Hole
B. Inlet Valve	K. Nozzle Air Bleed Holes	T. Throttle Bore
C. Fuel Bowl	L. Venturi	U. Primary Idle Hole
D. Float	M. Idle Channel	V. Choke Plate
E. Float Hinge Pin	N. Idle Fuel Adjustment Screw	W. Throttle Plate
F. Filter Screen	P. Emulsion Channel	X. Throttle Shaft Seal
G. Main Adjustment Screw	Q. Idle Air Pickup Hole	Y. Drain Valve
H. Fuel Bowl Retainer	R. Idle Chamber	Z. Idle "RPM" Adjusting Screw

Figure 95. Cross Section of Walbro Carburetor.

This view of the Walbro carburetor will supply a more complete understanding of how fuel and air moves through the carburetor into the engine.

Although other components in the engine have an effect on performance similar to carburetion difficulties, dirt is the major cause of field service carburetor problems. Proper cleaning is essential and the passages shown on the cross sectional view must be blown out with compressed air.

NOTE:

In Figure 94 the atmospheric vent hole (L) must be thoroughly blown out when cleaning the carburetor. See Figure 89 for the location of the atmospheric vent hole (E) on the fixed jet carburetor.

The fixed jet carburetor illustrated in Figure 96 does not contain a high-speed adjusting needle. The fuel flows directly from the float bowl housing into the main orifice (A). On early production the main orifice is located at point (B). When cleaning the main orifice, use a No. 66 drill which is .033 in diameter. Also on late model fixed jet carburetors there are three idle fuel feed holes. The third hole will be located below the letter S in Figure 95.

NOTE:

Carburetors with the main orifice at point (A) will give improved hillside performance over point (B). Follow the direction on page 67 paragraph C to adjust the float setting; however use a clearance of 1/16 to 3/32 on the fixed jet carburetor.

WARNING:

All passages must be cleaned thoroughly when overhauling the carburetor.

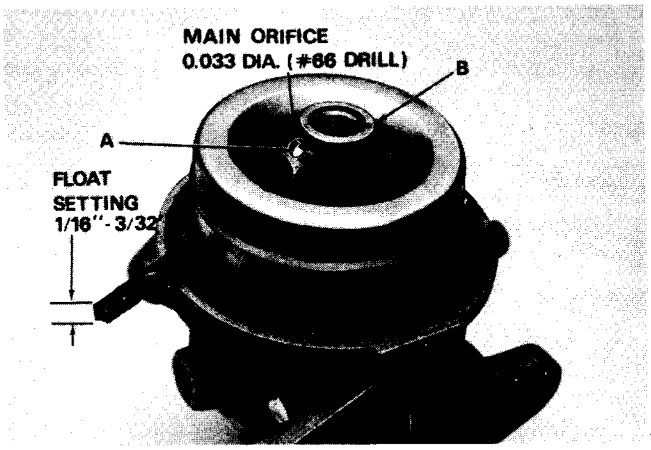


Figure 96. Fixed Jet Carburetor.

6. Needle and Seat Inspection.

The needle and seat assembly must be inspected for wear before reassembly and installation into the carburetor. (See Figure 97.)

a. Inspect the apex of the needle (A). Draw your fingernail down the side of the apex to determine if a ridge is present. The needle and seat must be replaced as a matched assembly if the ridge is apparent.

b. Next, inspect the float for leakage or damage and replace the float if damage is noted. If the float shows any indication of collapsing (accordian effect), it must be replaced.

NOTE:

Use of an air hose while the float is still in the carburetor can cause leakage or damage to the float. Air under pressure being forced through the high-speed needle hole in the float bowl housing could cause this float damage.

7. Carburetor Reassembly.

To reassemble the carburetor it will be necessary to install a new gasket, the seat, the needle, the spring and the float assembly in the order listed.

a. Make certain, if the spring (B) has a fastener, that it is connected to tab (C) on the float. (See Figure 97.)

b. Hold the carburetor in an inverted position and check the float setting. (See Figure 98. — reference A.)

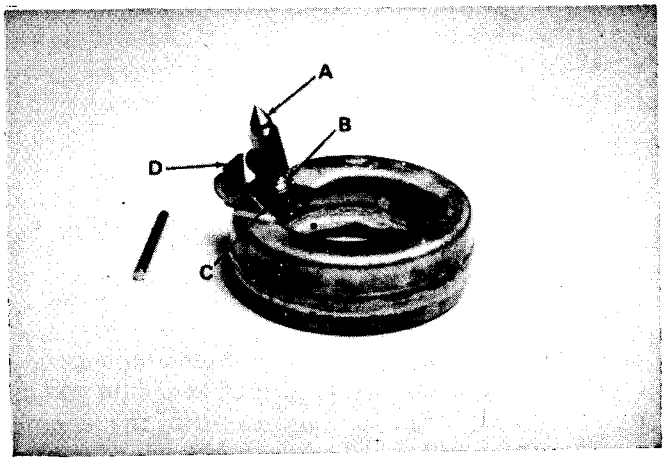


Figure 97. Needle and Seat Inspection.

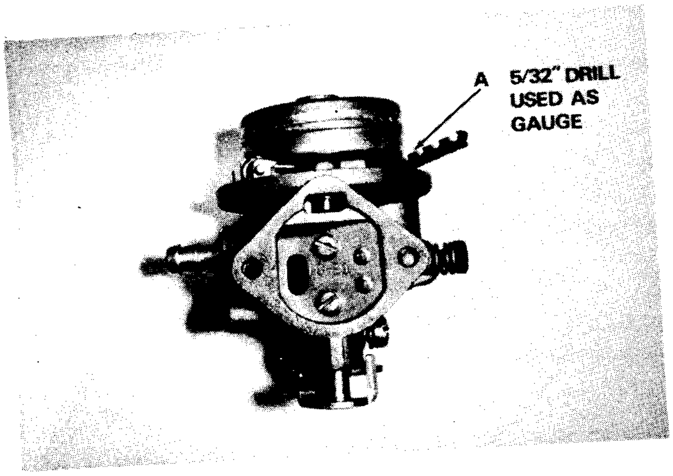


Figure 98. Float Adjustment.

c. Adjust the clearance between the float and the casting rim to 5/32 of an inch (illustrated by a 5/32" drill) by bending tab (C). (See Figure 97.) The float travel setting (D) is 3/16". Tab (D) must be bent to limit float travel.

NOTE:

The float setting on the fixed jet carburetor is 1/16 to 3/32 of an inch.

d. Next, install the metering nozzle (B). (See Figure 99.)

e. Install the filter screen in the float bowl housing. Make certain that the screen makes contact with the bottom of the housing.

f. Hold the carburetor in an inverted position and install a new gasket on the threaded stem ("A" on Figure 99) of the carburetor body.

g. Place the float bowl housing on the carburetor body with the high-speed adjusting needle hole on the same side as the idle adjusting needle hole.

h. Center the inside gasket on the threaded hole ("A" on Figure 99) by revolving a screwdriver in the retainer screw hole on the float bowl housing. Place a new gasket on the retainer screw and turn the screw in finger tight.

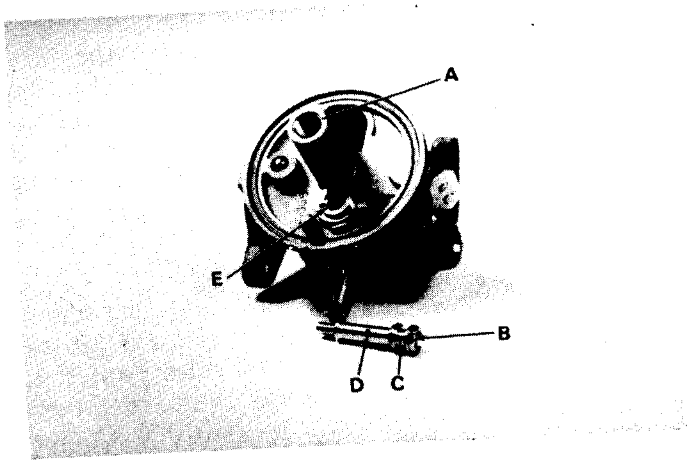


Figure 99. Meter Nozzle Installation.

NOTE:

It is very important to proper carburetor adjustment that the retainer screw be tightened securely but not stripped.

i. Hold the carburetor exactly as illustrated in Figure 100. Using a box wrench, tighten the retainer screw (A) slowly until you feel the carburetor digging into the palm of your hand.

j. Reinstall the choke plate and throttle plate, (if removed) as described in Carburetor Inspection, (paragraph 3, page 60).

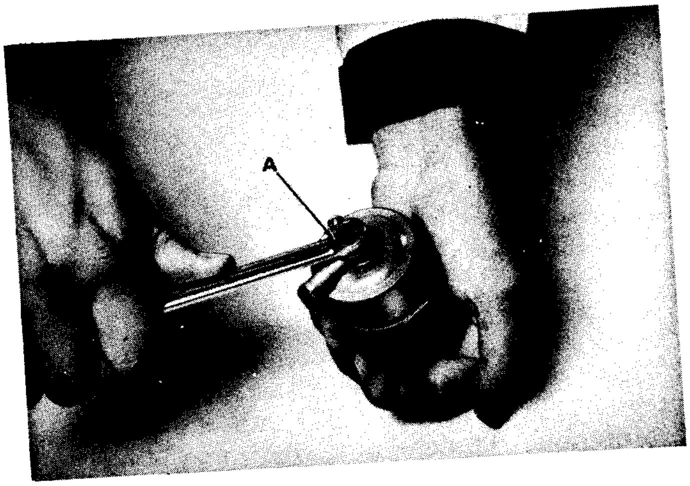


Figure 100. Retainer Screw Installation.

k. To complete assembly of the carburetor, refer to Figure 88 and install the idle speed regulating screw (B). The throttle plate must be closed completely before turning in the screw. Screw (B) must make contact with the stop on the throttle disc but should not open the throttle plate.

l. Next, install the idle fuel regulating screw (C). Inspect the orifice for screw (C) to be certain the loose vertical wire (which is housed inside) is not visible and then turn in screw (C) until it gently bottoms.

