FARM MACHINERY MAINTENANCE PROGRAM FOR PAKISTAN

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by

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CHAPTER I

When, owing to persistent demand of the Muslims for a separate homeland in areas where they were in majority, the Indian subcontinent was divided into two states and Pakistan emerged as an independent sovereign state on August 14, 1947.

Pakistan consists of two parts, East Pakistan and West Pakistan, which are separated from each other by about 1,000 miles of Indian territory. East Pakistan lies between the longitudes 88° E and 92.30° E and between the latitudes 21° N and 27° N; West Pakistan is situated between the longitudes 61° E and 75° E and the latitudes 24° N and 37° N.

West Pakistan touches the Himalayan foot-hills and the Hindukush mountains in the north. It is separated from Russia by a narrow stretch of mountain ranges and extends from Pamirs down to the Arabian sea. In the west are Afganistan and Iran, while in the east and south it is bounded by India.

East Pakistan lies between the Indian provinces of West Bengal and Assam and the Union of Burma, with the Bay of Bengal in the south.

The areas in the north-west of West Pakistan are mountainous regions, but the rest of West Pakistan is farmed of the alluvial Indus plain. Similarly, except for an insignificant extension of Lushai Hills, East Pakistan consists of the alluvial Brahmaputra plain.

The landscape varies from the snow-covered peaks of the Himalayas in the north to the arid desert in the south and southwest. There are seven principal rivers running through the country. These are fairly well spaced and ideally suited for the construction of diversion dams for irrigation. The rainfall varies from four inches a year in the south to forty inches in the north of West Pakistan and from 50 inches to 135 inches in East Pakistan.

The climate is continental in West Pakistan. On a summer day the temperature in the shade may go up to 120°F and may not fall below 90°F during the night. During the cold weather, while the maximum temperature on a calm and clean day may touch 75°F, it falls almost to freezing point after midnight. Along the sea coast, the climate is fairly hot in summer and mild in winter. There are four well defined seasons, but autumn and spring are of exceptionally short duration. Most of the rainfall occurs during the latter half of summer, and the winter season is generally dry with short and infrequent spells of rain during December and January.

In East Pakistan, the climate is tropical, humid and warm during the summer and mild and dry during the winter. The main temperature during the winter months if 45°F and in summer 90°F. The rainfall is heavy and the bulk of it falls during the monsoon season which extends from May to September.

The total land area of Pakistan is 234 million acres of which 136.8 million acres or 58.5 per cent of the total area, has so far been fully surveyed. The analysis of the surveyed area reveals that 37.2 million acres or 27.2 per cent of the surveyed area is not

available for cultivation. Out of the area available for cultivation only 54.6 million acres are sown, which represents only 39.9 per cent of the surveyed area.

As 10 million acres are sown more than once a year, the total cropped area amounts to about 64.6 million acres.

In West Pakistan, winter is the most important single factor for increasing agricultural production and productivity. The Province is climatically arid and semi-arid except for the small zone lying below the Central Himalayas in the North. Of the total geographical area of about 200 million acres, only about 41.4 million acres are cultivated, of which one-fourth is rainfed, and the remaining three-fourths is irrigated by a vast canal system. Unfortunately, irrigation water supplies are limited and in many areas farmers have reacted by spreading the water thinly and allowing it to percolate only to the depth of the plant roots. The result has been large accumulation of salt in the root zone, which together with the extensive seepage from the canal network, has produced conditions of water-logging and salivity as a result of which between 70,000 and 100,000 acres are being lost to cultivation each year.

Water is also the major proglem of East Pakistan. The Province was a monsoon climate and out of 35 million acres, about 22 million acres are cultivated under rainfed conditions. The rains, however, fall during a relatively short period of time (June - September). These monsoon rains are usually adequate in total but their failure in certain years causes drought, and their abundance in other years results in floods.

The critical need for water development has prompted the Government to harness water resources for developing irrigation facilities especially in West Pakistan, to check on rush of saline sea water in the coastal areas of East Pakistan and to control floods and provide drainage facilities in both the Provinces. In East Pakistan the goal of the water development program under the Third Five Year Plan is to increase the area irrigated by power pumps from 200 thousand acres to 750,000 acres by 1969-70. In West Pakistan with the new equipment provided under the Third Plan mechanization program a goal has been set for the increase from 5,750 to 15,000 tubewells by the Department of Agriculture. It is also expected that the number of tubewells being installed by private firms will go up considerably during the next five years.

It is estimated that in west Pakistan 1.7 million acres of additional land will be cropped, 8.3 million acres of already cultivated area will improve in acre-yields, and 2.0 million additional acres will be added as a result of higher cropping intensities. On the same basis, it is estimated that in East Pakistan the irrigation and reclamation program will bring under cultivation 2.1 million acres of additional area, and 2.7 million acres of already cultivated area will be improved during the Third Plan period.

Mechanization will play an increasingly important role in the agricultural sector during the Third Five Year Plan period. In many parts of East Pakistan, it is possible to raise two, and even three crops on the same land during a year, provided that in addition to the availability of water, facilities exist for quick tillage of the land

immediately after harvest. Intensive agriculture in West Pakistan also requires quick ploughing where irrigation facilities are available. In addition, development of new areas for cultivation, especially in new irrigation projects, requires mechanized levelling and tillage.

The scope for mechanization in West Pakistan is very large. With increased irrigation facilities, substantial areas now lying uncultivated within the irrigated tracts and along the rivers can be brought under cultivation.

During the Third Plan, the number of tractors in both the public and private sectors in West Pakistan will be further augmented. Requirements of wheel-type tractors by private individuals will be met increasingly by local manufacturers. An assembling plant has been set up that will be completely converted eventually to domestic manufacturing. This firm will provide approximately 500 tractors in the first year, and about 1,500 in the sixth year of operation.

During the First Plan period the existing fleet of Government operated tractors was strengthened and seven agricultural workshops were set up in West Pakistan for operation, maintenance and repair of machinery, training of mechanics and operators, and for allied research. Additional agricultural machinery was procured during the second plan and these seven workshops were reorganized and strengthened while six new sub-shops were set up to cope with the expansion of the program. During the Third Plan workshop and repair facilities will be extended up to the district level to improve the efficiency of the machinery. The program started in West Pakistan during the

Second Plan for distributing improved implements at subsidised price, will be expended during the Third Plan period. Facilities will be provided for carrying out intensive research for evolving improved implements and machinery suited to the needs of various areas.

All possible facilities are being provided to agriculturists by the Government to bring more land under the plow. The Agricultural Development Bank has sanctioned loans of over Rs. 42.8 million, out of recent international Development Agency loan of $27 million, for the purchase of agricultural machinery by farmers. Five thousand small power tillers are being imported from Japan for mechanised farming in East Pakistan. The tractors costing nearly Rs. 1.5 million are to be imported from Yugoslavia by the West Pakistan Agricultural Development corporation. The corporation will subsequently undertake assembly and manufacturers of these tractors. Tractors and other farm equipment worth $ 17 million are to be imported against the recent American loan of $ 27 million.

As it is clear the mechinization is increasing in Pakistan, because of the Governments effort and farmers need for quick tillage after harvest and intensive agriculture. It is not only necessary to increase machinery for improvement of agriculture but it is also necessary to maintain the machinery which is already present. A machine can give full services for longer time and at less cost if it is maintained as recommended by the manufacturer in the operator's manual.

In Pakistan usually the maintenance is neglected. At the Government farms no one feels responsibility because no one is the owner. At private farms farmers also don't maintain their machinery properly because:

1. Most farmers don't understand operator's manual, because it is always written in english.
2. Most operators don't understand machinery well, because they never had experience with any machine before.
3. Some farmers neglect maintenance because they don't understand the importance of maintenance.
4. Most farmers don't operate the machinery themselves. They hire operators, who are usually illiterate and are not interested in proper maintenance.
5. Most farmers don't keep adequate maintenance records.
6. The farmers usually don't have their tractors periodically checked by a qualified mechanic.

There are other reasons also for poor maintenance in Pakistan but usually it is because the farmers don't feel it necessary. This feeling often results in more break-downs and it costs more money and time because the repair shops are not many and are too far away at most places. Moreover spare parts and repairs cost more in Pakistan. Machinery maintenance practices are easy, save money, and avoid costly breakdown. Good tractor maintenance practices help maintain the horsepower it was designed to develop.

The life and service given by a tractor are dependent largely upon the care and treatment accorded it by the operator. Farm power equipment is made of high-grade materials, fine precision and workmanship are used in its manufacture, and its design in every respect is being constantly improved and refined.

For proper maintenance operating records should be kept. Most tractors have hour meters and operating records are easy to keep up

to date. For a good operating record some type of check off record form should be made. With this type of check-off record, one is reminded of both the 10-hour daily service jobs and the jobs that come at longer intervals. For operating record, service intervals recommend in operator's manual for doing the various jobs should be used. The one used here will be the one which is recommended for most tractors used in Pakistan.

Completing the service jobs when they need to be done is largely a matter of keeping records and scheduling a time to do them. They require simple tools and an understanding of what is to be accomplished. To help understand the value of maintenance, information has been summarized in this report.

Even when a regular maintenance schedule is followed, it is well to take the tractor to a good tractor mechanic occasionally for the checking and servicing jobs that require specialized knowledge, experience and special tools.

PROCEDURE OF THE PROGRAM

The procedure for the farm machinery maintenance program will include:

1. Teaching
2. Distribution of printed material
3. Demonstrations
4. Motion Pictures
5. Radio

The agencies through which this program will be carried out, will be:

1. Agricultural Colleges
2. Farm Machinery dealers
3. Agricultural Extension Department
4. Agricultural Engineering - Agriculture Department

The teaching will be done mostly in Agricultural Colleges and by Agricultural Extension staff.

Short courses may be offered in the colleges according to the facilities and equipment available. At present the colleges are sending their students for voluntary work at the farms during summer. Those students, who are trained, could be given instructions and sent to places where more machinery is used and there is a need of teaching the farmers.

Agricultural extension staff know little about machinery, but they could be given instructions during their training period. Because extension department has workers all places where they could reach farmers easily, they could do this job very effectively.

All the machinery maintenance material presented in this report will be translated into local languages. It will be printed into smaller section and separate parts. This printed material will be distributed through Agricultural Extension department, farm machinery dealers, and colleges.

The demonstration work will be done by college students and teachers, machinery dealers (for the machinery they are selling), Agricultural engineering department of Agriculture, and by agricultural extension department.

The motion pictures of machinery maintenance will be shown with the other motion pictures that are shown these days by the agricultural

extension department. They have trained staff and equipment for this purpose.

At present we have farmers program on all radio stations, for the local farmers in local languages. With the cooperation of the radio station authorities, some programs can be made for presentation in the farmers program which they listen regularly.

CHAPTER II

MAINTENANCE AFTER 50 HOURS OF OPERATION

MAINTAINING THE BATTERY

Checking the level of the liquid in the battery is one of the most simple of tractor maintenance jobs. Perhaps that is the reason it is often neglected.

Operator's manuals vary in their recommendations as to how often to check and add water, from 50 hours to as long as 200 hours or monthly. This may be due partly to the liquid capacity of the battery provided with the tractors some provide more reserve than others. Another reason is the location of the battery on the tractor. If it is immediately back of the engine it will become warmer and more water will evaporate than if it is under the seat.

To care for a battery, you need to understand its construction and how it works. The chemical action is shown in the following chemical equation:

$$Pb+PbO_2+2H_2SO_4 \underset{\text{charging}}{\overset{\text{discharging}}{\rightleftharpoons}} 2PbSO_4+2H_2O$$

The left side of the equation shows a battery cell in a charge condition. The right side shows a cell in a discharged condition.

In the charged condition, the positive plate contains lead peroxide (PbO_2), and the negative plate is composed of sponge lead (Pb).

The liquid in the battery is called "electrolyte". It contains about 36 per cent sulfuric acid (H_2SO_4) and 64 per cent water. When you start to use electrical energy, such as for lights or engine starting, the energy is developed by chemical action. The electrolyte reacts with the lead on the negative plate and the lead peroxide on the positive plate. Lead sulfate forms on both the positive and negative plates. The acid content of the electrolyte becomes less and less because it is used in forming lead sulfate ($PbSO_4$). The specific gravity of the electrolyte decreases.

If you don't recharge the battery, a point is reached where so much of the active material has been changed into lead sulfate, the cell can no longer produce sufficient current to be of practical value. At this point, the cell is said to be "discharged".

In the discharged condition both plates contain lead sulfate ($PbSO_4$) and the electrolyte is largely water. Recharging is accomplished by forcing electric current through the battery the opposite direction from normal battery current flow. This causes the lead sulfate and water to change back to lead, lead oxide, and sulfuric acid as shown on the left side of the chemical equation.

The sulfuric acid does not need to be replaced unless it is lost through leakage or is spilled from the battery. The water is lost partly from evaporation but mostly through chemical action within the battery while it is being charged. It is this that some of the water in the electrolyte is changed to hydrogen and oxygen gases. These pass out the vent holes in the battery caps. If water is not added to replace the amount that is lost, the tops of the plates become exposed.