NOTE:
The vertical wire, which is used to prevent vapor lock, can be seen in the screw orifice by holding the carburetor upside down.

m. At this point install the high-speed adjustment needle (H), until it gently bottoms. Make certain the screwdriver slot in the high-speed adjusting needle, (at the flat side of the needle) is aligned with a notch in the float bowl housing.

NOTE:
If this alignment cannot be made, the needle has been overtightened causing enlargement of the metering orifice in the float bowl housing. The float bowl housing must then be replaced, in order to attain the prescribed final carburetor adjustments. All final carburetor adjustments are covered in "Final Engine Adjustments" on page 74.

D. MAGNETO

The Jacobsen 321 utilizes three different magnetos. Removal of the magneto from the engine is covered under Engine Teardown and Inspection.

In this manual we will cover the standard breaker magneto and the CD breakerless magneto. The Blaser solid state breakerless magneto is not replaceable as an assembly nor are any parts serviceable. To determine which magneto is used on your engine, refer to Figures 101, 102, and 103.

When service is required on the Blaser magneto, the entire magneto (including flywheel) must be replaced by the CD breakerless magneto shown in Figure 102, or a standard breaker magneto.

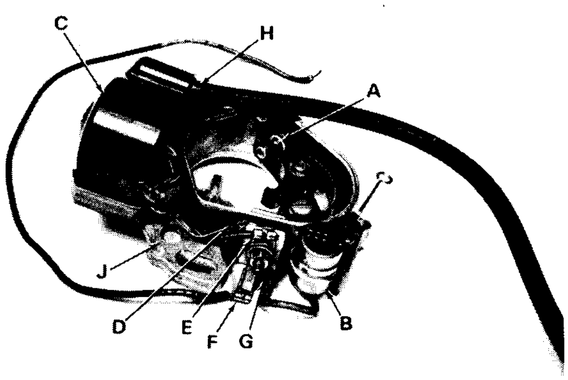


Figure 101. Standard Breaker Magneto.

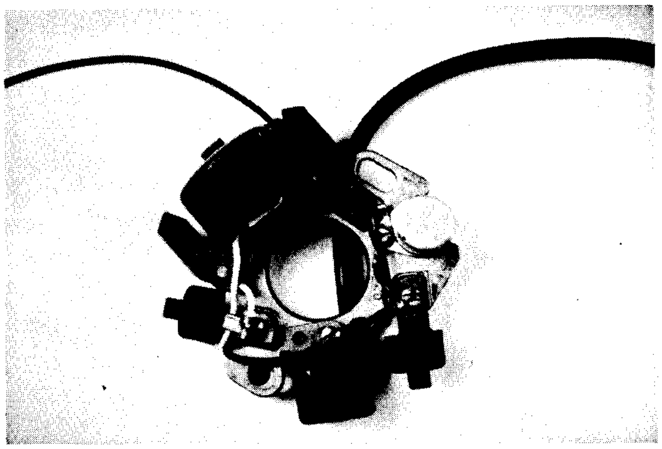


Figure 102. CD Breakerless Magneto.

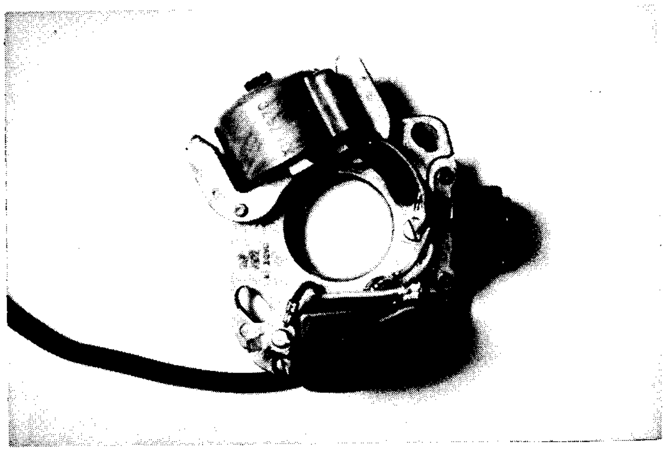


Figure 103. Blaser Solid State Breakerless Magneto.

To convert a Blaser magneto to a standard magneto with breaker points, the original Blaser flywheel must be replaced with a standard flywheel. This must be done due to the double set of magnets in the Blaser flywheel (located about 120 degrees from each other) which will reduce electrical output if used with the wrong magneto.

1. Magneto Nomenclature.

The nomenclature for the standard breaker magneto in Figure 101 is as follows:

a. Breaker Points
b. Condenser
c. Coil (primary and secondary)
d. Coil Secondary Wire (ground)
e. Coil Primary Wire (live)
f. Ignition Short-out Wire (live)
g. Condenser Lead (live)
h. High Tension Lead
j. Stator Assembly (includes points, coil condenser)

2. Stator Assembly Inspection.

While the stator assembly is removed from the engine, it should be inspected for any of the following problems.

NOTE:

Figure 101 shows the correct placement for all wires.

1. The silver leaf spring tension band on the rocker arm is grounded against the stator plate. Result — No spark at all.
2. Pitted, corroded or dirty points. Result — Insufficient voltage for a spark.

NOTE:

Filing of points should be done as a temporary measure only, as the filing removes a protective corrosion coating. New points should be installed as soon as they are available. Install a new breaker cam lubricating wick with each new point set.

3. Condenser too weak or too strong. Result — Pitting and erosion of the breaker points.

NOTE:

Always use the correct capacity condenser, (Wico x 11000). See condenser test data in Section V — Service Data.

4. Forcing the coil over the laminated stackings on the stator plate. Result — External cracks in the coil casting and broken primary or secondary wires. See coil test in Section V — Service Data, page 46.
5. Secondary wire not properly grounded to the stator plate. Result — No spark.
6. Primary wire loose or grounded to the stator plate. Result — No spark.
7. The ignition short-out wire is grounded against the stator plate. Result — No spark.
8. The condenser wire is loose or grounded against the stator plate. Result — No spark.
9. Incorrect removal of lead from coil. Result — Void wire area in rubber end of the high tension lead, which could cause a timing delay or weak spark.
10. Look for pin hole leaks in the rubber end especially where rubber passes through metal openings. Result - magneto short-out.
11. The stator improperly centered around the crankshaft seal. Result — A warped stator plate.

NOTE:

Improper centering of the stator on top of the seal could also cause scraping on the inside of the flywheel.

After completing the checks listed above, you are ready to reinstall and properly time the stator plate. Install the stator plate in the reverse order of removal. See Engine Teardown, page 51.

3. Ignition Timing.

There are two elongated mounting holes in

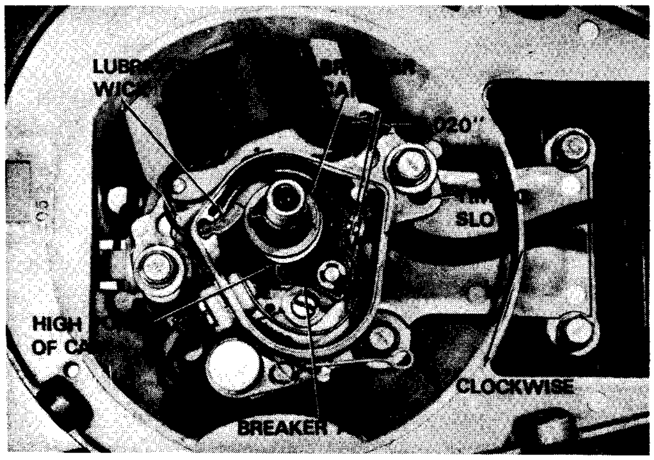


Figure 104. Stator Assembly Inspection.

the stator plate which regulate the timing of the engine. (See Figure 104.)

The engine will run with the timing set anywhere within these elongated slots, however it will only perform properly under load when the timing is set to a precise position.

a. Position the high tension lead wire and the ignition short-out wire under the stator plate. (See Figure 105.)

NOTE:

Failure to position the wires under the stator plate could result in an ignition short caused by contact with the flywheel.

b. Insert the high tension lead wire through the hole in the engine backplate and then reinstall the metal spark plug clip to the end of the lead wire.

c. Looking at the ignition end of the crankshaft, turn the stator assembly clockwise as far as it will go. The stator must be sitting perfectly flat around (not on top of) the crankshaft seal. Now install and secure the two mounting screws.

The timing is now correctly set at full retard, 22° or 1/16 of an inch before top dead center.

NOTE:
The only exception to the timing process outlined would be the horizontal engine used on the Jacobsen 20" Snow Jet. On this model the stator must be rotated full counterclockwise which sets the ignition timing at full advance 28° or 1/8 of an inch before top dead center.

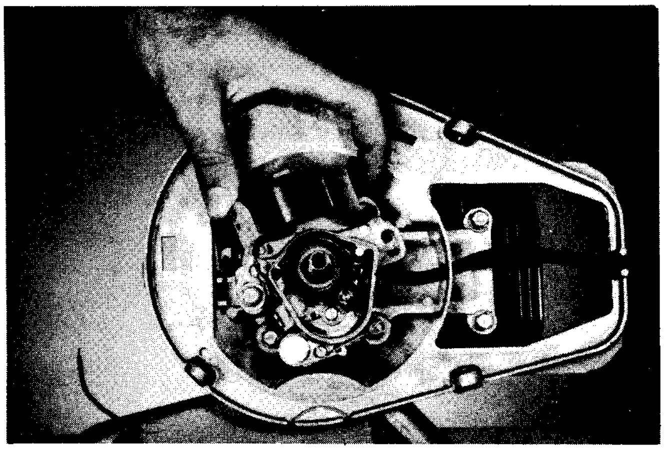


Figure 105. Ignition Timing.

4. Point Setting.

The point setting on any magneto must be a very exacting measurement. Being out of proper adjustment just a few thousands of an inch can greatly reduce the maximum potential voltage that the magneto should produce.