Operator's manuals warn that you should maintain the battery liquid level above the level of the plates. Because when the upper portions of the plates and separators are exposed to air, they dry out. Those portions that dry lose their ability to function normally. Consequently, your battery loses that much of its capacity, which means less power for cranking. It also means shorter battery life - the strong acid concentration may break down the separators between the plates during the time the liquid level is low.

It is important that you maintain your battery at, or near, full charge. There are two reasons: First, when a battery is weak, the lead sulfate that forms on both the positive and negative plates, becomes hard. When the battery is recharged, the hardened lead remains and prevents those portions of the plates from taking a full charge. This lowers the overall electrical capacity of your battery.

Second, the capacity of your battery for cold weather starting is greatly reduced. Even a fully charged battery at $0^{o}F$ has only 40 per cent of the capacity it has at $70^{o}F$. That is the reason a weak battery may give fair service until the weather turns cold. Then it appears to go bad all at once.

Maintaining Battery Liquid Level:

1. Remove caps from battery cells. Most caps are threaded and screw on or off. However, some are simply pressed into position and lifted out. Turn them upside down and lay them on the side of the battery case. This keeps acid off the battery top.

Do not smoke or light a match while the caps are removed. If the battery has been charging, hydrogen gas is present. A concentration as low as 7 per cent may burn and explode in the presence of a spark or flame.

2. Fill each cell to proper level with clean water. Fill until the level of the electrolyte is about 3/8 inch above the level of the plates.

   Avoid overfilling.

3. Replace caps on battery. Be sure there is no green corrosion on the battery caps. When operating under dusty conditions, check the vent hole in the cap each time the battery is serviced.

Checking the Battery Frame and Cable Connections.

Check for loose terminal connections or a loose hold down clamp on the battery. If the terminals are loose, there is resistance to the flow of current at this point so that equipment supplied by the battery does not get the full benefit of the battery voltage. And if the hold down clamp is loose, the battery is free to bounce which in turn may damage the plates and can cause short circuiting. Tighten the clamp just enough to prevent movement of the battery.

If there is corrosion on the battery terminals, clean the battery.

Checking Battery Charge

There are two methods of testing a battery: (a) with voltameter equipment or (b) by specific gravity. The specific-gravity method (hydrometer) is more commonly used. The procedure for this method is:

1. Remove battery caps.

   Note the level of the electrolyte in the cells. If it does not cover the plates, add water; delay checking your battery until after you have operated your tractor about four hours so the water has time to mix into the electrolyte.

2. Insert hydrometer nozzle, compress bulb, then slowly release to drain electrolyte into barrel.

3. Adjust electrolyte level until float rides freely.

4. Hold hydrometer vertically while taking reading. Adjust your position while reading the scale so your eye is level with the liquid.

5. Return electrolyte to cell from which it was removed.

6. Check remaining cells in the same manner.

7. Flush hydrometer with clean water.

8. Interpret results of reading from each of the battery cells from the following table.

Specific Gravity Reading	What it Means
1.300	Battery is being overcharged or there has been a loss of electrolyte from spilling or leakage.
Between 1.214 and 1.280	Battery is in good condition. Some batteries are fully charged with a reading of 1.270 while others are fully charged at 1.250 or less.

	Batteries intended for use in warmer climates are often of the lower specific gravity type.
Under 1.215	Battery charge is too low. Have it recharged.

CHECKING AND ADJUSTING V-BELT TENSION

Most tractors are equipped with either one or two belts which operate the water pump, fan, and generator. Some tractors also use a second belt to drive the hydraulic pump used for power steering. Most operators manuals recommend that you check the belt(s) for tightness and condition about once a week. However, you will probably not need to adjust it until after several weeks of operation. Belt replacement will be less frequent if regularly checked.

V-belts are designed to ride on the sides of the pulley grooves, not at the bottom. As long as they ride on the sides there is ample friction area to deliver power without the belt being particularly tight.

If you tighten a V-belt too much, bearing wear increases rapidly and belt life is shortened.

If a V-belt is too loose, it will slip and cause the equipment it drives to operate at a lower speed. Lower speed on the fan and pump will provide less engine cooling and there is a good chance the engine may overheat. The generator operating at reduced speed may lower the charge rate and cause the battery to lose charge.

It is important that V-belt be kept clean. Oil or grease allowed to accumulate on them will soften the rubber and cause permanent damage.

Checking Condition of V-Belt

If the belt is commencing to show cord separation, or is soaked with grease, or has stretched and worn until it rides in the bottom of the pulley groove, replace it with a new one.

Be sure to replace with a new belt of the type and quality recommended for your tractor. There is a wide selection of V-belts designed for all types of operating conditions, loads, etc. The one supplied by your dealer is the most likely to meet the conditions under which your V-belt must work.

Checking Tension of V-belt

1. Check your operators manual to determine amount of deflection needed. Deflection is the distance the belt can be pushed (or pulled) from its normal position.
2. Deflect belt and measure deflection. The amount of deflection recommended in operators manuals varies from $\frac{1}{4}$ inch to 1 inch. The reason for these variations is the differences in distance between pulleys on various tractors, the varying cross-sectional size of belts, and the different types of belts used.

Adjusting Tension of V-Belt

If the deflection increases either more or less than recommended for your tractor, proceed as follows for adjusting or installing new one:

1. Make certain the ignition switch is turned off (if you have a spark-ignition engine). This is a safety precaution. When adjusting or replacing a belt you may move the crank shaft enough to cause one cylinder to fire and start the engine.
2. Loosen belt tension adjustment. There are two types adjustments for belt tension. One is the adjusting strap type which provides for loosening a bolt at the generator and rocking the generator to one side or other to loosen or tighten the belt. The second type provides adjustable pulley flanges so the groove in the pulley may be widened or narrowed. The adjustment may be on either the fan pulley or the crankshaft pulley.
3. (Remove old fan belt and replace with new one if replacing a belt.) If you have provided all the slack available with either type of adjustment, you can slip the belt off the smaller pulleys and over the fan blades.

   When installing a new belt that fits tightly, provide maximum slack, then start one side of the belt over the edge of one of the pulley flanges and turn the engine slowly.
4. Adjust to proper tension.

   Most people have a tendency to over-tighten a V-belt. If your belt is tightened by pulling the generator pulley back into belt, try doing it by hand first. Then tighten adjusting set screw or bolt and see if the belt is tight enough. If a pry is necessary, apply pressure easily.
5. Tighten adjusting nuts securely.

LUBRICATING THE CLUTCH-RELEASE MECHANISM

Most farm tractors use a dry disc-type clutch to engage and disengage power delivered from the engine to the transmission. An important part of the clutch is the clutch-release mechanism. Through it you engage or disengage the clutch by means of a hand lever or foot pedal.

On most of the newer tractors, the mechanism is prelubricated at the factory and needs no further attention until the clutch assembly is removed for a major overhaul. However, on some new models and many of the older ones, the assembly requires regular lubrication. The recommended frequency of lubrication varies with different makes and models of tractors from 10 hours to as long as 240 hours. Most companies indicate lubrication on a weekly basis.

The throw-out bearing will wear rapidly if you keep your foot on the pedal while your tractor is in operation. This is because the bearing remains in contact with the clutch-release fingers and continues to rotate at about the same speed. Another reason is that clutch riding causes the clutch discs to slip which burns out the facings.

Lubricating the Clutch-Release Mechanism

1. Check your operator's manual to determine if clutch-release mechanism has a lubrication fitting. If greasing is required, the fitting may be on the side of the tractor. If not, the fitting is reached through a hole in the side or bottom of the clutch housing.

2. Apply lubricant sparingly. Most operator's manuals suggest either one or two short strokes from a grease gun. It is important to follow these recommendations because over-lubrication may force grease on to the clutch facings causing slippage and rapid wear. It will also cause clutch chatter. However, if it is under-lubricated, rapid bearing wear will result and in time it will fail.

MAINTAINING THE HYDRAULIC SYSTEM OIL LEVEL

On some tractors the hydraulic system is used only for implement control. On others, a second but separate system is used for hydraulic steering. On some of the newer tractors one hydraulic system serves both purposes.

Manufacturers are well agreed on the importance of checking the hydraulic system oil level. Most of them recommend a weekly check (50 - 75 hours); some suggest a daily check while some recommend 200 hour intervals.

If the hydraulic system on your tractor is in good shape, it won't require additional oil often. This leads some farmers to think that regular checks are not necessary. But over a period of years, you will find regular checks pay a good return on the time they take.

There are several reasons why regularity is important. If a leak develops, you will be able to detect it at once. This will keep down oil waste and will also keep air from being drawn into the system resulting in faulty operation. If you allow the oil level to get too low there is a loss of lifting action, the oil tends to overheat and

the hydraulic pump becomes noisy. If air enters the system, oil tends to oxidize much faster. As the oxidation inhibitor wears out, gum and sludge commences to form.

CHECKING HYDRAULIC OIL LEVEL

1. Adjust hydraulic implement control so that cylinder(s) is in retracted position. On most tractors the oil level is checked with the cylinder(s) retracted (not under pressure). This is especially true with single-acting hydraulic system. If oil is added with the cylinder(s) extended, there will be too much oil in the hydraulic system when the cylinder(s) retract.
2. Check hydraulic oil level.

   There are various provisions for checking oil levels. Some tractors have a separate dip stick, others a check drain plug and some provide a dip stick on the filler cover or cap. Be sure to clean the area around the dip stick before you remove it.
3. Clean dirt from filler cap or cover and remove it.
4. Add oil until proper level is reached. If you use a funnel or container, be sure it is clean.

   Use only the kind and grade of oil recommended for your tractor.

   Don't overfill, this may cause the hydraulic pump to overheat.
5. Start engine and work hydraulic control lever several times.

6. Recheck hydraulic oil level and add oil if necessary.

7. Replace filler cap.

SERVICING THE DRY-TYPE AIR CLEANER

Two types of air cleaners are used on farm tractors. They are: (1) the oil-bath type, and (2) the dry (paper-filter) type.

The two cleaners work on different principles. The oil-bath cleaner depends on washing the air free of dust particles by pulling it through a bath of oil. The dry-type cleaner depends on a special paper to filter out dirt particles.

The can-shaped appearance of the dry-type cleaner causes it to look very much like an oil-bath cleaner when mounted upright. However, a dry-type cleaner can also be mounted horizontally.

There are several advantages in favor of a dry-type air cleaner over an oil-bath cleaner. They are:

1. Easier to service.

2. Require less frequent servicing.

3. Fuzz and chaff cause less restriction to air passage.

4. Less messy.

5. More efficient at a wide range of engine speeds.

6. Neglect of air-cleaner servicing does not harm the engine.

Frequency of cleaning the dry-type cleaner varies from 50 hours intervals to as long as 100 hours. This varies in accordance with different manufacturers recommendations, and the conditions under which the tractor is operated.

It is well known that dirt, which enters the intake manifold of an engine and passes into the engine cylinders, mixes with the oil

on the cylinder walls to form a grinding compound. Tractor manufacturers have made every effort to equip their tractors with the most efficient air-cleaners available so you may get the longest possible usage from your tractor before an overhaul is necessary.

Removing the Filter Element

1. Stop engine, if it is running. This is important to keep the engine from sneaking in dirt while the filter element is being removed.
2. Squeeze dust unloader if supplied on your air cleaner.
3. Remove hood or grill, if necessary, to provide access to air cleaner unit.
4. Wipe off dust accumulated around end of cleaner where element will be removed.
5. Loosen hand screw or clamp that holds the end cap on the end of the cleaner and remove cap.
6. Clean the area around the element and clean the dust cap and baffle on air cleaner, having end caps. Use a dry cloth. Don't use gasoline, fuel oil or solvents.
7. Remove filter element from cleaner.
8. Check condition of rubber gasket on end of filter element. If the gasket is damaged or missing, replace the filter element with a new one.

Cleaning the Filter Element

There are three methods of cleaning the filter element. They are: (1) topping to loosen dust so it can be shaken out, (2) use of compressed air, and (3) washing with water and a detergent.

Tapping is the least effective and should be done only when no compressed air is available or when cleaning the element in the field.

Use of compressed air is very satisfactory if used as recommended.

Washing the filter is necessary when the filter element becomes dark indicating that oil or soot has deposited on it.

Cleaning by Tapping

1. Tap filter element, against the palm of your hand or a firm surface, to loosen dirt but gently enough that element is not damaged.
2. Rotate element during tapping procedure and shake out dust.

Use of Compressed Air

1. Direct air from air nozzle against inside of filter element to the outside-opposite normal air flow. The air must be dry and pressure at the nozzle not exceed 100 lbs. per square inch.
2. Continue blowing and rotating the element until it is clean.

Washing

1. Clean away as much dirt as possible with clean water from a hose, or use compressed air.
2. Wash element in warm water and detergent. Use a nonsudsing detergent. Don't use fuel oil, gasoline or other petroleum solvents.
3. Rinse the element. Use clean water and then shake excess water from element.
4. Allow element time to dry. Allow approximately 24 hours at 70°F. For drying time. Don't use compressed air to dry

the filter. It will rupture the paper element.

5. Inspect element for damage. If there is even a slight rupture in the element, throw it away.

Installing the Filter Element

1. Replace the filter element in the cleaner.
2. Tighten wing nut that holds the element in place. Tighten with fingers only, so as not to over tighten. Be certain engine is not running when the element is replaced.
3. Complete remaining procedure in reverse order from those used to remove the filter element.

CHECKING AND SERVICING OTHER PARTS OF THE TRACTOR

Other points that are generally checked or lubricated at 50 hour intervals are:

1.	Water pump (if equipped with grease fitting)	1 stroke (of grease gun)
2.	Brake-shaft fittings	2 strokes each
3.	Clutch-shaft fittings	2 strokes each

CHAPTER III

MAINTENANCE AFTER 100 HOURS OF OPERATION

CHANGING CRANKCASE OIL

A crankcase-oil change is indicated here for the 100 hour service interval because it is the period most commonly recommended by tractor manufacturers. However, there are rather wide variations in the recommended periods for changing crankcase oil. With gasoline operated tractors the intervals vary from 90 to 200 hours, and with diesel tractors from 60 to 150 hours. Therefore it is important to check your operators manual.

Before the introduction of additive oils, crankcase oil oxidized with use, which caused it to thicken. But enough fuel got past the pistons and into the crankcase to dilute the oil so that thickening wasn't noticeable. As the oil thinned from dilution, the oil film between rubbing surfaces became thinner. This made it less effective for lubricating the bearing and cylinder walls, and wear increased.

Now that we have better built engines operating at higher compressor ratios, higher speeds, under heavier loads and under winter as well as summer conditions, the job expected of oil has become even greater. Additive oils have helped meet these needs. Since additive oils do not deposit sludge but hold contaminants in suspension, they gradually become contaminated with soot, sludge, varnish-forming materials, metal particles, water, unburned fuel, dirt, and dust.

Oil filters remove the larger particles but as the contaminants increase, the oil loses its lubricating qualities. Wear increases rapidly. A point is finally reached where the oil is unable to take up additional contaminants. Then varnish deposits start to form on the pistons, valve lifters and rings and sludge will develop. The oil change intervals recommended in your operator's manual are timed so the oil in your tractor should not reach that stage of contamination if you are maintaining your tractor properly.

Changing Crankcase Oil

1. Operate engine until thoroughly heated. Oil will drain more rapidly while hot; more of the contaminants are removed while the oil is still agitated. If crankcase is drained while oil is cold, some of the more highly contaminated oil may remain in the engine.
2. Remove drain plug (and clean if of magnetic type). Use a wrench that fits the drain plug, not a pair of pliers. If the drain plug is magnetic, strike the plug against a solid object to remove the accumulated particles. Be careful not to damage threads.
3. Allow crankcase to drain for several minutes. This allows time for oil to drain from various parts of the engine.
4. (Flush crankcase. Check your operator's manual.)
5. Replace drain plug. If drain plug is equipped with a copper gasket, be sure it is in place on the drain plug.
6. Refill crankcase with new oil. Check the oil cans, funnel, or any other containers you may be using, to make certain

they are free of dirt. Use the viscosity and type of oil recommended in your operator's manual.

7. Start engine and operate it for a few minutes. This gives the oil an opportunity to fill the oil filter and establish a true level on the dip stick. Also check the pressure guage to make certain the oil pump is working properly.
8. Check for oil leak.
9. Check oil level on dip stick. If oil is not to the "full" line, add until it reaches that level. Don't overfill.
10. Store used oil in a drum or small closed container. This is a matter of good housekeeping and safety. Used oil is almost certain to contain some fuel which means it is a fire hazard if left in open containers where it may be exposed to sparks or open flames.

REPLACING OIL FILTERS

The oil filter and air filter on your tractor have more to do with how long your engine will last than any two other items on your tractor. The reason - both filters are responsible for removing abrasive dirt and foreign materials that contribute to rapid wear in your tractor engine.

With high quality additive oils, the materials that formerly developed into sludge are now held in suspension in the oil as finely divided particles. Many of these particles are too small for a filter to remove so they remain in the oil and cause it to darken. Consequently darkened oil is not an indication of need for a filter change.

It is also difficult with additive oils to tell by the appearance of a filter when it should be changed. It may not appear dirty but be loaded with fine abrasive particles. Consequently, the only safe procedure is to change the filter at the intervals recommended in your operator's manual. These intervals vary from 90 to 480 hours depending largely on the type of fuel being used and the capacity of the filter in relation to engine size.

Over the years that farm tractors have been built there have been a number of different filters and filtering materials used. But any tractor you are likely to own now is almost certain to be equipped with a replaceable, cartridge-type filter.

The cartridge may contain either: (a) a specially treated, pleated-paper element, or (b) a waste-packed element. Of these two, the pleated paper element is used almost exclusively.

There are two types of oil filtering systems. They are: (1) The by-pass system and (2) the full-flow system. In the by-pass system only a portion of the oil moves through the filter as it leaves the pump. The rest goes directly to the engine bearings.

With the full-flow system all of the oil moves through the filter unless it is partly or completely blocked because of a dirty filter or cold oil.

Replacing an Oil Filter

1. Find location of oil filter. On many tractors the oil filter is located on the side of the engine. On a diesel engine it may be similar in appearance to a fuel filter.
2. Wipe dirt from filter and from around filter area.

3. Remove drain plug (if provided) from base of filter and catch oil in pan. Engine must be stopped while oil filter is changed.
4. Loosen filter bowl or cover and remove.
5. Remove old filter cartridge and discard it.
6. Clean inside of filter bowl and base with kerosene or diesel fuel.
7. Replace drain plug.
8. Install new gasket, if supplied with filter. New gaskets are usually supplied with new filters. However, if a new gasket is not available, examine the old one. It may still be usable.
9. Install new filter unit. If your replacement cartridge is the type that is installed in a filter bowl rotate the element slightly to help it become seated. If you have a spin-on filter that uses a rubber gasket, turn the filter on until the gasket contacts the base, then tighten no more than ½ turn.
10. Replace filter bowl (if of that type) and tighten in place.
11. Operate engine and check for leakage around filter. This is important. A small leak can cause enough oil loss to damage your engine.
12. Check oil level and add oil if needed.

SERVICING THE CRANKCASE BREATHER

Crankcase ventilation is for two purposes:

1. To avoid a buildup of pressure in the crankcase.
2. To remove gases and vapors.

All farm tractors have some method of ventilating the crankcase; however, the method varies with different makes and models. The two methods in most common use are: (a) use of a breather cap and (b) by means of a ventilator pump. The latter seldom requires attention.

The breather cap method is most used. The breather cap is usually mounted on the valve cover.

The whirling action of the crankcase and piston movement cause a pulsating motion of air through the breather cap. This in and out air movement provides ventilation and at the same time avoids a buildup of pressure inside the crankcase from blow by gases. The breather filter has the important job of removing dust and abrasives from air that is entering the crankcase.

If the crankcase breather becomes clogged, the buildup of pressure may force oil past the seal on either the front or rear main bearing. Once a seal is broken, your tractor will begin to use oil. If the oil from a rear main bearing reaches your tractor clutch, it will cause it to start slipping.

When ventilation stops other situations develop. In normal engine operation some raw fuel, gases and moisture pass the piston rings from the combustion changer and enter the crankcase. This is called "blow-by". If these can't escape, the moisture tends to promote rusting and corrosion in the engine; the other materials cause deposits of varnish on various parts of the engine while operating under either low or high temperature conditions. Piston rings also tend to stock because normal blow-by is prevented.

Servicing the Crankcase Breather

1. Locate crankcase breather(s). Your tractor may have one, two, or three breather caps. They are commonly located on top of the valve cover and may also serve as the oil filter cap over the end of the filter spout. Others are mounted on the side of the valve cover.
2. Wipe dirt from cap(s) and adjoining area.
3. Remove breather. Many of them are held in position by friction. On others you will need to remove a wing nut or clamp.
4. Wash filter element in solvent such as diesel fuel or kerosene. Don't use gasoline. It is an effective cleaner but a serious fire hazard.
5. Shake out excess cleaning fluid.
6. Relubricate mesh with light crankcase oil. Use clean oil. Used oil is not very effective.
7. Remove excess oil.
8. Re-install breather(s). If a gasket or felt washer was present when you removed the breather, be sure you reinstall it. If the seal or washer is broken, replace with a new one.

MAINTAINING TRACTOR TIRES

Tire manufactures recommend that inflation pressures be checked every two or three weeks so as to be sure that they are maintained at proper pressures. Most operator's manuals contain about the same recommendations.

Over inflation causes extra tire strain. Cords may lose as much as 35 to 40 per cent of their tensite strength (resistance to rupture). Under inflation causes severe side wall flexing which builds up heat

and causes the plies to separate.

With proper inflation there is no unnatural buckling of the sidewalls and the tread fits squarely against the traction surface. Proper inflation helps insure long service and helps your tractor deliver satisfactory drawbar pull.

Check Tire Inflation

1. Remove valve cap and check pressure with guage. When checking a liquid-filled tire, the pressure of the liquid must be added to the air pressure to get the true tire pressure. This can be done in either of two ways: (1) check the pressure while the valve stem is in its lowest position, (2) check while the valve stem is in the top position, then add ½ pound per foot of liquid height. Liquid height is measured between the valve stem in its lowest position and the top of the liquid level in the tire. Use a low pressure tractor tire guage with one-pound markings to get an accurate check. If you are using water or calcium-chloride solution in your tires, use a guage that can be washed.
2. Add air (or deflate) as needed to secure proper pressure. Use the tire pressures recommended in your operator's manual. If you are using mounted equipment that puts most of the weight on one side of the tractor, put the most pressure in the tires on that side. If you plan to operate your tractor on a paved road or hard surface for several hours, inflate to maximum pressure.
3. Wash guage with clean water after using on tires containing calcium-chloride solution.

4. Replace valve cap. The valve core is not always leak proof. Caps help prevent air (and liquid) leaks and at the same time prevent dirt and moisture from entering the valve stems and cores.

Checking Tire Condition

1. Check side walls for cuts or breaks, cracks or "checking" caused by over inflation or long exposure to sun light. Radial cracks resulting from under inflation and heavy draw bar load. These should be repaired and tire kept properly inflated. Breaks inside of casing caused by under inflation. Cuts resulting from hitting something sharp. Cuts should be repaired to keep out water and sand and protect the cord fabric.
2. Check treads for nails, stones, cuts or snags. If cut or snag does not expose the fabric, remove stones and dirt then remove loose rubber and bevel cut into a cone-shaped cavity. Bevel prevents stones and dirt from accumulating in opening.

CHECKING AND SERVICING OTHER PARTS OF TRACTOR

Other points that are commonly lubricated or checked at the 100 hour service interval are:

1. Generator bearings 8 to 10 drops of engine oil.
2. Distributor shaft - 8 to 10 drops of engine oil.
3. Cam-shaft wick - 2 drops of engine oil.
4. Power-steering oil level - unless it is supplied from the hydraulic-control unit.

CHAPTER IV

MAINTENANCE AFTER 250 HOURS OF OPERATION

MAKING VALVE-CLEARANCE ADJUSTMENTS

Adjusting valve clearance goes by other names such as "tappet adjustment", "valve adjustment," "valve spacing," and "valve lash". All refer to the same operation.

Valve-clearance adjustment provides the proper clearance between the ends of the rocker arms and the ends of the valve stems during the time the valves arenot being depressed.

How often should you check valve clearance. Manufacturers differ in their recommendations - some say after every 150 hours of operation; others recommend longer intervals - some as long as every 600 hours of operation.

Proper valve-clearance adjustment is important to you for the following reasons:

a. valves give longer service.

b. the engine uses fuel more efficiently.

c. it starts more easily.

d. maximum power is produced.

e. the engine is less likely to overheat.

f. smoothest engine operation is provided.

When a valve is properly adjusted, there is clearance between the valve stem and the end of the rocker arm when the valve is closed. This

is very small, varying from approximately .006 inch to .030 inch; but it is extremely important. Each manufacturer recommends the proper clearance for each model of tractor. Recommendations vary depending on: (1) whether the engine is hot or cold at the time of adjustment, and (2) the design of the engine - some are designed to run hotter than others.

If valves are adjusted so there is little or no clearance, they are thrown out of time. This causes them to open too early and close too late. Also, the valve stems may lengthen enough from heating that the valves do not set completely. This allows hot combustion gases to leak past, causing them to overheat. The valves seat so briefly, so poorly or not at all that normal heat movement into the engine block does not have time to take place. This causes loss of compression, overheating of the valves and burned valves.

If there is too much valve clearance, there is a noisy lag in valve timing which throws the engine out of balance. The fuel-air mixture is late entering the cylinder during the intake stroke. The exhaust valve closes early and prevents waste gases from being completely removed. The valves themselves become damaged because they close with heavy impact which causes them to crack and break.

Preparing Tractor for Valve Adjustment

(Spark-ignition or Diesel Tractors)

The procedures that follow are for valve inhead engines since most farm tractors have that type of valve arrangement. If your tractor does not have a valve cover on top of the engine, the valve adjustments are available by removing a cover on the side. A few tractor engines can be checked and adjusted when they are hot, but on general tractor engines

must be stopped. The reason is that on many tractors the fuel tank must be taken off before the valve cover can be removed so there is no way to keep the engine operating.