An incorrect point adjustment can greatly reduce spark plug life. Earlier we explained that replacing the spark plug can cause a nonrunning engine to function properly. What happens is simply that a new spark plug reduces the voltage requirement to a level that a poorly performing ignition system can handle. This does not resolve the problem; it only prolongs the corrections of a serious contamination problem in the cylinder, spark plug life is shortened and ignition failure is inevitable. See Figure 101 for magneto nomenclature.

a. Examine the cam for wear. If wear is apparent, the cam should be replaced. Install the cam so the shoulder on the cam

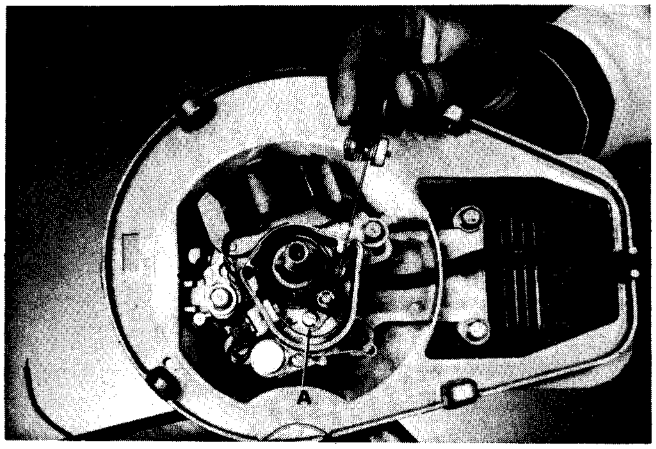


Figure 106. Point Setting.

is facing away from the engine.

NOTE:
Most small engines have a shoulder or an arrow on one side of the cam. It is standard practice to install the cam with the arrow or shoulder facing away from the engine.

b. Install the key that holds the cam and flywheel in place. Rotate the crankshaft clockwise until the point breaker arm is on the highest spot on the cam. (See Figure 105.)

c. Lightly loosen screw (A) but do not remove. A slight thread pressure on this screw will aid in holding the points in place while setting them to their proper clearance which is .020.

d. After setting the points, place a clean (not oily or waxy) piece of paper between the two contacts while they are closed and slowly withdraw the paper.

NOTE:

Drawing the paper through the contacts will clean the points and reduce the possibility of pitting due to oil or dirt on the point surface that may have been left during installation or adjustment procedures.

After the point setting has been accomplished, the fiber gasket and metal cover should be replaced. Check for ample spring tension on the cover hold down spring.

The flywheel can now be installed. Remove any rust build-up on the magnet before installation. The flywheel nut must be tightened to 300-360 inch pound torque.

Check basic Spark Available (not ignition) by using the magneto test plug number 313164. This will not verify ignition; it will only verify that the minimum 10,000 volts at cranking speed is being produced by the magneto components. The condition of the spark plug will dictate the voltage it requires to ignite the air and fuel under compression.

The voltage demands of the plug are in a constant state of change depending on the operating temperature of the engine and the ability of the engine to burn the fuel and leave the minimum amount of deposit residue in the cylinder.

As the three phases necessary for an internal combustion engine to run are carburetion, compression and ignition, this area is a critical point in the procedure. Check the engine for ignition. Refer to Section IV – Troubleshooting. If the engine passes the tests outlined in the text but will not start, refer to the carburetion section of troubleshooting.

E. STARTER

The following section of this manual will cover the three starters used on the Jacobsen 321 engine. Figure 107 will serve as an identification illustration for the two Eaton Starters.

1. Eaton Starters.

There are two different Eaton rewind starters used on the Jacobsen 321 engine. The overhaul procedure is basically the same on both models.

After the starter has been removed from the engine fan housing, the spring must be relaxed before repair can be continued.

CAUTION:

When working on any recoil starter, safety glasses are recommended. Extreme caution must be used when removing the starter rewind spring as the slightest jar can cause the recoil spring to erupt from its cavity and serious injury could be sustained.

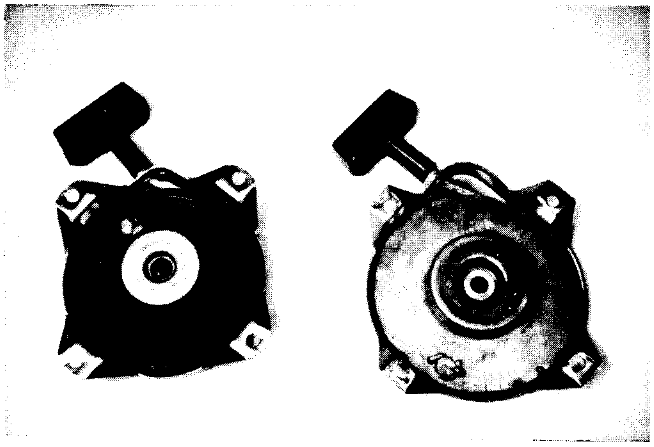


Figure 107. Eaton Starter Identification.

2. Tension Release of Rewind Spring.

   a. Relax the tension on the starter cord by holding the starter assembly with the pulley up. (See Figure 108.)

   b. Pull the starter rope until approximately twelve inches of rope extend from the pulley.

   c. Hold the pulley stationary with thumb pressure and hook the rope with a screwdriver at the position where it passes through the starter housing.

   d. Hold the rope away from the starter pulley and turn the pulley clockwise with the rope. Allow it to uncoil until the spring is no longer applying tension to the rope.

CAUTION:

When removing the starter pulley, use extreme caution to keep the starter spring confined in the housing.

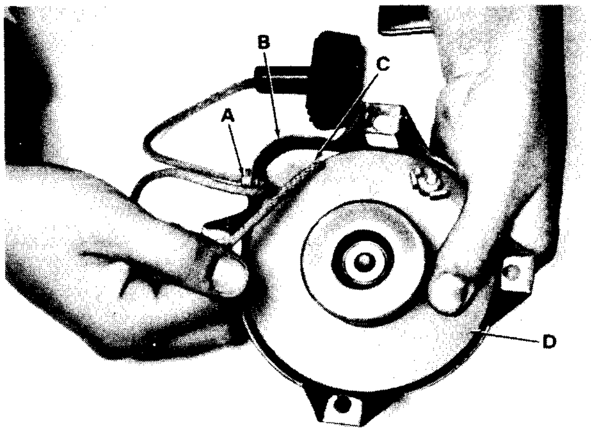


Figure 108. Tension Release of Rewind Spring.

NOTE:

On earlier models the tension spring is not encased in a keeper or retainer cup. These models also used a split pulley sheave that can be separated for rope replacement.

3. Starter Rope Replacement.

   a. To replace the starter rope, insert a new rope through the pulley (D) and then through the rope exit hole (A) in the starter housing (B). (See Figure 108.)

   b. Reinstall the handle grip and tie a knot at both ends of the rope.

   c. Pull all the excess rope through the exit hole (A), grasp the rope with your fingers at point (C) where it enters the starter pulley (D).

   d. Hold the rope securely with your fingers. Wrap the pulley (spring tension) by pulling the rope counterclockwise approximately four revolutions.

   e. Hold the starter pulley (D) stationary with your thumb and remove all the slack from the rope. Release the thumb pressure on the pulley and slowly allow the rope to rewind into the pulley.

NOTE:

To avoid spring damage by overwinding, pull the starter rope to its full extent and manually rotate the starter pulley counterclockwise. If it will not rotate 1/4 of a turn counterclockwise before bottoming out, the spring is overwound and must be relaxed one turn.

4. Spring Installation.

a. Relax the spring tension on the starter pulley as covered previously in this section.

CAUTION:

When removing the old spring, extreme caution must be exercised to avoid eruption of the spring from its cavity.

b. Keep the new spring confined in its housing during installation. Holders are provided on replacement springs to facilitate installation.

NOTE:

On certain types of starters the holder slips off as the spring is installed in the housing.

c. When installing the new spring, care should be taken to position the spring with the windings in the same direction as the spring being removed.

d. Repair or replace all other components where damage is apparent. Clean all thoroughly before reassembly.

e. Refer to Figure 109 and reassemble the starter in the reverse order of removal.

5. Up and Away Starter Disassembly and Repair.

a. Remove the fan housing from the engine.

b. Relax the tension on the starter rope by pulling approximately twelve inches of the rope from the housing. Hold the pulley to prevent the rope from retracting.

c. Raise the rope with your finger, at the point where the starter rope leaves the pulley. Release the pulley and the spring will automatically unwind. The rope may then be removed.

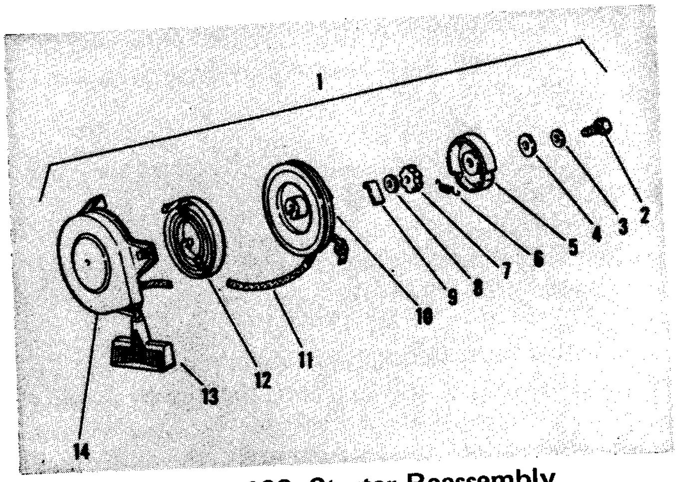


Figure 109. Starter Reassembly.

d. Using a tru-arc pliers (A) or a fine tipped screwdriver, remove the snap ring (B). Then remove the pawl lever (C) and the pawl (D). (See Figure 110.)

e. Next, lift the cup and the recoil spring (E) from the hub of the pulley (F).

Since one end of the coil spring is attached to the hub of the pulley, a slight clockwise turn may aid in the removal of this assembly.

f. Remove the pulley from the fan housing and make any necessary repairs or re-

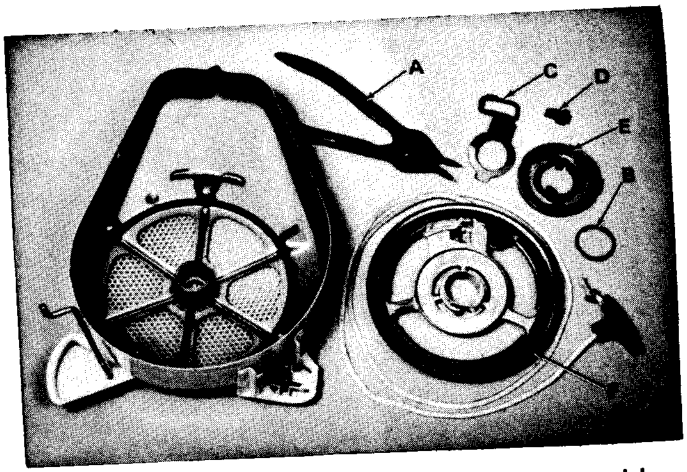


Figure 110. Up and Away Starter Disassembly.

placements to the starter components. Clean all parts thoroughly before reassembly.