1. Read your operator's manual to determine whether you should check valve clearances while the engine is hot or cold.
2. Remove tractor parts that interfere with removal of valve cover. On some tractors there is nothing but the valve cover to remove. On others, it may be necessary to remove one or all of the following: The air-cleaner cap, the muffler, the hood and the fuel tank if mounted close to the valve cover.
3. Clean dirt from valve cover and from around spark plugs. Use diesel fuel or kerosene on waste or rag. Clean until all dirt is removed.
4. Remove nuts or cap screws that hold valve (rocker-arm) cover. Put nuts or cap screws in a container so you won't loose them.
5. Carefully remove valve cover to protect gasket.
6. To avoid accidental starting of engine during valve adjustments, take these precautions. With spark-ignition engine either: (1) disconnect the center terminal wire to the distributor or (2) if you plan to clean the spark plugs, disconnect all spark plug wires and remove plugs. With diesel engines, be sure the fuel supply is shut off.

Making Valve-Clearance Adjustments.

1. Check cylinder head for tightness. The head may not require further tightening unless it has been removed recently. However, it is best to check it before making adjustments of valve-clearance. Tightening it afterward may change the clearances.

2. Slowly turn crankshaft until piston in number 1 cylinder is at top dead center (TDC) of compression stroke. No. 1 cylinder is the one next to the radiator on upright engines. On horizontal engines. it is the one next to the fly wheel. When a piston is at TDC on the compression stroke, both the intake and exhaust valves are closed and the push rod followers are riding on the low sides of the cams. This is the only position you can satisfactorily adjust both valve clearances at the same time. There are several ways of determing TDC of the No. 1 cylinder on the compression stroke. Methods that work for both spark-ignition and diesel engines are:

   a. Use of timing marks on the fan pulley or flywheel. Check your operator's manual to make certain you are using the correct markings.

   b. Watch the intake valve on the No. 1 cylinder. When it closes, turn the crank $\frac{1}{2}$ turn.

Methods that work for spark-ignition engines only are:

   a. Position the No. 1 spark-plug wire so it is about $\frac{1}{4}$ inch from engine block. Turn crank until spark jumps the gap.

   b. Place your thumb over the spark plug opening and crank the engine until the end of the compression stroke when no further pressure is felt.

Use one of the above methods that is most convenient for your particular tractor.

3. Select the filler-gage thickness(es) recommended for the valve on your tractor. Some tractors use the same feeler-gage

thickness for both the exhaust and intake valves. Others require more clearance for the exhaust valve.

4. Check clearance by inserting gage between valve stem and rocker arm of both valves. The first valve is exhaust, the second intake. If you think the present setting may be too wide, try the next larger size feeler gage. If it is hard to insert, the present setting is correct.

   If clearances are correct on both, proceed with step 8.

   If the clearance is not correct, proceed with the steps that follow.

5. Loosen adjusting screw lock nut on valve rocker arm.
6. Turn adjusting screw with screw driver until feeler gage will just slip in and out of gap.
7. Hold adjusting screw with screw driver and tighten lock nut with wrench. It is well to recheck with the feeler gage after the lock nut is tightened.
8. Determine which cylinder fires next. To determine which cylinder fires next you will need to know the firing order. This is commonly shown on the side of the engine. If not, it is in your operator's manual.
9. Crank engine until next cylinder in firing order is on compression. With 2- and 4- cylinder engines, turn the crankshaft ½ turn. With 6- cylinder engine, turn the crankshaft 1/3 turn.
10. Adjust valves following same procedures as on No. 1 cylinder and proceed in same manner with remaining cylinders.

Reassembly after valve adjustment

1. Clean and install spark plugs (spark ignition engine).
2. Start engine and check lubrication of rocker arms. If you have removed your fuel tank you will need to reconnect it temporarily for this purpose. Some manufacturers, who recommend setting valve clearances while the engine is cold, suggest rechecking valve clearances after the engine has become thoroughly heated.
3. Place gasket in position on cylinder head. If the old gasket was damaged or broken when you remove the valve cover, use a new gasket.
4. Replace valve cover. Make certain the gasket fits squarely under the edges of the valve cover.
5. Install other parts of tractor that were removed to gain access to valves.
6. Provide safe disposal of oily rags. It is good housekeeping and safety practice to provide a five or ten gallon can with cover for oily or soiled rags.

MAINTAINING TRACTOR SPARK PLUGS

(Spark-ignition Engine)

Farmers differ widely in their idea of how often to service and replace spark plugs. This is shown by an Illinois study of 60 farm tractors.[1] Operator's manuals are often not very definite either. Some manuals indicate that spark plugs should be checked and serviced "regularly", "when required", "periodically", or "when not firing

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[1] J. A. Webber. Maintenance Inspections of sixty Farm Tractors: University of Illinois, Agriculture Experiment Station, Bulletin 624, 1958.

regularly." Others suggest definite time intervals such as 150 hours, 200 hours, or 250 hours.

The merits of keeping your spark plugs in good condition can be judged from a Kansas study of 50 farm tractors.[1] New plugs were installed in each tractor unless new ones had been installed within two weeks preceding the test. With new spark plugs the effect on horsepower varied from no change to as much as 8.6 per cent increase. The average increase for all tractors was 5.6 per cent. Fuel consumption decreased an average of 6.1 per cent.

In each of seven tractors that misfired under load, new plugs increased their horsepower 21.5 per cent and decreased fuel consumption by 14.2 per cent. "...in all seven cases, misfiring was eliminated by installing new spark plugs...."

It is well recognized too that if used spark plugs are still in good mechanical condition they can be cleaned and re-gapped to give added power and fuel savings.

When a plug is new, the edges of the electrodes are sharp. A spark will jump the gap under cylinder pressure with as little as 10,000 volts. But the spark gap increases as the engine is used. Hot combustion gases and continuous electrical discharge both erode and corrode the electrodes until the edges become rounded and the spark gap increases. The gap increases about .001 inch with each 20 hours of tractor operation. After 200 hours of operation, the gap may be wide enough to require 15,000 volts to fire it.

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[1] Floyd N. Reece, and G. H. Larson; A Study of the Performance of Fifty Farm Tractors; Technical Bulletin 99 (Agricultural Experiment Station, Kansas State University, May 1959) p. 15

If your tractor is new and the ignition system is in good condition, it will have little trouble producing 15,000 volts or even up to 25,000 volts. But as the ignition system gets older, it may have a trouble developing enough voltage to fire a worn plug. This makes spark-plug maintenance all the more important on older tractors.

What Type of Spark Plugs to Use

Whether you are buying new spark plugs or reconditioning old ones, it is important that you understand the differences in spark plugs and how they affect the operation of your tractor.

Your operator's manual indicates the size and type of plug that best fits your particular tractor engine. These are also given on charts by various spark plug manufacturers.

There are several sizes and types of spark plugs developed to meet most any combination of the following:

1. Operating conditions - whether the engine operates under heavy load, light load or moderate load.
2. Kind of fuel used.
3. Engine design.

Operating conditions vary from light loads, with periods of prolonged idling, to heavy continuous loads where the engine stays hot constantly. To meet these conditions and to provide the most satisfactory performance from your tractor, manufacturers make available spark plugs for "cold", "normal", and "hot" conditions. The difference

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[1]Floyd N. Reece, and G. H. Larson; A Study of the Performance of Fifty Farm Tractors; Technical Bulletin 99 (Agricultural Experiment Station, Kansas State University, May 1959) p. 15

in the three spark plugs is the length of the insulator tip - the length determines how rapidly heat passes from the spark plug to the engine coilant. The longer the insulation tip, the farther the heat must travel and hotter the plug becomes.

By using spark plugs of the proper heat type, you get longer, trouble free service from them and from your tractor. The spark plugs become hot enough they burn themselves free of carbon yet they do not become hot enough to overheat and burn the electrodes thus widening the spark gap.

If you use hot plugs under heavy-load conditions, you can expect them to overheat. Overheating will cause blistering, burning of the electrodes and engine knock. The latter is caused by the plugs becoming so hot that they ignite the fuel charge before the spark plug fires. This temperature is around 1,600° to 1,700°F.

If you use cold plugs under extensive idling and light load conditions, you can expect them to foul with carbon causing the engine to skip and there will be a gradual buildup of carbon inside the combustion chamber. This occurs at 700°F to 800°F and below.

Engine design affects the length or "reach" of plug recommended. This is particularly true in 14 millimeter sizes, which is one of the common sizes used on farm tractors. There are 4 different "reaches" of 14 mullimeter plugs, 3/8", 7/16", 1/2" and 3/4". These are designed to fit different depths of engine heads so that the base of the plug will be even with the inside of the combustion chamber.

If longer reach plugs are used than recommended for your engine, they will extend into the combustion chambers and may interfere with piston and valve action.

If plugs are used with a reach that is too short, the spark is shielded, resulting in improper combustion of the fuel in the cylinder. In this case the exposed threads in the cylinder head fill with deposits so that it is difficult to install a plug with the proper reach until the threads are cleaned with the proper thread tap.

Removing Plugs from Engine

1. Disconnect spark plug wires from plugs. Position ends of spark plug wires so you can connect them to the same cylinder when they are reconnected.
2. Loosen plugs one or two turns, then remove dirt. Use a spark plug socket wrench that fits the plug. Don't use an open end or box end wrench or a set of pliers.
   Remove dirt with an air blast, small paint brush or cloth to keep it from entering cylinders.
3. Remove each plug and arrange so each can be identified with its cylinder. By keeping each plug identified with the cylinder from which it was removed, you may be able to detect a cylinder that is using oil or one that is not working properly.

Conditioning the Plugs

1. Check the condition of each plug. Ones that are worn should be replaced with new ones of the type and size recommended for your tractor. If you replace all plugs, proceed with step 1 in replacing plugs.
2. Remove oily deposits from plugs. Put plugs in a pan of solvent such as kerosene, distillate or diesel fuel to remove oily film from porcelain body.
3. Clean threads with a wire brush. This is important for re-

moving dirt so the plug will not bind when reinstalled.

4. Remove deposits from plugs. If you have a sand-blast unit available, it will do the job better and faster. Expose plug to blast for about 3 to 6 second and "wobble" plug with a circular motion. You can also use a small-bladed knife for removing hard deposits.
5. Blow loose material from plugs. This is important to keep any remaining sand particles from forming glass-like deposits and to prevent abrasive materials from entering the cylinders.
6. File electrodes on plugs until both have flat surfaces. For filing, bend the ground electrode (don't bend the center electrode) away from the central electrode enough to allow room for a thin (distributor point) file. File rounded end of center electrode until it is flat. Follow the same procedure with the cupped surface on the ground electrode. Remove as little material as possible. Bend the ground electrode back into its original position before attempting to set the spark gap.
7. Determine proper spark-gap spacing for your tractor. Determine this from the operator's manual or from one of the charts issued by spark-plug companies.
8. Regap plugs. Make all adjustments by bending ground electrode with a gap setter. Check with a feeler gage of the proper thickness for the gap you need. A flat feeler gage can be used for new plugs but for used plugs it is difficult to completely remove the cup in the ground electrode. Use a

wire feeler gage, which tends to follow round contour that may remain after filing terminals.

Replacing the Plugs

1. Replace plugs and tighten with fingers. Be sure to put a gasket on each plug. It is best to use new gaskets to assure proper seating, but if you don't have any, check the condition of your old ones. If they haven't been flattened by too much plug tightening, they may still be usable.
2. Completely tighten plug with a spark-plug socket wrench or torque wrench. If you haven't a torque wrench, give the plugs an additional turn.
3. Check connections and insulation on spark-plug wires when reattaching them to spark plugs. If insulation is cracked, be sure to replace with new high-tension wires. Press connections into distributor cap at opposite end. Loose connections at this point cause arcing.
4. Check polarity of spark at spark plug. If ground electrode on spark plug is "dished", the polarity is wrong- from 5 to 45 per cent more voltage may be required to fire the plug. To check polarity, hold the metal connectors about $\frac{1}{4}$ inch from the spark plug terminal. Insert pencil lead in between. If the spark feathers and has a slight orange tinge on the plug side, polarity is correct. If the spark feathers on the connector side, polarity is reversed. Correct by interchanging primary wire connections on the ignition coil.

CLEANING THE BATTERY

As you use your tractor, dirt, moisture, and acid gradually accumulate on top of the battery. The acid is carried out of the battery with the gas that is liberated while the battery is being charged. It settles on the battery top and provides a damp surface where dust and dirt will cling. It also gets on the battery posts and terminates and causes corrosion.

If a battery is charged but not being used, it has a natural tendency to discharge. (at $0^{\circ}F$ a fully charged battery may lose a year before it becomes completely discharged. At $125^{\circ}F$ the discharge period may be shortened to a month). If acid and corrosion have collected on top it will discharge much faster.

Cleaning the Battery

1. Disconnect cable and ground strap from battery terminals if they are corroded. Loosen ground strap first. This prevents short circuits in case you accidentally lay a wrench or screw driver on the battery in such a way as to contact the opposite battery terminal and some part of the frame.
2. Clean cable clamps and battery post. A wire brush is easiest to use and quite effective on outside surfaces. Sandpaper is satisfactory for cleaning inside of clamps.
3. Remove loose dirt and corrosion particles from top of battery.
4. Brush soda-and-water mixture on top of battery, on parts and on clamps. Use about two tablespoons of baking soda in a pint of water. Mix thoroughly and apply on the battery.

Keep water or soda and water from entering the battery; it will weaken the acid in the electrolyte.

5. Wash away residue with clean water.
6. Repeat steps 4 and 5 until there is no further foaming.
7. Dry top of battery with a clean cloth.
8. Apply a coating of light-grease to post and cable clamps. This helps protect against further corrosion.
9. Reconnect cable and ground strap. Connect cable first to help avoid grounding the battery with your tools. Don't hammer the clamps into place on the battery posts. Clean terminals and tight clamps are especially important for diesel engine which require a heavy current flow when starting.

CLEANING THE SEDIMENT BOWL AND FILTER

Most farm tractors are equipped with a combination sediment bowl and fuel filter or screen. On some diesel tractors the sediment bowl and filter combination is considered the first stage of a two or three stage filter system. However, some diesels omit this type of filter in favor of a more elaborate filter system.

How often you should clean the sediment bowl and fuel filter depends on the make and type of tractor you have. Recommendations vary widely. For gasoline tractors the intervals range from 10 hours of operation to as long as 250 hours; some manuals say "periodically".

The purpose of a sediment bowl and filter is to allow water to settle out and to catch particles of scale, rust or other foreign matter that will clog the jets of a carburetor. Moisture is a problem in fuel for all types of engines. It is particularly bad about mixing with diesel fuel, it causes rapid wear in the injectors.

The sediment bowl and filter design is much the same for all types of fuels.

Cleaning the Sediment Bowl and Filter

1. Close valve(s) on fuel supply line. For liquid-fuel tractors the shutoff valve is frequently a part of the filter assembly.
2. Loosen the nut that holds the sediment bowl in place. Sediment bowls on most liquid fuel tractors are held in place with a jam nut.
3. Remove bowl with twisting motion. There is less danger of breaking the gasket if the glass bowl is twisted while being removed.
4. Remove gasket. If the gasket is cracked or hard, be sure to replace it with a new gasket.
5. Remove strainer screen or edge-type filter. The screen is easily removed from the top of the sediment bowl since it is held in place by the clamping action between the bowl and gasket. If an edge type filter (disc filter) is used in place of a screen, it will need to be unscrewed from the base of the assembly.
6. Wash screen or filter element. If the filter element is a disposable type, it should be replaced with a new one. Wash the screen type in diesel fuel or kerosene. If the screen or disc filter is difficult to clean, it may be because of gum and varnish residues that have collected. Use a paint remover, varnish solvent, acitone or mixture of one part alcohol and one part benzol.

7. Clean sediment bowl. Use some of cleaning solution on a cloth, then wipe dry enough that no lint is left in the bowl.
8. Open fuel valve and observe flow of fuel. This tends to remove any dirt between the tank and the sediment bowl. It also serves as a check on the condition of the vent hole in the fuel-tank cap. If the vent hole is clogged, the flow will be slow. Be sure to catch fuel that is wasted from the fuel line in some kind of a container. Careless handling of fuel causes a serious fire hazard.
9. Re-install gasket, strainer (or filter) and sediment bowl. If you have disc filter element, tighten it with your fingers.
10. Tighten bowl against gasket. Tighten completely for spark-ignition engines. For diesel engines, it may be installed loosely until air has been bled from the system; then tighten.
11. Open the fuel valve, start your tractor and check for leaks.

ADJUSTING THE CARBURETOR
(spark-ignition engines)

Operator's manuals usually do not suggest a regular time for carburetor adjustment. However, it is an important tune-up procedure; so it is included here as one of the jobs for the 250 hour service interval.

In a Kansas study of 50 farm tractors,[1] it was found that 46 per cent were being operated with the air-fuel mixture too rich, 26 per cent with the air-fuel mixture excessively lean, and 28 per cent required no change in carburetor adjustment.

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[1] Floyd N. Reece and G. H. Larson; A study of the Performance of Fifty Farm Tractors; Technical Bulletin 99, Agricultural Experiment Station Kansas State University, May 1959 pp. 17-18

The study showed that when the carburetors were corrected from too rich a mixture to the proper mixture, horespower was affected very little but fuel consumption showed an average savings of about 9.5 per cent. A rich mixture will also cause carbon deposits to accumulate in the combustion chamber.

The Functions of a Carburetor

The function of the carburetor is to provide the proper mixture of fuel and air to the engine. Under normal conditions, the mixture is about one pound of fuel to 13½ pounds of air or a ratio of 1:13.5. However, an engine will run on ratios varying from as rich as 1:7 to as lean as 1:20.

In an engine as the engine piston moves down with the intake valve open, a vacuum tends to develop in the cylinder. Atmospheric pressure forces air through the air intake, past the fuel nozzle and through the tube (intake manifold) to the engine cylinder (combustion chamber).

If the tube was the same size all the way from the air intake to the cylinder, little if any fuel would spray from the fuel nozzle. But the tube is much smaller at the fuel nozzle. This is called a "venturi". When the incoming air reaches this point, its speed (velocity) is greatly increased. This causes a partial vacuum (suction) at the fuel nozzle tip.

Since the atmospheric pressure on the fuel in the float chamber remains the same, the gasoline is forced out of the fuel nozzle by atmospheric pressure into the low pressure area of the venturi.

When there is a sudden demand for power, the engine governor opens the throttle valve suddenly. Then the mixture needs to be rich if the engine is to respond quickly. In a carburetor there is an accelerating well which is one means of meeting this need. It is a compartment

that surrounds the lower part of the nozzle and remains full of fuel while the engine is operating under normal load. When there is a sudden demand for power, the governor opens the throttle valve and air moves past the nozzle much faster, picking up additional fuel. This action causes lower air pressure at the nozzle tip than at the air bleed. This pressure difference forces fuel from the accelerating well through the holes in the lower part of the nozzle assembly and out through the nozzle tip to supply the richer mixture.

As quickly as the heavy demand for power is over and the governor partially closes the throttle valve, the accelerating well refills in preparation for the next heavy demand.

The carburetor must also perform another task - it must supply a richer idling mixture. This requires a fuel-air ratio of about 1:12. An engine does not operate well at idling speed unless a rich mixture is supplied. To provide for this situation, carburetors are built with a special provision to supply the proper idling mixture. The fuel passes from the accelerating well up through a special passage and is mixed with air where it joins the passage from the idle air bleed. The mixture then passes into the manifold through the upper idle part above the throttle valve. The throttle valve can be completely closed but your engine will continue to run because of this provision in the carburetor. Air also enters through the lower idle part with the throttle valve completely closed.

As the throttle valve is opened, the lower idle part becomes exposed to vacuum from the manifold. Through it an additional supply of fuel-air mixture is delivered to the engine. About this time the

the main fuel nozzle begins to supply fuel and continues to do so on an increasing scale as the throttle valve opens.

Two other features on a carburetor you should know about are: (a) the choke valve and (b) the pressure-equalizing arrangement to the fuel float chamber. The choke valve is located at the carburetor air intake. It is the one you close when starting a cold engine in order to provide an extra-rich starting mixture. When you choke your engine you close the choke valve so that most of the air supply is cut off. What air is supplied either passes around the edges of the choke valve if it doesn't completely close, or a small amount of air is metered through a special opening provided in the valve. With most of the supply cut off, a greater vacuum develops in the manifold causing an increased amount of fuel to be supplied through the fuel nozzle.

The pressure-equalizing connection is a passage that connects at the carburetor air inlet and extends around the venturi to the fuel float chamber. This keeps the air pressure in the float chamber the same as that entering the carburetor. This is an important provision because the air cleaner causes a slight-drop in air pressure as air passes through it on its way to the carburetor. Without this connection, fuel in the float chamber would have to be exposed to atmospheric pressure. Atmospheric pressure would be enough more than that of the air entering the carburetor to force extra fuel through the nozzle tip and make the mixture extra rich.

This means the float chamber must be air tight so as to be completely scaled against atmospheric pressure. This also helps keep dirt and dust from entering the carburetor.

Preparing for Carburetor Adjustment

Before making carburetor adjustments, it is important that the carburetor screen be clean if the carburetor has a screen and that there are no leaks in the intake manifold or around the carburetor gaskets. If the carburetor screen is clogged or if there are air leaks, it will be difficult or impossible to get the results you wish out of the carburetor adjustments.

1. Determine if your tractor has a carburetor screen. The screen is located at or near the fuel inlet to the carburetor.
2. Shut off valve on fuel line and disconnect line at the carburetor.
3. Remove screen from carburetor. It is usually attached to the fitting that screws into the carburetor inlet.
4. Clean the screen and complete the reassembly.
5. Start tractor engine and check for air leaks at manifold connections and around carburetor gaskets.

   If there is any point where it appears there might be an air leak put a few drops of oil over the area and see if they are sucked into the carburetor or manifold. If so, and if tightening doesn't correct the leakage, you will need to install new gaskets before you can secure satisfactory carburetor adjustments.

Adjusting the Idling Speed Screw

The idling speed screw determines how completely the throttle valve closes, thus determine the idling speed of the engine. The adjustment is on the outside of the carburetor but is some times difficult to find if it is on the engine side of the carburetor.

Over a period of time this screw will gradually work out, allowing the engine to idle too slowly and causing it to die when the speed-control lever is completely retarded.

1. Start engine and warm to operating temperature at about ½ throttle.
2. Set speed-control lever at completely retarded (closed) position.
3. Locate idling speed adjustment.
4. Adjust to normal idling speed. Turning the adjusting screw clockwise increases engine speed; turning it counter clockwise decreases it.

   Check your operator's manual for proper idling speed. This varies with different makes of tractors from as low as 300 rpm to as high as 500 rpm.

Adjusting the Idling Fuel-Air Mixture

Some manuals indicate a setting of so many turns from the completely closed position. These recommendations are usually quite satisfactory if you use the one that apply to your particular tractor. However, a somewhat finer adjustment can be secured by using the procedure that follow:

1. Set speed-control lever at idling position. Your tractor should still be at normal operating temperature. If it isn't, operate the engine until the normal temperature is reached.
2. Locate idle mixture adjusting screw. On most carburetors the idle-mixture adjustment is close to the idle-speed adjustment. However this is not always true.

3. Turn idle-mixture screw clockwise slowly until engine begins to "roll" or slow down. On some tractors, closing the idle-mixture screw decreases the air flow and causes a richer mixture. This is what causes the engine to "roll". On others, closing the idle-mixture screw decreases the fuel flow resulting in a leaner mixture which causes the engine to slow down. Use one-eighth turns when adjusting the needle valve. After each eighth turn wait a few seconds until the engine has a chance to adjust to the new fuel mixture.
4. Turn adjusting screw back slowly until engine runs smoothly. Use one-eighth turns and wait until your engine has a chance to adjust after each turn. You may open the valve enough that the engine "rolls" or slows depending on whether the adjusting needle controls the air or fuel. Turn the screw clockwise. If you find that the engine is not affected by one or two complete turns of the adjusting screw, this may indicate trouble - a leaking float valve, too high a fuel level in the float chamber or deposits in the manifold around the throttle valve which are restricting air flow. See your dealer.

Adjusting the Load Fuel-Air Mixture

The valve that controls the adjustment for full-load or high-speed conditions goes by such names as "main-adjusting needle", "Power-adjusting needle" and "high-speed load adjustment". All refer to the same adjustment.

It is particularly important that the engine be up to full operating temperature when this adjustment is made.

1. Run engine at full throttle either with or without load. If you can provide a constant load-belt, power take-off, or dynamometer without having your tractor in motion, you can get a somewhat more satisfactory adjustment. Add load until speed decreases slightly from its high idle speed. (Don't try to provide load that requires that your tractor be in motion while you make adjustments. There is too much chance of an accident.) If you can make adjustments without load, follow up with a final check to make sure the adjustment is satisfactory under load.
2. Turn load adjusting screw clockwise until engine begins to lose power. This indicates that you have reached the boarder line on the lean side of the mixture.
3. Turn adjusting screw counter clockwise until engine gives off black smoke from exhaust. The adjustment is now providing too rich a fuel-air mixture.
4. Turn screw clockwise until engine runs smoothly and at full speed. Make one-eighth turns on needle and wait for engine to adjust.
5. Check carburetor adjustment by accelerating engine quickly while under load. The engine should accelerate quickly when you adjust the speed-control lever suddenly if the carburetor is properly adjusted. Backfiring indicates too lean a mixture and dark-colored smoke indicates too rich a mixture.

ADJUSTING TRACTOR BRAKES

Few operator's manuals mention a certain time for adjusting brakes. Those that do, recommend intervals that vary from 200 hours to 400 hours of tractor operation.

As long as tractor speeds are slow, uneven brake adjustment may not be too serious. But, with top tractor speeds available on most present day tractors, uneven adjustment between the two wheel brakes could easily upset the tractor.

Brakes are fairly easy to adjust; but the job of adjusting may be quite confusing because brakes are located differently and look different in different makes and models.

Types of Brakes and How They Work

There are three types of brakes in common use on tractors.

a) External band brakes (external contracting).

b) Shoe brakes (internal expanding).

c) Disc brakes (mechanical and hydraulic)

The band-type brake is simplest. Braking action is secured simply by pulling the band tightly around the rotating drum.