6. Up and Away Starter Reassembly and Spring Tensioning.

   a. To reassemble the starter, use the reverse order of removal.

      NOTE:

      When installing the spring cup (E), be certain the point where the spring fastens to the cup is 180° from the hole where the rope passes through the cowling. Failure to do so before rewinding of the rope will result in a weakly wound recoil spring.

   b. Grasp the rope in the manner shown and using it to turn the pulley, rotate the pulley 3-3/4 turns from starting point (A). (See Figure 111.) This will tension the spring.

   c. Next, apply pressure to the pulley with your thumb to avoid recoil. Take the slack out of the rope, release the pulley and slowly allow the rope to rewind.

      NOTE:

      The four tear drop shaped raised areas (B) on the spring cup provide a friction drag for the pawl lever and must never be lubricated.

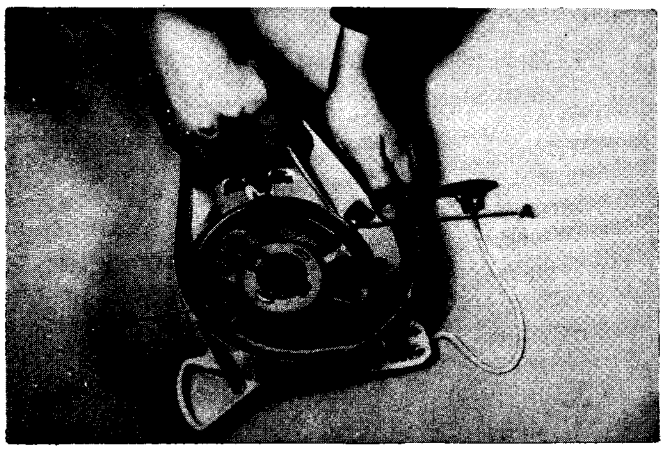


Figure 111. Up and Away Spring Tension.

F. FINAL ENGINE ADJUSTMENTS

1. High-Speed Needle.

   a. First check the high-speed adjusting needle for proper calibration with the notch in the float bowl housing. (See Figure 112.) Open the adjusting needle 60 minutes (one full swing of the minute hand around a clock face), counterclockwise from the notched position. Also open the idle mixture screw 60 minutes for initial start.

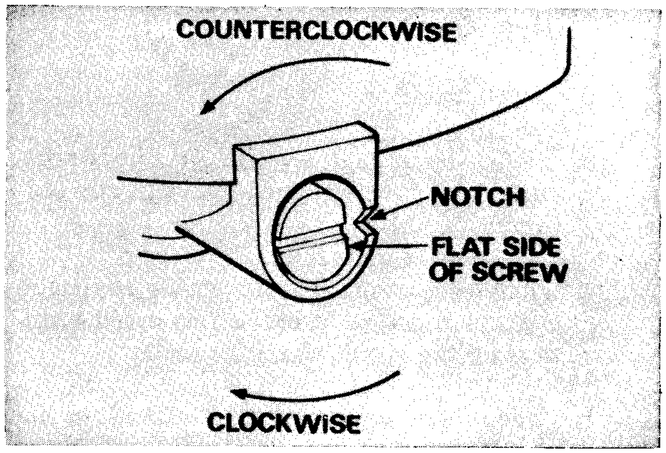


Figure 112. High-Speed Needle Adjustment.

   b. Now, start the engine, set the throttle to full speed, and allow the engine to warm up for a few minutes.

   c. At this point it is necessary to give the carburetor a final troubleshooting check before making the final adjustment.

   d. From the position of one turn open, turn the high-speed needle in (clockwise) approximately 15 minutes (1/4 of a turn). At this point the engine speed should slow down. (See Figure 113.)

   e. Next, return the needle to one turn open and turn the high-speed needle counterclockwise, approximately 15 minutes. The engine at this point should also show a slight slow down in speed.

      NOTE:

      If the engine performs as stated above, you may now go on to the final adjustment procedure. If, however, it does not react as described in d and e, the carburetor is malfunctioning and the problem

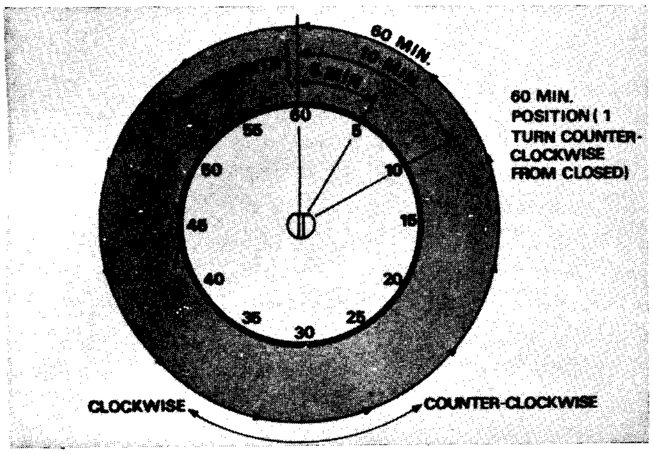


Figure 113. Adjustment Increments Used.

must be corrected before final adjustment can be obtained.

If the engine does not perform properly, the following problem areas should be checked.

1. The bottom retainer screw. – May be loose or stripped.

2. The small float bowl gaskets. – May be leaking.

NOTE:

These gaskets should be replaced each time the retainer screw is removed from the carburetor body.

3. Passages in the carburetor body. – May be dirty.

NOTE:

Refer to the proper procedure for cleaning the carburetor passages under Fuel and Air Flow page 64.

Any one of the reasons stated will cause the engine (fixed jet or adjustable carburetor) to "run rich", which will cause lack of power, short spark plug life, excessive carbon build-up, excessive smoking and possible overheating.

If the engine performed as stated during checks d and e on page 74, return the needle to one turn open and complete the final carburetor adjustment.

a. Turn the high-speed needle slowly clockwise until the engine slows down (about 15 minutes.) Next, turn the needle counterclockwise until the engine is running at peak RPM (somewhere around one turn open). Use a Tachometer if available.

b. Next, slowly adjust the needle approximately 3 to 5 minutes counterclockwise until a slight stuttering exhaust sound is heard.

This should be the correct shop adjustment for the high-speed needle. Ultimate field adjustment can only be obtained after the engine has been performing under a full work load for approximately 20 minutes.

The ultimate adjustment can then be obtained by adjusting the high-speed needle in or out a minute or two, until the engine will accelerate smoothly and just barely show evidence of a very light exhaust smoke.

NOTE:

ALL FINAL HIGH-SPEED ADJUSTMENTS (IN THE SHOP OR THE FIELD) MUST FALL BETWEEN 52 AND 68 MINUTES OPEN, USING 60 MINUTES AS ONE FULL TURN OPEN. See Figure 114 for maximum and minimum adjustment settings for late model Walbro Carburetors. The starting notch, which is the point where the adjusting screw bottoms, could be located anywhere around the face of the opening. Its location depends on the point the adjusting screw makes its first thread cut in the casting. In Figure 114 the starting notch is located at the 12 o'clock position.

2. Idle Adjustment.

a. Refer to Figure 88 and tighten the idle mixture screw (C), clockwise to make the initial idle adjustment. Seat the screw gently; excessive force may damage the needle or the carburetor body.

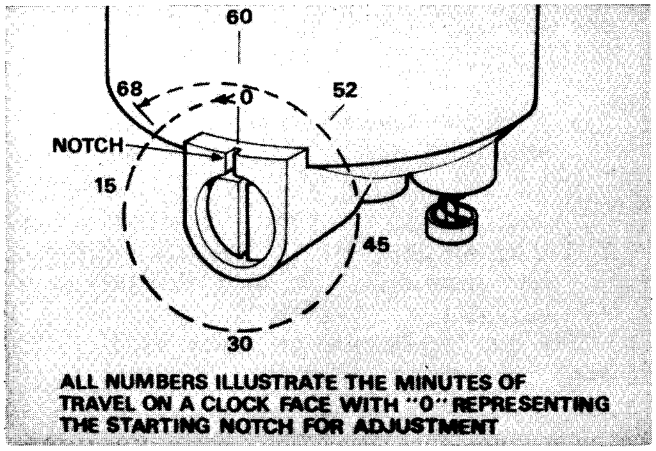


Figure 114. Final Adjustment Limits.

b. Next, open the screw one turn (60 minutes) counterclockwise. This calibration is preset on some carburetors and is not adjustable. (See Figure 87. — Carburetors 2 and 3.)

c. While the engine is running, move the throttle control to the slow or light position. Now turn the idle mixture screw (if one is present) clockwise in 5 minute increments until a satisfactory fast idle speed is obtained.

d. To make the final idle adjustment, turn the screw counterclockwise approximately 5 minutes from the fast idle speed position.

3. Choke Adjustments.

These choke adjustments refer to early production Walbro Carburetors with throttle controls located on the handle. If the handle and/or control wires are removed and reassembled, the choke must be correctly adjusted.

a. On machines having a single "choke-fast-idle-stop" control on the handle, set the speed control lever to the full "fast" position.

b. Check the hook in the choke link to be certain it is in contact or no more than a maximum of 1/16" away from the first loop in the choke spring. (See Figure 115.)