The shoe brake is similar to those used on automobiles. Springs hold the brake shoes off the brake drum until forced against the drum when the brake pedal is pressed.

The mechanical disc brake is some what more complicated but is coming into more common use. The brake has two driven discs, faced on each side, that turn with the axle. Whenever the tractor is in motion these discs rotate. Between the two discs are two actuating metal discs held together by springs. Between these two discs are three steel balls located in caps. These discs cannot rotate far because

of blocks in the brake housing.

Some tractors are equipped with combination band and mechanical disc brakes to provide additional braking capacity. Both work at the same time.

The hydraulic disc brake has recently been introduced on tractors. The brake shoes and disc for each brake are enclosed in an oil filled compartment. Oil is supplied from the transmission. This is called a "wet-disc-type" brakes. The hydraulic pump is a type that supplies oil under pressure when needed instead of wasting it through the relief valve.

Procedures for adjusting tractor brakes vary, depending on: (a) The type of brakes used on the tractor, (b) the location of the brakes and (c) the kind of linkage between the pedals and the brakes. The procedures thatfollow are general and will serve for adjusting brakes on most tractors.

Adjusting the Brakes

These procedures are for mechanical brakes only. Hydraulic brakes do not require this kind of adjustment.

1. Check to see what provision is made for brake adjustment. If the brakes are of the band or disc type, they will most likely have a pullrod adjustment. Many band brakes have a lock-nut and yoke adjustment. Shoe brakes have a side internal screw adjustment.
2. Jack up rear of tractor until both rear wheels clear the ground.

3. Release brake locks. Tractors with both brake pedals on the right hand side usually have a lock or latch on the left pedal. When the pedals are fastened together with an interlock, both brakes are locked by the same latch.

4. Complete the preliminary arrangements for adjustment of first brake. If lock is on one brake rather than on both, start with that brake first. It is important that this brake not be adjusted so tightly that it will fail to latch.
   You may need to loosen one (or two) lock nut(s) or remove an adjusting-slot cover.

5. Tighten adjusting screw, adjusting rod or adjusting nut.
   The amount the brakes should be tightened is measured in different ways depending on the type of brakes and the type and make of tractor. In general, a brake is tightened by shortening the linkage between the brake pedal and the brake. It is tightened until there are 1½ to 3 inches of free travel on the brake pedal between its released position and the point where you can feel the brake start to take hold.
   Some tractors with shoe brakes have a clevis adjustment that adjusts the free play of one second or third notch. Don't overtighten. If the brake will not latch in any of the notches it is too tight.
   With a shoe brake tighten the adjustment until you feel a drag when you rotate the tractor wheel by hand. Then back the adjusting screw off until there is little or no drag when you rotate the wheel by hand.

6. Complete re-assembly, or tightening of locknuts, to maintain adjustment.
7. Adjust second brake in the same manner as the first. In adjusting the second brake be sure to adjust it so that it supplies the same amount of free foot-pedal travel as the first. If this is not done, when you press both brakes at the same time, the brake with the tightest adjustment will act first and throw the tractor sideways. This is extremely dangerous at higher operating speeds.
8. Check to make certain that the brakes are equalized. While your tractor is still jacked up check to see if the brakes apply equal pressure both wheels. To do this proceed as follows: (a) latch brake pedals together, (b) start engine, (c) shift into third or fourth gear, (d) engage clutch to start wheels rotating, (e) disengage and shift into neutral, (f) apply brakes and observe if one wheel slows before the other. If so, adjust brakes until the two wheels brake evenly.
9. Lower tractor from jack(s).

ADJUSTING THE ENGINE CLUTCH

You will probably not need to do more than check the clutch to make certain it is in proper adjustment at most of the regular 250 hour service intervals. A clutch will operate for a long period of time without adjustment unless the driver has been operating the tractor with his foot resting on the clutch pedal. This will cause very rapid wear and will require frequent clutch adjustment.

Once the clutch starts to slip, it will wear rapidly. The clutch should be tightened immediately; otherwise, the wear may become so great that you will have to have a service shop reline the facings.

The clutch is a means of disconnecting the engine from its load while starting and idling. It is also a means of gradually loading the engine when the clutch is engaged. From the standpoint of user there are two types of clutches: (1) the foot clutch and (2) the handclutch. The foot clutch is in more general use at the present time.

In a foot clutch power from the engine is applied to the flywheel which is directly connected to the pressure plate. The driven plate which connects to the drive shaft, is clamped securely between the flywheel and the pressure plate, and is held in that position by spring pressure applied by the pressure plate. In the engaged position the clutch assembly rotates as a unit and delivers power through the drive shaft to the transmission. Different makes of clutches call for different clearances, generally between 1/16 and 3/16 inch. As the clutch facings wear, the release fingers move closer to the clutch-release bearing until finally there is no clearance; then adjustment must be made. If the adjustment is neglected and the fingers press continuously on the clutch-release bearing, pressure on the driven plate is reduced and slippage results.

The clutch is disengaged by pressing on the pedal which forces the clutch-release bearing against the release fingers. These in turn pull the pressure plate away from the driven plate so that no further power is supplied to the drive shaft and transmission even though the flywheel and pressure plate assembly still continue to rotate. There is now clearance on each side of the driven plate.

If you are using a hand clutch, the design is somewhat different even though the clutching principle is the same. With a hand clutch, when the lever is moved from engaged to disengaged position or vice versa, it moves easily at first, then resists motion and moves into the opposite position with a definite snapping action. This is called a "toggle effect" and enables you to leave the clutch in that position without having to hold the lever.

When this clutch is properly adjusted, the adjusting yoke must be in the right position to provide the proper over-center action. There is then enough pressure to keep the clutch from slipping and wearing.

These clutches are the dry, single disc type. They are the types most commonly used on tractors. However some tractors use multiple disc clutches which may operate in either an oil bath or as dry clutches. In adjusting any of them the same general procedures are used.

The procedures that follow are necessarily general in nature, since there are many different provisions for clutch adjustment. It is well for you to use your operator's manual. However, these procedures will work with most tractors.

Adjusting Foot-Operated Clutches

1. Determine from your operator's manual how much free travel is needed. Recommendations vary from ½ inch to more than 1½ inches, depending on the make and model of tractor.
2. Check clutch pedal for free travel. Free travel of the clutch pedal is the distance the clutch pedal can be depressed before resistance is noticed. If your tractor has sufficient pedal free travel, omit the remaining steps.

3. Locate means provided for clutch adjustment.

   The adjustment will be some place on the linkage between the pedal and the clutch-release bearing. Types of adjustments include: set screw and lock nut, adjustable yoke and lock nut, slotted lever and adjustable cam and locknut.

4. Adjust linkage until clutch pedal has sufficient free travel.

5. Tighten locknut so that it holds adjustment securely.

Adjusting Hand-Operated Clutches

1. Check clutch-lever action to determine if adjustment is needed. If the lever moves over center in either direction with a definite snap, no further adjustment is needed. If it pushes over center easily or is extra hard to engage, adjustment is needed. The procedure that follows applies to most hand-operated clutches. An exception is the hand clutch used on some John Deere tractors; this is adjusted by removing the pulley cover and, with the clutch engaged, tightening the three clutch nuts equally until proper lever action is secured.

2. Disengage the clutch.

3. Place gear-shift lever in neutral.

4. Remove hand-hole cover on clutch housing. The hand-hole cover is commonly located on the side of the tractor or on the lower side of the clutch housing.

5. Turn clutch by hand until locking mechanism is on side next to hand hole.
6. Loosen lock and tighten collar one notch at a time. Most adjusting collars turn to the right for tightening. However, some are turned to the left for tightening.
7. Check clutch lever for proper operation.
8. Replace lock pin and make certain it is properly seated.
9. Replace hand-hole cover.

CHECKING AND SERVICING OTHER PARTS OF THE TRACTOR

Other points that may require lubrication or checking at the 250 hour service interval are:

1. Starter motor lubrication-8 to 10 drops of oil if there is provision for oiling. Many starters used on tractors are prelubricated at the factory and require no further lubrication until disassembled for repair.
2. Transmission and differential oil level check.
   Your tractor may have provision for checking oil level by means of: (a) a dip stick or (b) oil-level plugs on the side of the gear case. Clean the area around the dip stick or oil-level plugs before removing to keep dirt from entering the gear case. If gear oil is needed, use the type and viscosity recommended for your tractor.

CHAPTER V

MAINTENANCE AFTER 500 HOURS OF OPERATION

Many farm tractors are operated no more than 500 hours per year. For such tractors the 500 hour jobs and yearly jobs can be combined and completed at one time.

SERVICING THE DISTRIBUTOR (SPARK-IGNITION ENGINE)

Servicing the distributor and timing the ignition are usually considered a tune-up job. For that reason many farmers like to include them in 250 hour service jobs when most of the other tune-up work is done.

There are two types of ignition systems used on tractors. They are:

1. Battery-powered ignition system.
2. Magneto-powered system.

Before farm tractors were equipped with starters and lights, magnetos were widely used as a source of power for the ignition system. Some manufacturers still offer magneto equipment instead of battery power if a purchaser wishes to use it, but most all farm tractors sold at the present time are battery powered.

Recommendations on how often to service the distributor vary from 200 hours to as long as 1,000 hours for different makes and models of tractors. Some operator's manuals state that the breaker points should be cleaned and adjusted "when required" or "periodically."

The function of the distributor is so closely tied with spark-plug operation and engine timing that it is usually included as a part of either study. However, it is well known that the distributor must be well maintained for proper spark-plug performance and for full benefits of proper engine timing.

To understand how a battery-powered ignition system works, it is important to realize that the system has only two functions to perform: (1) provide a hot spark at the spark plug- the job of the ignition coil- and (2) time the spark so it occurs at the right instant to ignite the fuel in the cylinder - the job of the distributor. This action is accomplished through two electrical circuits - a primary and secondary.

The primary circuit is supplied with either 6 or 12 volts. When the tractor is operating, the primary circuit is controlled by the opening and closing of the breaker points in the distributor, This motion is supplied by a rotating cam which is geared to the engine cam shaft. At the instant the rubbing block that opens the points is riding the low side of the cam. This permits the breaker points to close. Current then flows from the battery through the primary winding of the ignition coil, to the distributor and to the ground connection where it returns to the battery.

The only reason for this current flow is to energize the ignition coil. The primary winding is wrapped around an iron core in the ignition coil. There are relatively few turns of wire - approximately 250. As soon as current starts flowing through the winding, the iron core becomes an electromagnet that sets up magnetic flux lines around both

the primary and secondary windings. At this point, the cam lobe in the distributor turns enough to open the breaker points and break the primary circuit.

The instant the primary circuit is broken, the magnetic flux lines collapse. In doing so, they cut across several thousand turns of secondary winding in the ignition coil. This induces high voltage (up to 25,000 volts) in the secondary circuit that is needed to jump the spark-plug gap.

It takes only about 1/1,000th of a second to complete the primary and secondary actions.

In the distributor used on 4-cylinder engines there are 4 lobes on the distributor cam and 4 spark plug wire terminals in the distributor cap. While the distributor shaft makes a complete revolution, the breaker points open and close 4 times. The rotor tip has brushed past each of the 4 terminals and each of the plugs has received a spark. Six-cylinder engines require 6 lobes and 6 spark plug wire terminals in the distributor cap.

Maintenance of a distributor requires that you understand about the condenser, the small can-shaped unit that is usually in the same compartment with the breaker points. The ignition system will not function well without it. The reasons for this are (a) when the distributor cam opens the contact points on the primary circuit and the magnetic flux lines collapse, they induce voltage in the primary winding (as well as the secondary) of the ignition coil - as much as 100 to 300 volts. This causes sparking as the breaker points separate and causes them to wear rapidly. The condenser prevents sparking by providing a place where the current can flow until the points are

safely separated (b) the condenser also helps collapse the flux lines more quickly, thus causing a higher secondary voltage.

Checking the Condition of the Distributor

1. Remove dirt from outside surface of distributor and cap.
2. Remove cap and clean inner surfaces. Leave wire connected. Use a clean, dry cloth to remove carbon, dust, moisture or oil deposits. Some distributor caps have small ventilator holes. Check to see that these are open.
3. Check distributor cap for chips or cracks. If cap is cracked, replace it with a new one.
4. Remove distributor arm (rotor) and clean. Check for cracks or excessive burning of the metal strip.
5. Remove dust cover, if one is used, and check condition of felt seal.
6. Check the centrifugal-advance mechanism. Turn distributor shaft in direction of normal rotation. It should rotate freely for a short distance as the weights move outward. It's springs should return it to its original position when released. If it doesn't work properly, have a service man check it.
7. Check condition of breaker points. If the contact points are rough but show only slight pitting and metal deposits, smooth with an ignition file. Blow out the dust after you have completed the filing. If points are badly pitted and worn, replace them with a new set.

   Badly burned points may be due to : (a) oil or foreign material on the contact surfaces, (b) a defective condenser,

(c) a contact-point gap adjustment that is either too wide or too close, or (d) points that are out of alignment. If the condenser is not working properly or is not of the proper capacity for your ignition system, there will be a cone-shaped deposit of metal on one point and a cone shaped pit on the other. Proceed as follows:

a. Check tightness of screw that holds the condenser.

b. If screw is tight, have condenser checked at your service shop.

Replacing Breaker Points

1. Remove breaker arm and spring.

2. Remove stationary breaker point and bracket.

On most distributors one end of the breaker point bracket is held by the same pivot pin that held the breaker arm. The other end is sometimes held by a locking screw. The second screw is for adjusting the position of the points and is an "eccentric screw" or "adjusting screw". On others, the bracket and breaker point are held by one screw. With this type the hole in the bracket is slotted so the breaker point can be adjusted to the proper position.

3. Clean, then lubricate cam with petroleum jelly or multi-purpose grease. Use only enough for a thin film on the cam lobes.

4. Install new points in reverse order. Be sure electrical connections are tight.

Adjusting Breaker Points

1. Turn engine until cam opens breaker points to widest position. If your engine is not provided with a crank, touch the starter lightly until cam is in position, or put the transmission in high gear and rock the tractor with the rear wheel. Some tractors have a slot in the flywheel housing so the flywheel may be moved with a heavy screw driver.
2. Check points for proper spacing. Use a feeler gage of the thickness recommended for your tractor. This may vary from .015 to .026 inch. If adjustment is needed, proceed with step 3.
3. Loosen lock screw on bracket that provides adjustment.
4. Adjust points for proper spacing and alignment. Some distributors provide an eccentric or adjusting screw which opens or closes the gap depending on which way you turn it. Be sure to provide a proper width gap.
   Be sure the breaker-point faces fit together squarely.
5. Lock breaker points in position with lock screw.
6. Recheck gap between points and wipe points clean.

Re-Assembling the Distributor

1. Lubricate wick in center of cam shaft. Use two drops of motor oil.
2. Re-assemble distributor in reverse order from that outlined in "checking the condition of the distributor."
3. Check condition of wires leading to spark plugs and to ignition coil. If these wires have been exposed to oil and grease or to mechanical wear, the insulation may have become defective;

this may allow a voltage leak to ground and cause a weak spark at the spark plug. If insulation is broken or soft, replace with new high tension wire.

TIMING THE IGNITION
(spark-ignition engines)

Installation of new breaker points is almost certain to cause your engine timing to be different than it was with the old points. Timing will also change as the rubbing block wears, as the points burn and as the gap adjustment changes. Consequently, it is good practice to check ignition timing whenever you adjust the old points or install new breaker points.

There are two methods of timing an engine that can be done readily on the farm:

1. The breaker-point method.
2. The timing-light method.

The timing-light method is the better of the two because it is more accurate.

Proper timing means that the ignition is set so the distributor will supply a spark to each cylinder at a time when the fuel will burn with greatest efficiency.

When the timing is too late, the retarded spark causes late firing; exhaust gases escape while they are still quite hot.

When timing is too early, the engine may knock. This too can cause temperature to increase within the cylinder.

A study of 50 farm tractors in Kansas[1] showed that re-timing caused increased horsepower or decreased fuel consumption in 26 cases. After proper setting of the timing, the average horsepower increased 5.3 per cent and average fuel consumption decreased 5.3 per cent.

Timing by the Breaker-Point Method

1. Locate timing marks on flywheel or fan pulley.
2. Loosen or remove spark plug from No. 1 cylinder. Loosen the plug 2 or 3 turns so you can hear air escape past it on the compression stroke. This will help you to tell when the No. 1 cylinder is on the compression stroke.
3. Remove distributor cap.
4. Crank the engine until No. 1 cylinder starts compression stroke. Be certain that ignition switch is off. Watch which way the distributor rotor is turning.
5. Continue to rotate slowly until proper marking appears on flywheel or fan shaft pulley.
6. Remove rotor and dust cap.
7. Note if breaker points are just starting to open. If the breaker points are just starting to open, the timing is satisfactory and you may re-assemble the distributor. Be sure that points are beginning to open rather than beginning to close. Crank the engine and observe if the points continue to close, timing is not correct; proceed with remaining steps.

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[1] Ibid., p. 19

8. Loosen clamps that hold distributor to engine block.
9. Turn the distributor body slowly in the direction the rotor normally turns until the points are completely together.
10. Turn distributor body slowly in opposite direction until points start to open.
11. Tighten clamps that hold distributor body and reassemble distributor.
12. Tighten No. 1 spark plug and attach spark plug wire.
13. Start the engine to see that it operates satisfactory.
14. If you removed a cover from over the timing hole, replace it.

Timing by the Timing-Light Method

1. Locate timing marks on flywheel or fan pulley.
2. Connect timing light as recommended by manufacturer. There are two types of timing lights: (a) those with two wire leads and (b) those with three wire leads. The two-wire type is connected with one lead attached to the spark plug and the other to a good ground connection. The three-wire type has one lead that connects to the spark plug and the other two to the battery terminals.
3. Determine from the operator's manual what timing mark to use with light. At idling speed it is often the TDC marking. When the engine is operating at top speed, the timing is automatically advanced so one of the advance marking will be used.
4. Chalk the timing mark so it is easy to see.
5. Start engine and run at speed recommended in your operator's manual.

6. Direct timing light at marking on the flywheel or on the fan pulley. If correctly timed, the proper timing mark will appear to stand still directly in front of the pointer. If timing mark is on either side of the pointer, proceed with the remaining steps.
7. Loosen clamps that hold distributor.
8. Turn distributor body slightly until timing mark is opposite pointer.
9. Tighten distributor and remove timing light.
10. Replace cover over timing hole if one was removed.

MAINTAINING THE STARTER AND GENERATOR

You may be lubricating your starter and generator at regular intervals but do you have a regular schedule for what little mechanical maintenance is needed? It will save you both time and money compared to waiting until an emergency repair is needed. Operator's manuals usually suggest this type of servicing every 500 hours or yearly.

The starter, sometimes called a "cranking motor" or "starting motor" is usually located on the side of the tractor next to the flywheel housing. On some tractors it is above the flywheel housing between the metal side panels.

Cranking the engine puts a heavy load on the starter, particularly when the crankcase oil is cold. It is designed to handle heavy loads of this type for about 30 seconds, but running the starter without pause will cause overheating and damage.

The generator is belt driven and located at the front of the tractor. Its job is to supply electrical energy while the engine is running for recharging the storage battery and for the ignition, lights

and other electrical needs about the tractor. When the tractor is not running, the battery supplies electrical energy. It operates continuously while the engine is running.

Some tractor manufacturers are installing alternators in place of generators on their tractors. A generator develops direct current which is suitable for direct use by the battery and electrical equipment on the tractor. An alternator develops alternating current which must be "rectified" - changed to direct current - before it can be used. This is done rather simply within the alternator by means of electronic "check valves" called diodes. They allow current to flow one direction but will stop a reverse flow.

Servicing the Starter and Generator

1. Wipe dirt from starter or generator housing.
2. Remove cover band. Some generators have no cover band.
3. Inspect for thrown solder. If a starter or generator has been overheated, you can tell by the ring of solder that has been thrown against the band or the inside of the housing if of the type without a band. If it appears that the starter or generator has been overheated, take it to a service shop.
4. Check brushes for wear and binding action. When checking a brush for wear, do not pull on the wire that connects to the brush while it is being held under spring tension. Remove the tension clip from the brush first. If you are checking a generator, it may have either two or three brushes. If you are checking a starter, it will have four brushes. If

the old brushes are worn to less than half their original length, replace them with new ones.

5. Replace worn brushes. Disconnect the brush wire lead where it fastens to the brush holder, lift brush tension clip remove old brush and slip new one into place. Reconnect wire lead to brush holder.
6. Check brushes for binding action in holder. If brush tends to bind in the brush holder, remove and wipe brush holder with a clean cloth.
7. Check electrical connections for tightness.
8. Inspect commutator for wear and roughness. If the commutator is rough or out-of-round, it will have to be machined smooth by an experienced service man. If the commutator appears to have only dirt and a glaze on the surface, proceed with step 9.
9. Remove dirt and glaze from commutator surface. Use No. 00 sandpaper on a stick with a square end, moving the stick back and forth on the commutator until all gum and dirt have been removed. You can also use a brush-seating stone.
10. Seat new brushes on commutator. If not seated properly continue to use the brush-seating stone on the commutator until the brushes are seated.
11. Blow dust from commutator, brush holders and casing.
12. Replace band.
13. Polarize the generator before starting the engine. If any of the wire leads are disconnected while the starter or

generator were being serviced, polarize the generator. Re-connect the wire and touch a short jumper wire momentarily between the two parts on the regulator marked "BAT" and "GEN" (sometimes marked "ARM"). This establishes correct polarity of the generator.

SERVICING DIESEL ENGINE FUEL FILTER(S)

The service interval for fuel filters on diesel tractors varies from 250 hours to as long as 2,000 hours or more depending on the make and model of tractor, the number of filters used and their size.

Servicing the fuel system of diesel tractor and keeping it free of dirt and water is more important than a gasoline tractor. Because the damage done to a diesel tractor is much more costly to correct. Consequently, this discussion stresses two points: (a) regular servicing of fuel filters and (b) extreme cleanliness.

The sergice life of the injection pump and injector nozzles may be a matter of only a few hours if water and dirt particles are allowed to reach them. This is because the injection pump and the injector nozzle have very finely machined parts - sometimes with clearance as small as 0.0001 to 0.0003 inch. These finely machined parts are necessary to develop and use the high pressure required at the nozzle tips so the engine will operate properly and efficiently.

Since these parts are so delicately machined, some manufacturers will not even let their dealers service either the injectors or the injection pump. They require that these units be sent to the factory or a factory-approved service center where they can be serviced under strictly clean conditions and with precision machines. This means

that the cost of having injectors and injection pump repaired is quite high and could be discouraging to farmers if this type of servicing is required after a few hundred hours of use.

It is not possible to eliminate all moisture and dirt particles from fuel. However, proper handling and proper care in changing filters can reduce dirt and moisture to such a point that your tractor will give thousands of hours of service without repair to the injection pump or the injector bodies.

From the standpoint of a tractor operator there are five parts to the diesel fuel system with some tractors having a sixth. They are:

1. Fuel tank
2. Low-pressure line, where the filters are located
3. Injection pump
4. High-pressure line (on some)
5. Injectors
6. Return-fuel line (on some)

The fuel tank on most farm diesel tractors is located high enough that most, or all, of the low-pressure line can be fed by gravity. Tractors equipped with a transfer pump develop fuel pressures of approximately 12 to 70 pounds on the low-pressure line between the transfer pump and the injection pump.

The fuel filters are located in the low-pressure line. Low-pressure line and the fuel tank are the only parts of the system that require regular servicing which can be done by the operator.

The job of the injection pump is to apply very high pressure to the fuel (2,400 to as high as 20,000 pounds per square inch). This

high pressure is used by the injector nozzles to make a fine mist of the fuel as it is sprayed into the cylinders. This is to provide an immediate and mixture with the air in the cylinder for even burning. The pump is also responsible for timing the injection so that it perform much the same function that the electrical distributor does on a spark-ignition engine.

Some injection pumps consists of a combination injection pump and injector nozzle. With this type, no high-pressure line is needed. Each cylinder has a separate injection with this type of injection pump operated by a rocker arm; so on engine with this type of injection pump there are 3 roker arms per cylinder - two for operating the valves and one to power the injection pump.

Most diesel engines have a return fuel line which returns excess fuel from the injectors or from the injection pump or both, to the fuel tank. Excess fuel helps cool the pump and injectors and helps lubricate them.

Proper servicing calls for attention to the filter(s) on the low-pressure line. You must see that each is serviced regularly and carefully. If there is only one filter, it is all the more important. There are no other filters to help share the job of removing moisture and dirt particles.

Where there are two or three filters, the first-stage filter (sometimes called a primary or auxiliary filter) removes most of the water and coarse material. The second-stage filter (sometimes called an intermediate-stage filter or the final-stage filter if only two are used) removes the finer particles and a small amount of water. If a

third-stage filter is used, it is intended to remove any remaining smaller particles.

Your operator's manual indicates at what service interval the filter should be changed. Your tractor may have special gages connected with the fuel line which show when the filters should be changed.

Changing Fuel Filters

These procedures can be used in replacing fuel filters on almost all farm tractors with replaceable filter elements or for cleaning permanent-type filters. Procedures are the same for the first, second, and third stage filters except some manufacturers use a sealed filter for the third-stage. This is replaced by the dealer, usually at the time the tractor is overhauled. The first-stage filter needs rather frequent replacing or cleaning. However, the second stage filter can be used for much longer intervals than the first stage before it requires servicing.

1. Turn off supply at tank.
2. Clean outside of filter body and engine area around filter. Use a cloth and diesel fuel to remove dirt, then wipe the cleaned area dry with a clean cloth.
3. Drain fuel from filter. Most filters have a drain cock at the base or a plug. Catch the fuel in a pan.
4. Remove old filter. Most filter bowls are held in place with a stud bolt, or in case of an edge-type filter, with three or four stud bolts.
5. Clean inside of filter bowl (unless it is a self-contained type). If you use a cloth, be sure it is lint free and clean.