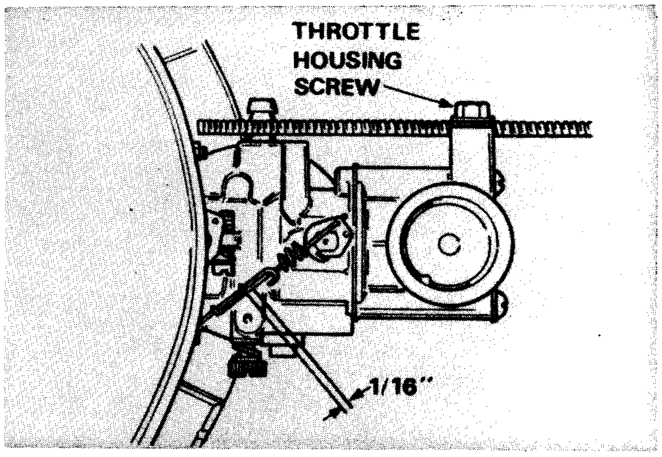


Figure 115. Choke Adjustment.

c. If the choke is partially on the loop or if there is more than 1/16 inch clearance between the hook and loop, loosen the screw holding the throttle wire housing. (See Figure 115.)

d. At this point the housing may be moved forward or to the rear to make the correct setting. After the housing is positioned properly, tighten the throttle housing screw securely.

4. Engine Control Cable.

For the engine to function properly, the engine control cable must be installed correctly on the carburetor. Merely moving the engine control lever (on the upper handle) permits choking, varying the engine speed and stopping the engine. The correct installation of the engine control cable is necessary so that the positions marked on the control panel match the operation of the levers on the carburetor.

The important connection is the engine control cable under the cable clamp after the wire end is connected to the carburetor control lever. (See Figure 116.) For the engine to function properly, when the engine control lever is moved to START (CHOKE) position, the choke on the carburetor must be fully closed. When the engine control lever is moved to STOP position, the choke control lever must make good contact with the spring STOP switch.

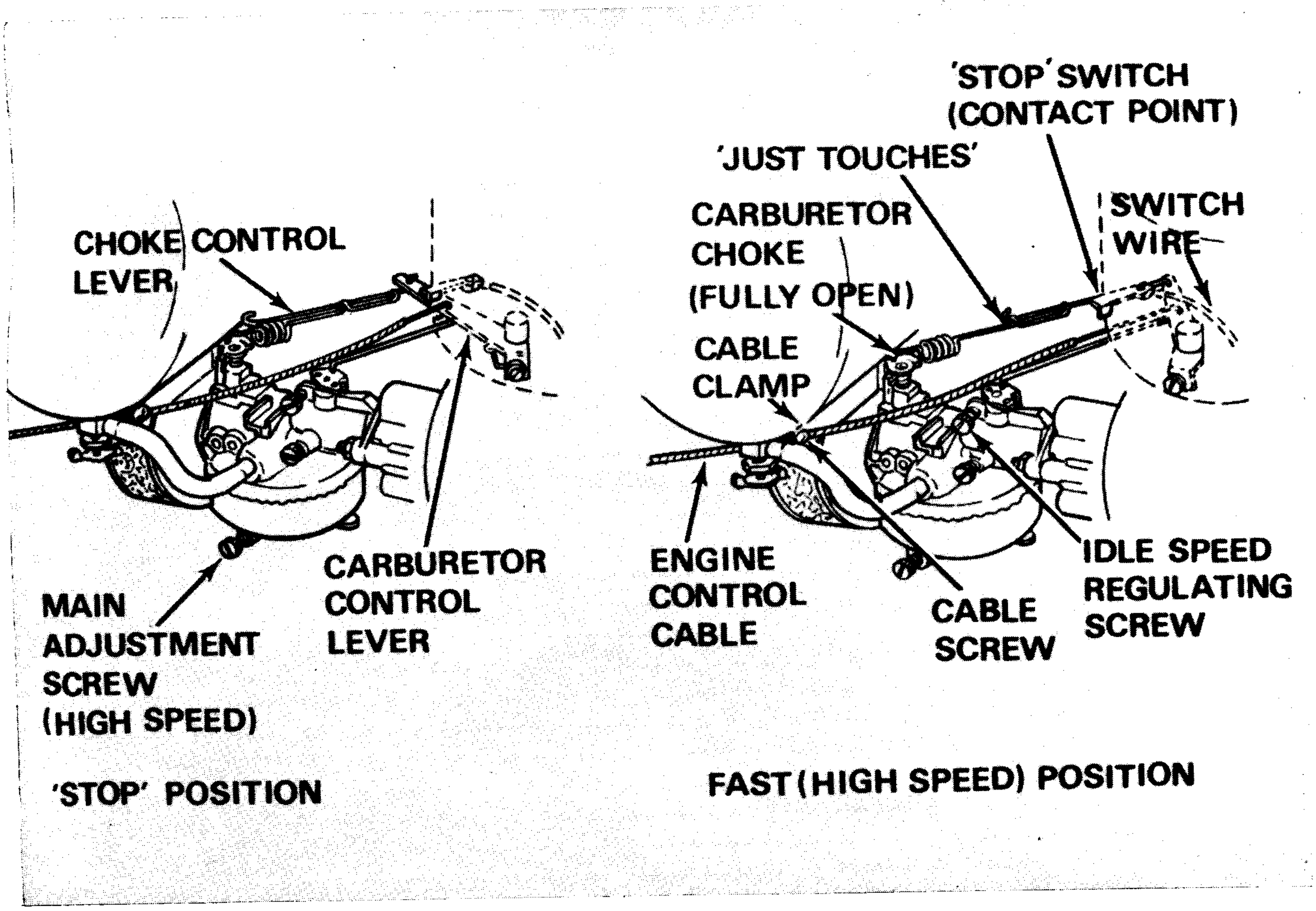


Figure 116. Engine Control Cable Adjustment.

a: To adjust, loosen the clamp screw so the engine control cable will slide back and forth.

b. Move the engine control lever, (on the upper handle), to FAST position.

c. Move the control cable forward or backward until the choke control lever just touches the carburetor choke. The choke must be fully open at this time. Now tighten the clamp screw.

d. At this point, test the setting by moving the engine control lever to the STOP position and checking if the choke control lever makes contact with the spring STOP switch. Move the engine control lever to the STOP (CHOKE) position and observe if the carburetor is fully choked.

After following all the steps listed in the Final Adjustment Section, your engine should be functioning properly.

NOTES

GOOD WORKMANSHIP IS NOT SOMETHING YOU GIVE THE CUSTOMER; IT IS SOMETHING YOU DO FOR YOURSELF.

SECTION VII

CLEANING AND STORAGE

A. GENERAL

This section will cover the proper cleaning and off-season storage of your Jacobsen 321 engine. A few minutes spent in preparation for the off-season storage of an engine always proves a wise investment. This investment of time proves out when the engine is put back into operation.

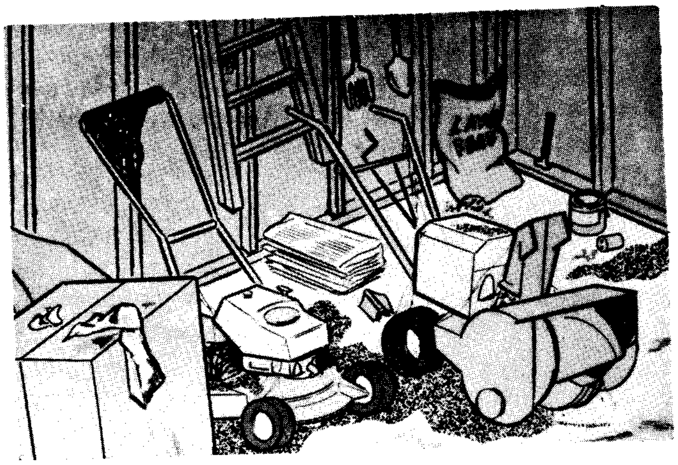


Figure 117. Engine Storage Is Important.

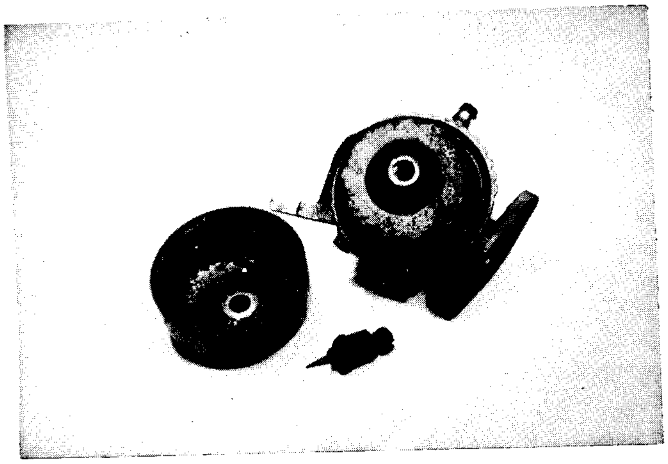


Figure 118. High Gum Deposits.

B. FUEL

Approximately 30 days from the day it is refined, gasoline will begin to deteriorate. The older a gasoline becomes, the higher the gum deposits will be and the lower the octane rating. (See Figure 118.) High gum deposits and a low octane rating will cause hard starting and excessive carbon deposits in the engine. For this reason it is wise to run an engine out of fuel at the end of each season's use.

This fact holds particularly true in the case of snow removal equipment. Using old gasoline that was refined in the summer months may also cause starting problems. This is due to the fact that fuel refined during the summer months is climatized for warm weather and should not be used during cold weather periods. The opposite holds true for a fuel refined in the winter months. Engines that must operate in cold weather are generally more difficult to start because fuels and lubricants become stiffer in cold weather.

1. Fuel Run-out & Drain.

   a. Start the engine and then shut off the fuel flow at the fuel tank.

   b. Allow the engine to run until all the fuel in the carburetor has been consumed.

   c. Disconnect the fuel line from the carburetor and open the shutoff valve on the fuel tank. Drain the tank completely.

   d. At this point, the fuel line can be connected and the shutoff valve should be closed.

   NOTE:
   Never wash the inside of the fuel tank with a cleaning solvent. The solvent will remove the light oil film from the inside of the tank and may cause rust scales to develop, (due to condensation) during storage. Rust scales will contaminate the fuel and cause problems when the engine is put back into service.

2. Spark Plug.

   a. Remove the spark plug and squirt approximately 1 tablespoon of oil (light weight engine oil) into the spark plug hole. Pull the starter cord three or four times to distribute the oil around the cylinder bore.

b. Clean and replace the spark plug and carefully wash the engine.

NOTE:

After servicing the engine, the equipment it powers should be greased, oiled and adjusted before storage.

If problems have developed during the season, a wise owner will have his equipment serviced during the off-season. The serviceman can then do a more thorough job of servicing and repair than he could during the "pre-season" rush. Having service performed during the off-season may save you the inconvenience of a long wait for the return of your equipment.

It is easy to forget to have your mower serviced during the off-season. But spring grass grows quickly — as much as 3 inches in three weeks — and while you are waiting for those tardy repairs, your lawn may get out of hand. Lawn authorities say that the root system of most grasses will be damaged if more than 1/3 of the growth is cut away at any one time. If your grass becomes overlong because your mower is out for service, trim it back gradually. Cut off about 1 inch at a time and space the cuttings two or three days apart until your lawn is back to the desired length.

SECTION VIII

EXPLODED VIEWS AND PARTS LIST

HOW TO ORDER REPAIR PARTS

Refer to your parts list and order replacement parts as follows:

1. Specify the correct 6 digit part number for each item. Do not order by item number. There are over 16,000 individual Jacobsen parts available to customers all over the world. The complete model and serial number of the equipment being repaired must be used to find the correct part number.

2. Where Jacobsen equipment is powered by an engine of another manufacturer, engine parts must be ordered through a representative or dealer of that engine manufacturer. Be sure to supply the model and type number located on the engine identification plate used by the manufacturer when ordering engine parts.

3. Parts must be ordered through your nearest Jacobsen Servicing Dealer. Consult your yellow pages under Lawn Equipment.

4. Parts may be ordered only through your Jacobsen Dealer. No direct factory orders will be accepted.

5. The following exploded views of the horizontal and vertical engines, and all carburetor exploded views are for nomenclature use only. The number attached to each part is of no value when ordering replacement parts. You must use the original Parts Manual received with your equipment as many parts may look alike but are not totally interchangeable with all 321 engines built in the last 10 years.

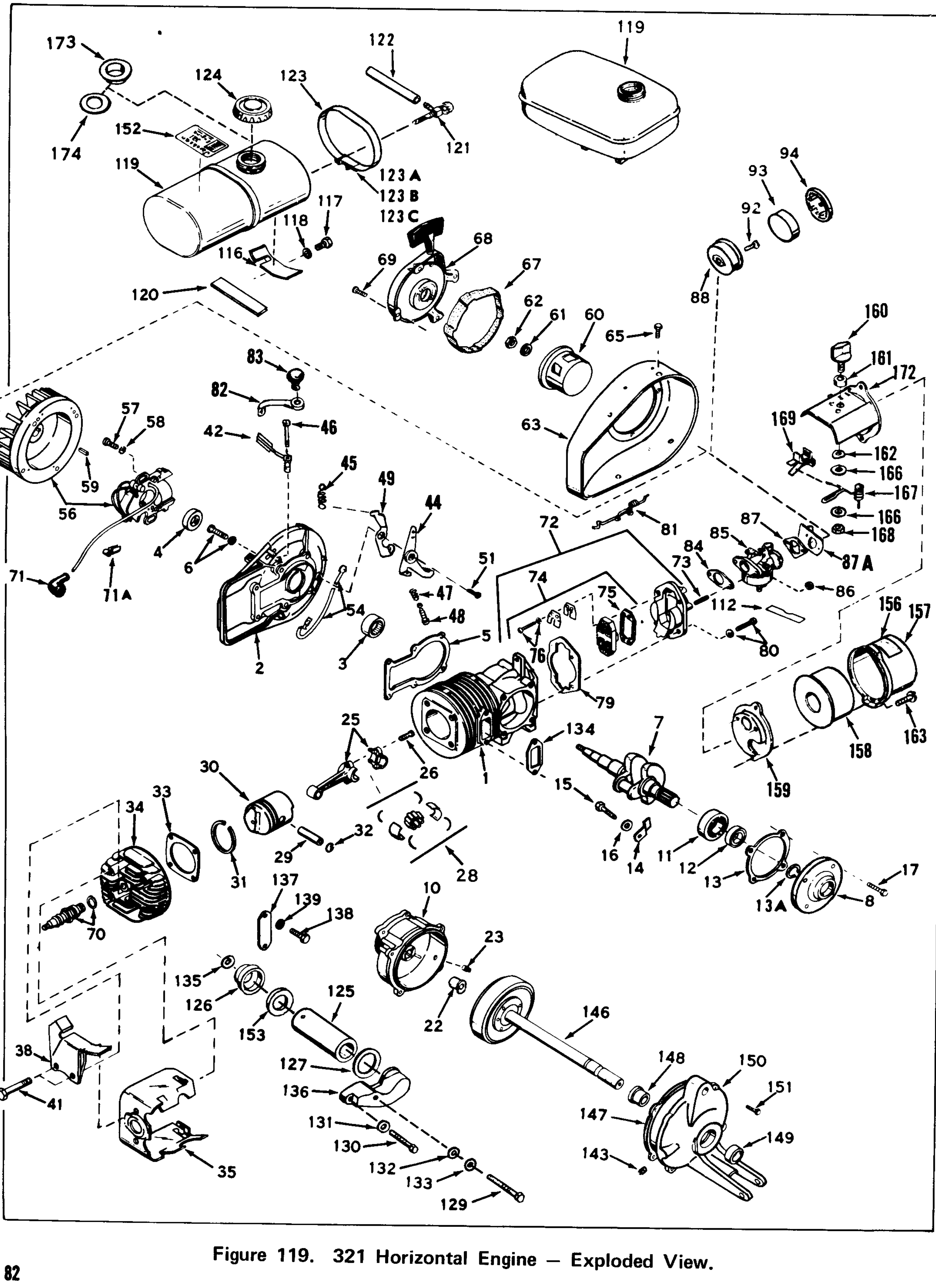


Figure 119. 321 Horizontal Engine — Exploded View.

NOMENCLATURE LIST

Fig - Item	Description	Fig - Item	Description
119 - 1	Cylinder and Crankcase	119 - 57	Screw and Lockwasher
2	Backplate w/Bearing and Seal	58	Washer
3	Backplate Bearing	59	Flywheel Key
4	Backplate Oil Seal	60	Rewind Starter Hub
5	Backplate Gasket	61	Washer, Belleville
6	Screw and Lockwasher	62	Nut
7	Crankshaft	63	Fan Housing
8	Crankcase Head	65	Screw
10	Crankcase Head	67	Starter Screen
11	Bearing	68	Rewind Starter Assembly
12	Oil Seal	69	Screw and Lockwasher
13	Crankcase Head Gasket	70	Spark Plug
13A	Ring, Snap	71	Spark Plug Cap
14	Bearing Retainer Clip	71A	Terminal, Spark Plug
15	Screw	72	Carburetor Adapter and Reed Plate Assembly
16	Lockwasher	73	Stud
17	Screw	74	Reed Plate
22	Gearcase Bushing	75	Reed Plate Gasket
23	Plug	76	Screw, Reed Plate Mounting
25	Connecting Rod Assembly	79	Adapter Mounting Gasket
26	Screw	80	Screw and Lockwasher
28	Bearing Assembly, 28 Rollers, 2 Liners, 4 Guides	81	Choke Link Assembly
29	Piston Pin	82	Governor Link
30	Piston	83	Push Rivet
31	Piston Ring	84	Carburetor Mounting Gasket
32	Piston Pin Retaining Ring	85	Carburetor Assembly
33	Cylinder Head Gasket	86	Nut
34	Cylinder Head	87	Plate Mounting Gasket
35	Air Deflector	87A	Bracket, Throttle Wire
38	Fuel Tank Mounting Bracket	88	Air Filter Housing
41	Screw	92	Screw
42	Governor Vane Assembly	93	Air Filter
44	Control Lever Assembly	94	Air Filter Cover
45	Governor Vane Spring	112	Decal, Choke and Shut-Off
46	Screw, Governor Vane	116	Tank Mounting Bracket
47	Spring, Speed Control	117	Screw
48	Screw, Speed Control	118	Lockwasher (Washer)
49	Lever, Governor Spring	119	Fuel Tank Assembly
51	Screw, Control Lever Mounting	120	Pad, Fuel Tank Mounting
54	Stop Switch Wire	121	Shutoff Valve Assembly
56	Magneto Assembly	122	Fuel Line

NOMENCLATURE LIST (CONTD.)

Fig - Item	Description	Fig - Item	Description
119 -		119 -	
123	Tank Mounting Strap	147	Gear Reducer Cover Gasket
123A	Screw	148	Gear Reducer Cover Bearing
123B	Lockwasher	149	Gear Reducer Cover Seal
123C	Nut	150	Gear Reducer Cover
124	Fuel Tank Cap Assembly	151	Screw
125	Muffler	152	Decal, Name, Mix
126	Muffler Cap	153	Muffler Gasket
127	Muffler Mounting Gasket	156	Decal, Air Cleaner
128	Bolt	157	Air Filter Body
129	Screw	158	Air Filter
130	Screw	159	Bracket
131	Lockwasher	160	Knob
132	Muffler Head Gasket	161	Spacer
133	Washer	162	Washer
134	Exhaust Flange Gasket	163	Screw
135	Lockwasher	166	Washer
136	Muffler Head	167	Spring
137	Exhaust Flange Cover	168	Nut
138	Screw	169	Stop Switch Assembly
139	Lockwasher	172	Bracket Assembly
143	Plug	173	Baffle Assembly
146	Gear and Shaft Assembly	174	Gasket, Fuel Tank Cap

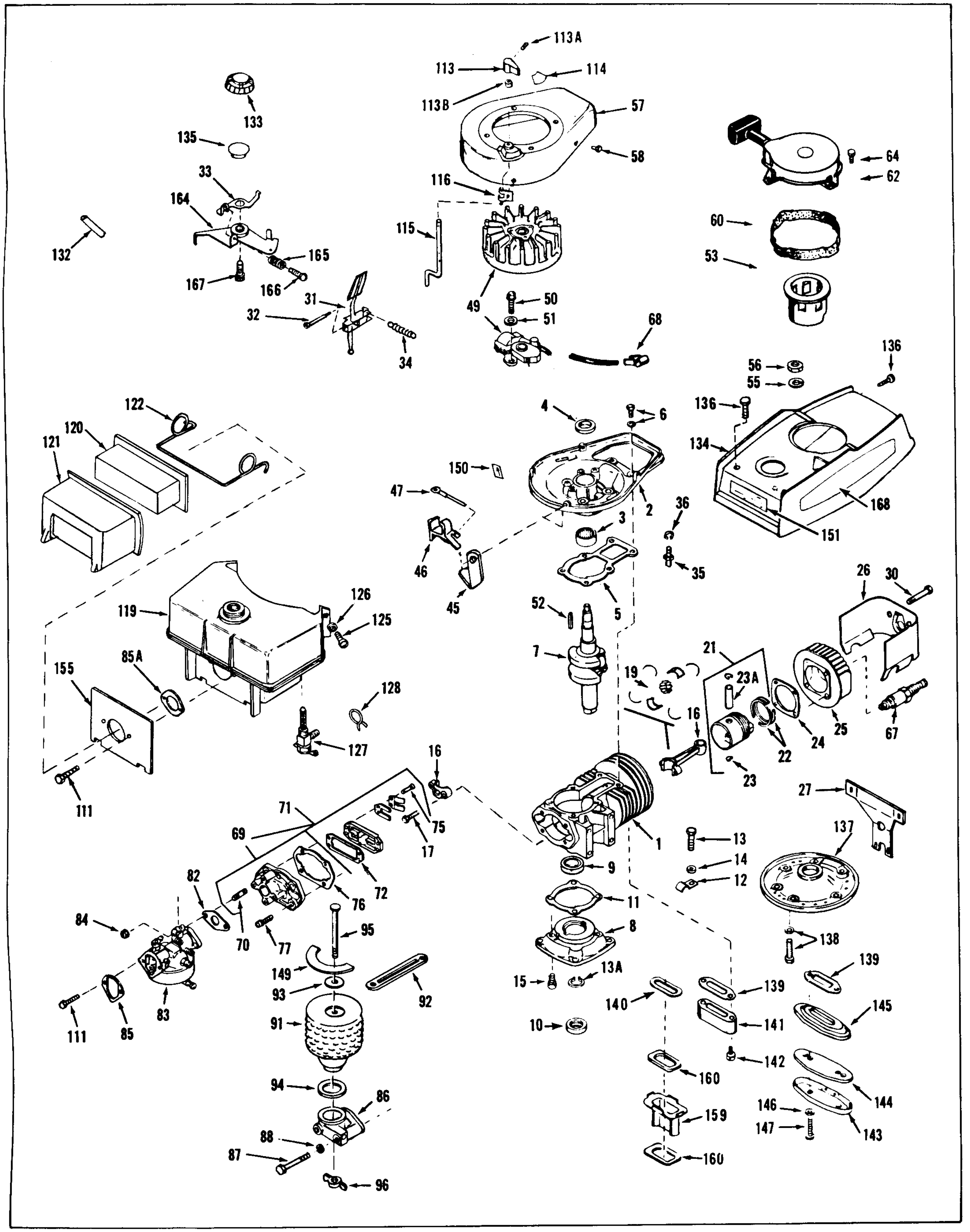


Figure 120. 321 Vertical Engine — Exploded View.

NOMENCLATURE LIST

Fig - Item	Description	Fig - Item	Description
120 - 1	Cylinder and Crankcase	120 - 51	Washer
2	Backplate w/Bearing and Seal	52	Flywheel Key
3	Backplate Bearing	53	Rewind Starter Hub
4	Backplate Oil Seal	55	Washer - Belleville
5	Backplate Gasket	56	Nut
6	Screw and Lockwasher	57	Fan Housing Assembly
7	Crankshaft, Including Reference 13A	58	Screw and Lockwasher
		60	Starter Screen
8	Crankcase Head	62	Rewind Starter Assembly
9	Bearing, Crankshaft	64	Screw and Lockwasher
10	Oil Seal	67	Spark Plug
11	Crankcase Head Gasket	68	Spark Plug Terminal
12	Bearing Retainer Clip	69	Carburetor Adapter and Reed Plate Assembly
13	Screw		
13A	Ring - Snap	70	Stud
14	Lockwasher	71	Reed Plate Assembly
15	Screw	72	Reed Plate Gasket
16	Connecting Rod Assembly	75	Screw and Lockwasher
17	Screw	76	Adapter Mounting Gasket
19	Bearing Assembly, 28 Rollers, 2 Liners and 4 Guides	77	Screw and Lockwasher
		82	Carburetor Mounting Gasket
21	Piston and Pin w/Rings	83	Carburetor Assembly
22	Piston Ring	84	Nut
23	Piston Pin Retaining Ring	85	Elbow Mounting Gasket
23A	Piston Pin	85A	Gasket
24	Cylinder Head Gasket	86	Air Filter Elbow
25	Cylinder Head	87	Screw
26	Air Deflector	88	Lockwasher
27	Cowling Brace	91	Air Filter
30	Screw	92	Air Filter Strap
31	Governor Vane	93	Washer
32	Screw - Governor Vane	94	Air Filter Gasket
33	Governor Spring Lever	95	Screw
34	Governor Spring	96	Wing Nut
35	Screw - Governor Detent	111	Screw
36	Lockwasher - Governor Lever Mounting	113	Knob-Control Rod w/Set Screw
		113A	Set Screw, Control Rod Knob
45	Shut Off Switch	113B	Control Knob Spacer
46	Stop Switch Assembly	114	Decal - Control Panel
47	Wire Shut Off Switch	115	Rod - Control
49	Magneto Assembly	116	Clip - Control Rod
50	Screw and Lockwasher	119	Fuel Tank Assembly

NOMENCLATURE LIST (CONTD.)

Fig - Item	Description	Fig - Item	Description
120 -		120 -	
120	Air Filter	142	Screw and Lockwasher
121	Air Filter Cover	143	Muffler Cover
122	Air Filter Cover Spring	144	Muffler Baffle Plate
125	Screw	145	Muffler Body
126	Lockwasher	146	Washer
127	Shut Off Valve	147	Screw
128	Shut Off Valve Clamp	149	Decal - Air Filter
132	Fuel Line - 3-7/8" Long	150	Decal - Stop
133	Fuel Tank Cap	151	Decal - Fuel, Mix
134	Engine Cowling	155	Plate - Air Cleaner
135	Baffle Assembly	159	Heat Deflector
136	Screw	160	Gasket
137	Muffler Cover Lower Unit	164	Control Lever Assembly
138	Screw and Lockwasher	165	Spring-Speed Control
139	Exhaust Flange Gasket	166	Screw-Speed Control
140	Exhaust Flange Gasket	167	Screw-Control Lever Mounting
141	Exhaust Manifold	168	Decal - Name

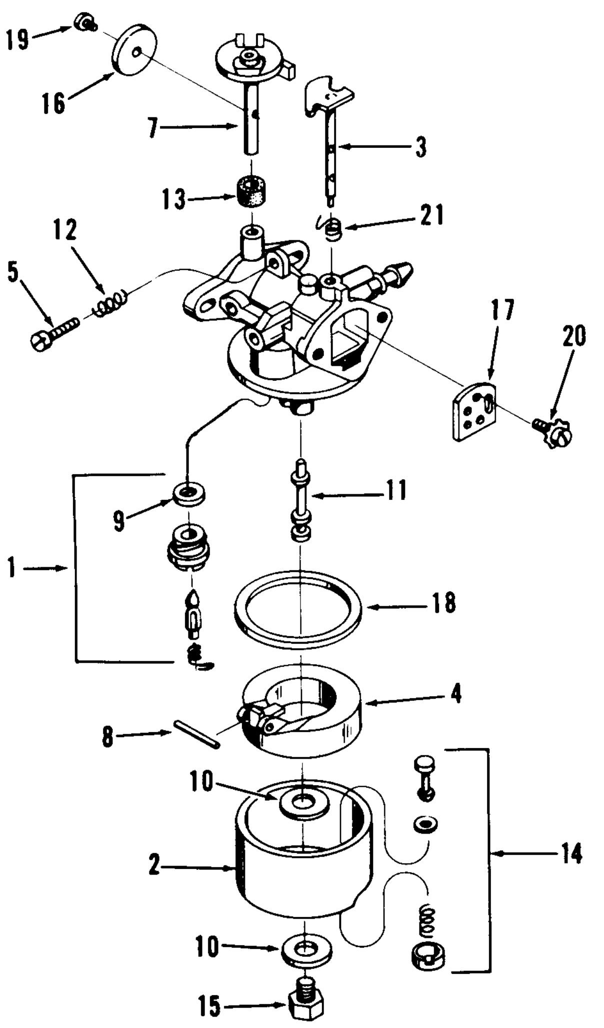


Figure 121. Carburetor Exploded View.

NOMENCLATURE LIST (FIXED JET)

Fig - Item	Description
121 - 1	Matched, Float Valve Seat, Spring and Gasket Assembly
2	Bowl Assembly - Float Bowl
3	Shaft Assembly - Choke
4	Float Assembly
5	Screw - Throttle Adjustment
7	Shaft Assembly - Throttle
8	Shaft - Float
9	Gasket - Float Valve Seat
10	Gasket - Nut To Bowl
11	Main Metering Nozzle
12	Spring Throttle Adjustment
13	Seal - Throttle Shaft
14	Bowl Drain Assembly
15	Retainer Screw
16	Throttle Plate
17	Choke Plate
18	Gasket - Bowl To Body
19	Screw
20	Screw
21	Spring - Choke Return

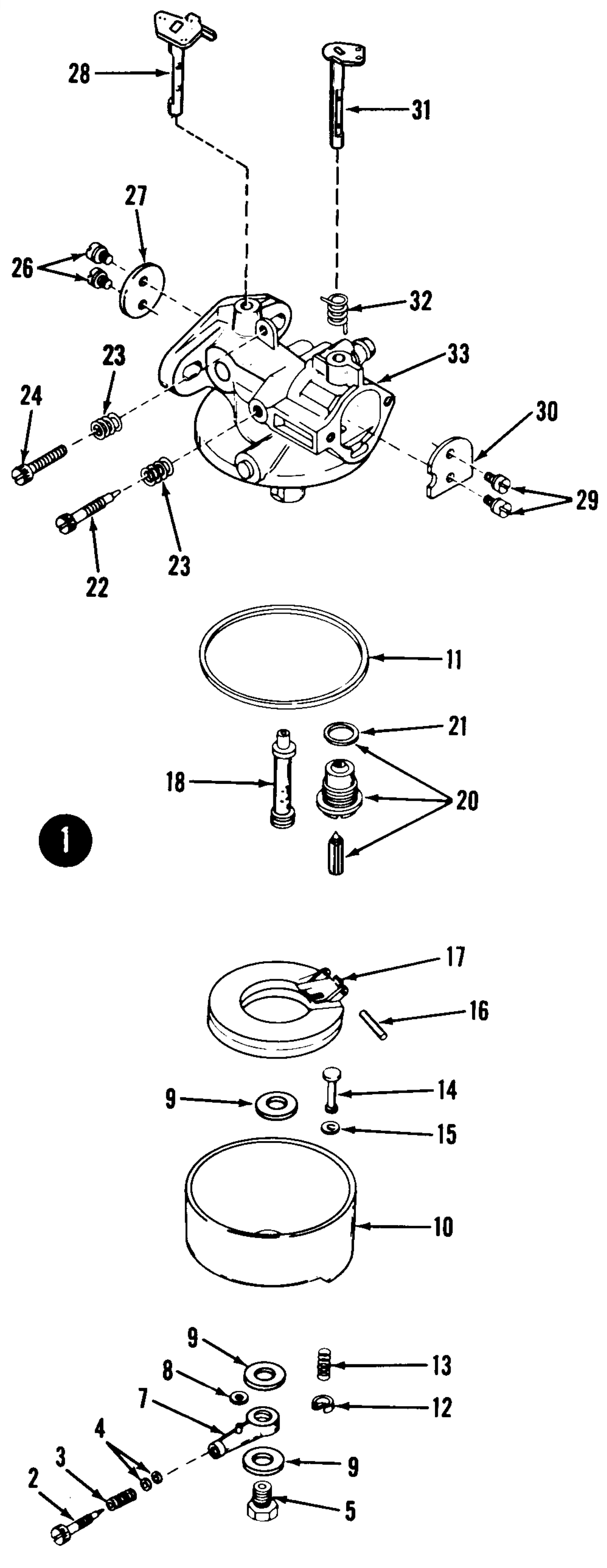


Figure 122. Carburetor Exploded View.

NOMENCLATURE LIST

Fig - Item	Description
122 - 1	Carburetor Assembly
2	High-Speed Needle
3	Spring
4	"O" Rings
5	Retainer - Bowl
7	High-Speed Needle Housing
8	Rubber Gasket
9	Gasket - Bowl Nut To Bowl
10	Bowl Assembly - Float Bowl
11	Gasket - Body To Bowl
12	Retainer Screw
13	Spring - Drain Bowl
14	Stem Assembly - Drain Bowl
15	Rubber Gasket
16	Shaft - Float
17	Float Assembly
18	Main Metering Nozzle
20	Matched Float Valve, Seat, Spring and Gasket Assembly
21	Gasket - Seal Valve Float
22	Needle - Idle
23	Spring - Throttle Adjustment Screw
24	Screw - Idle Speed
26	Screw - Throttle Plate Mounting
27	Throttle Plate
28	Shaft Assembly - Throttle
29	Screw - Choke Plate Mounting
30	Choke Plate
31	Shaft Assembly - Choke
32	Choke Return Spring
33	Carburetor Body

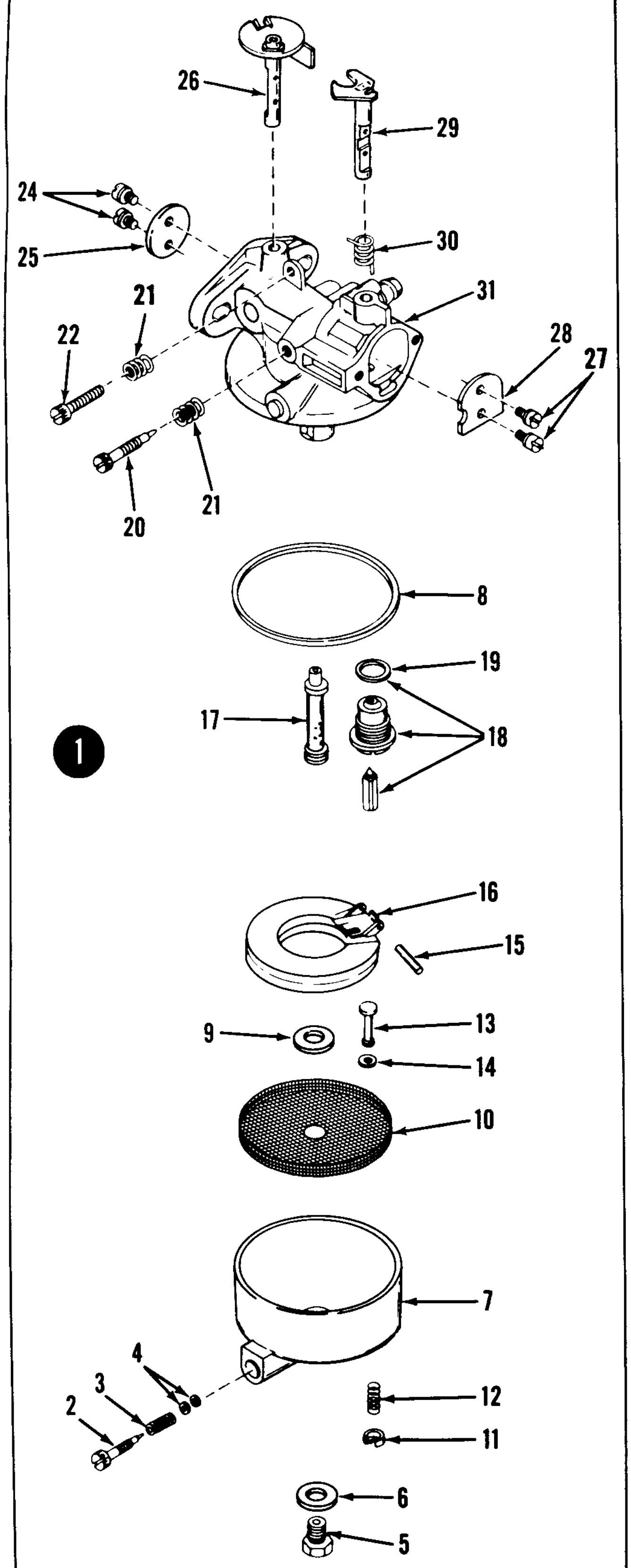


Figure 123. Carburetor Exploded View.

NOMENCLATURE LIST

Fig - Item	Description
123 - 1	Carburetor Assembly
2	High-Speed Needle
3	Spring
4	"O" Rings
5	Retainer Screw
6	Gasket - Bowl Nut To Bowl
7	Bowl Assembly - Float Bowl
8	Gasket - Body To Bowl
10	Screen
11	Retainer Screw
12	Spring - Drain Bowl
13	Stem Assembly - Drain Bowl
14	Rubber Gasket
15	Shaft - Float
16	Float Assembly
17	Main Metering Nozzle
18	Matched Float Valve Seat, Spring and Gasket Assembly
19	Gasket - Seal Valve Float
20	Needle, Idle
21	Spring
22	Screw, Throttle Adjustment
24	Screw - Throttle Plate Mounting
25	Throttle Plate
26	Shaft Assembly Throttle
27	Screw - Choke Plate Mounting
28	Choke Plate
29	Shaft Assembly - Choke
30	Spring Choke Return
31	Carburetor Body

NOTES

 LOOK FOR THE RIGHT SOLUTION; NOT THE EASY ONE.

NOTES

NOTES

JACOBSEN DEALER INFORMATION

Your business is service. To give good service, think of your repair and service department as a "hospital" to which ailing equipment is brought for attention.

Here is a simple "admission" procedure for that sick engine, mower or snow blower.

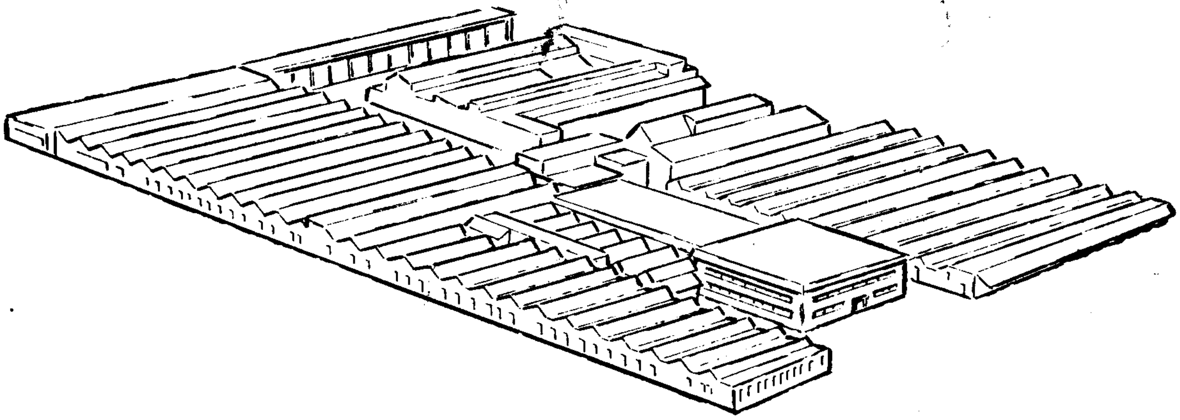
1. Always fill out the repair ticket in detail. Never admit a "patient" to your "hospital" until you have taken down a complete "history" of the disorder suffered.

2. Ask questions. Find out what was happening when the trouble was first noticed. Find out how the equipment was used (or abused). Was it used on hilly ground? In wet weather? Under dry or dusty conditions? How long had it been running? What kind of gas and oil was used? Who was using the equipment? (Wife? Son? Neighbor?)

3. Check for any visible damage not mentioned by the customer. Note it on the repair ticket and draw it to the customer's attention. (Damage not called to the customer's attention might later be represented as your fault.)

4. Discuss the operation of the equipment with the customer. Ask him what he likes about the equipment. What he doesn't. Give him any advice or information he requests. Be honest with your estimates and fair with your prices.

With the right information in hand you or your mechanics can go to work at once, locate the trouble in short order and return the equipment quickly to a pleased and satisfied customer.



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