6. Re-install cleaned filter element. New gaskets are usually supplied with replaceable filter elements. Be sure to use new gaskets if they are available. If not, examine old gaskets to make certain they are not hardened, stretched or otherwise damaged.
7. Complete the filter assembly and tighten it.
8. Replace the drain plug or tighten the drain valve.

Bleeding Fuel Lines

Each time the filters are drained and new filter elements installed, considerable air is left in the filter body and fuel line. If the air is left in the line, it may form an air lock when you try to start the engine. This will prevent a normal supply of fuel from reaching the injector pump. Your engine may not start; or it may not fire properly and may develop very little power. It is important to remove the air before you attempt to start the engine.

Procedures are the same for the first, second, or third-stage filters except noted under each step. If you have changed more than one filter, bleed the one closest to the fuel tank first.

1. Open bleed valve on top of filter. This may be a plug instead of a valve. If you have changed the first-stage filter, open that bleed valve only.
2. Open fuel tank valve.

   This will force the air out through the bleed valve and replace the air space with fuel. Some tractors are equipped with a handprime pump to be used in removing air.

   If a transfer pump is located between the fuel tank and the

filter you are bleeding, you will probably find a bypass line and valve. By opening the valve, fuel bypasses the pump so air can be bled out of the filter.

3. Close bleed valve.

SERVICING FRONT-WHEEL BEARINGS

The service intervals for front-wheel bearings as indicated in most tractor operator's manuals, vary from 500 to 1,200 hours of operation or yearly. The wheel-bearing service interval has been gradually lengthened as manufacturers have found better methods of protecting the bearing from dirt and water.

The front-wheel bearings on most tractors are packed with grease at the time of servicing; they receive no further attention for several months or a year. However, on some tractors there is a grease fitting for gun lubrication. This type is usually greased daily or twice a day. As new clean grease is added, old grease works out around the dust seal and helps remove dirt. These bearings must be taken apart, cleaned and repacked about once a year.

The following procedures are for tractors with two front wheels. If your tractor is equipped with a single front wheel, check your operator's manual.

Disassembling the Front-Wheel Bearing

1. Raise front wheels off the ground.

   Be sure your tractor is in gear or block the rear wheels so it won't move forward or backward.

2. Clean dirt from wheel and hub cap and remove hub cap.

   Most hub caps are either threaded and screwed on the hub or are held in place with three stud bolts.

3. Remove cotter pin and adjust nut. Use diagonal pliers for straightening cotter pin and for removing it. Lay other parts on a clean cloth or in a clean pan.
4. Remove thrust washer and out bearing. If the washer and outer bearing aren't loose, shake the wheel gently to dislodge them.
5. Pull wheel off the spindle. On some tractors the grease-seal retainer is pressed into the hub and holds the rollers and inner cone in position. With this type the bearing and seal will come off with the wheel and remain in the hub until tapped out. On the other tractors the grease-seal retainer remains on the spindle when the wheel is removed, which leaves the inner-bearing cone free to either come off with the wheel or remain on the spindle.
6. If the inner bearing remained in the hub, remove it. If the grease-seal retainer is not pressed into the hub, you can remove the bearing with your fingers. If the grease-seal retainer is pressed into the hub, you can remove it and the bearing by tapping the bearing cone gently.

Cleaning the Front-Wheel Bearings

1. Wash bearings thoroughly. "Swish" the bearing in the cleaning solution (derosene or diesel) and use a stiff brush to help loosen old grease deposits.
2. Remove solvent from bearings and other washed parts. If dry compressed air is available, it may be used to drying

the bearing but hold the bearing cone so the air blast won't spin it. Drying with a clean, dry cloth is satisfactory.

3. Examine bearings for wear. If there is evidence of much wear or corrosion, replace both parts of bearing.
4. Examine grease-retainer ring and seal. Replace if damaged.
5. Clean hub, hub cap and spindle with solvent.

Packing and Assembling the Front-Wheel Bearings

1. Pack each bearing with grease. It is important that all parts of the bearing receive grease. Use multi-purpose grease.
2. Replace inner bearing and grease-retainer seal if removed originally.
3. Coat spindle and inside of hub with grease.
4. Position wheel on spindle and install outer bearing.
5. Install thrust washer and slotted adjusting nut.
6. Turn wheel and tighten slotted adjusting nut until wheel "drags", then loosen. Loosen the nut until the nearest slot (castelation) is aligned with the hole in the spindle. Some manufacturers recommend loosening the nut as much as 1/16 to 1/3 turn.
7. Lock nut with cotter pin. Use a new cotter pin if available.
8. Replace hub cap.

MAINTAINING THE COOLING SYSTEM

Your tractor cooling system requires very little maintenance provided you give it regular care. Recommended maintenance intervals vary from 400 hours of operation to once a year.

The cooling system has the job of absorbing approximately 1.3 of the heat energy developed by tractor fuel. Anything that slows down the movement of heat from the cylinders to the cooling system, increases the tendency of your engine to overheat. When it overheats, you are likely to have such troubles as: sticking and burned valves, a cracked engine head or block, or excessive knock.

Flushing or Cleaning the Cooling System

If you are using one of the commercial flushing or cleaning compounds, follow the dirrections on the container.

1. Read the instructions on the container.
   (a) if cleaner or flushing compound may be added to present coolant, proceed with step 2.
   (b) If present coolant should be replaced with water, proceed with the following sub-steps.
      1) Run engine until thoroughly warmed. If the engine is warmed enough, the thermostat valve is open and will allow more complete drainage.
      2) Completely drain cooling system while the engine is still warm.
      3) Close drain cocks.
      4) Refill cooling system with water. If engine is hot, allow it to cool.
2. Add flush compound or cleaner.
3. Start engine and operate until normal operating temperature is reached. Cover the radiator so the engine will heat quickly and completely.

4. Check external condition of cooling system.
5. Completely drain cooling system.
6. (If you used an acid-base cleaner, be sure to use a neutralizer).
   (a) Add neutralizer provided and fill cooling system.
   (b) Run engine about 10 minutes, then drain.
   (c) Flush cooling system with water.
7. Refill with coolant.
   Use clean soft water and a rust inhibitor; or new antifreeze solution with soft water.

CHAPTER VI

MAINTENANCE AFTER A YEAR OF OPERATION

CLEANING THE TRACTOR

From a farmer's standpoint, the following are reasons that help justify regular cleaning of the tractor.

1. It reflects good management, adequate servicing and pride.
2. Helps protect paint and parts that are affected by tractor dirt.
3. There is less chance for dirt to enter the air-cleaner oil cup, fuel filters, cylinders, etc.
4. Cleaning helps reveal leaks in the cooling system, cracks in the distributor cover or loose parts about the tractor.
5. Safety is improved.

Cleaning the Tractor

There are two ways of cleaning the tractor on the farm. You can use: (1) a commercial solvent usually called a "de-greaser" or (2) kerosene or diesel fuel.

If you are using a de-greaser, check the instructions on the can.

The procedure for using de-greaser, diesel fuel or kerosene are as follows:

1. Allow tractor to cool, if it has been running.
2. Remove hood and side panels if necessary to reach accumulated dirt.
3. Use a putty knife to remove heavy accumulations of grease and grime.

4. Apply solvent on areas that need cleaning.
5. Let solvent set approximately 15 minutes.
6. Remove solvent from engine surface. Use a strong stream of water. If you use kerosene or diesel fuel, remove it with a strong soap solution. Flush with water.
7. Check for areas that have been missed.
8. Replace hood and panels that were removed originally.
9. Idle engine for 10 or 15 minutes for quick drying.

SERVICING THE OIL-BATH AIR-CLEANER ASSEMBLY

Besides daily servicing of the air-cleaner oil cup, most tractor companies recommend that you clean the entire air filter assembly occasionally.

The reason for occasional cleaning of the air-cleaner assembly is to remove dirt that collects in the center tube of the air cleaner and in the lower part of the filter element.

A Kansas study of 50 tractors[1] showed that 5 were in need of air-cleaner service. After servicing, fuel consumption decreased from 4.6 per cent to as much as 22.5 per cent. The average decrease for all 5 tractors was 11.4 per cent. At the same time horsepower was increased from 1 per cent to as much as 27 per cent; the average increase for all 5 tractors was 7.6 per cent.

Cleaning the Air Cleaner Assembly

1. Remove oil cup and screen tray. Some air cleaners have no screen tray.

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[1] Ibid, P. 13

2. Inspect center tube and lower filter element.

   If both the center tube and lower filter appear dirty, remove the complete filter body for adequate cleaning. If the center tube and lower filter appear clean, omit steps 4, 5, and 6.

3. Remove dirt from center pipe. Use a lintless cloth soaked with diesel fuel or kerosene and push it through the center tube with a stick.

4. Clean dirt from lower filter. On most air cleaners the lower filter can be removed for cleaning. Wash the mesh in kerosene or diesel fuel.

   If the filtering element is held in place permanently by spot welding or other means, flush the cleaning solvent through the mesh.

5. Clean shell and upper metal-wool filter.

6. Drain filter body and screen for several minutes.

7. Clean the screened air intake, cap or pre-cleaner.

8. Re-assemble filter parts. When assembling, be sure all connections are tight and any worn or damaged hoses or gaskets replaced.

SERVICING THE DRIVE MECHANISM

Most operator's manuals recommend draining and refilling the transmission once a year. However some suggest 6 months, others 500 hours and occasionally no recommended time is given.

The parts included in the drive mechanism of a tractor are a clutch, transmission, differential and power take-off. Some also include a belt-pulley drive and some a hydraulic system.

Most of the lubrication for gears and bearings in the drive mechanism, comes from the lower gears rotating in the oil supply. As the lower gears mesh with the upper ones, they transfer a film of oil to the upper gears and bearings.

If the changing of oil in the drive mechanism is put off, the bearings and gears in the drive mechanism often reach advanced stages of wear before a farmer realizes anything is wrong. This means an expensive repair job.

Servicing the Drive Mechanism

The procedures that follow are general in nature and satisfactory for servicing most tractors. However, there are enough variations among tractors and recommended procedures for servicing that is important for you to look over the instructions for your make and model of tractor.

To complete the lubrication of the drive mechanism of some tractors it is necessary to repack the rear-wheel bearings in a manner similar to that for repacking front wheels. Most tractors the drive mechanism lubrication is completed with the changing of gear oil in each compartment.

1. Drive tractor until gear oil is thoroughly heated.
2. Locate tractor on a level surface.
3. Remove drain plug(s) and clean if of magnetic type. If you have enough containers, all compartments can be drained at the same time. Most large compartments have at least two drain plugs.
4. (Replace transmission oil filter, if your tractor has one.)

5. Replace drain plug(s).
6. (Flush gear case(s) with flushing oil, diesel fuel or kerosene). If your operator's manual recommends flushing, the following are general procedures:
    1. Add flushing oil, kerosene or diesel fuel as indicated in your operator's manual.
    2. Drive tractor for several minutes. Don't try to pull a load.
    3. Drain, allowing plenty of time for flushing fluid to drain out.
    4. Replace drain plug(s).
7. Clean filler plug and surrounding area.
8. Refill with proper gear lubricant. Use the grade and type recommended for your tractor.
9. Replace filler plug(s).
10. Clean breather(s).

    All gear cases are equipped with breathers. They may be the same type used for crankcase breathers. Service in the same manner as the crankcase breather.

SERVICING THE HYDRAULIC SYSTEM(S)

The tractor hydraulic system may consist of the implement control only, or the hydraulic-steering system only, or both.

With any hydraulic system the problem of contamination is the same as the gear-drive mechanism - that of field dust, rust particles, moisture from condensation and metal particles. The working parts of the hydraulic system are finely machined so that contaminants of

this type seriously damage the surfaces of the working parts which leads to leaks in the system, improper operation and finally to failure.

The make-up of the hydraulic system varies with different makes and models of tractors. The system(s) may be any one of the following:

1. Hydraulic implement control only.
2. Hydraulic steering only.
3. Hydraulic implement control and hydraulic steering as two independent units.
4. Hydraulic implement control and hydraulic steering combined into one system; also, hydraulic brakes when used.

Servicing the Hydraulic Implement-Control System

Be sure to check your operator's manual for specific directions. Recommendations vary rather widely as to the procedures for servicing the hydraulic system. particularly regarding the matter of flushing and cleaning of the screen or filter. In general the procedures are as follows:

1. Position lower links to lowest position. With single-acting cylinders this will force most of the oil out of the cylinder.
2. Remove drain plug and drain oil.
3. Run engine briefly to remove oil from pump. Do this after the oil has stopped draining from the reservoir.
4. Remove filter cover and filter element or screen. The procedure is the same as when replacing the crankcase-oil filter.

5. Clean filter housing and screen.
6. Install filter and re-assemble.
7. Re-install drain plug.
8. (Flush the hydraulic system.)

   Some manufacturers recommend strongly against flushing. Others recommend flushing with hydraulic oil. Still others recommend flushing with diesel fuel or kerosene.
9. Thoroughly clean area around filler plug or plate.
10. Remove plate or plug and add the proper type of hydraulic oil.
11. Start engine and operate lift through several cycles. This helps to assure that all air has been removed from the system.
12. Recheck oil level and add oil if necessary.
13. Replace plate or filler plug.
14. Clean hydraulic breather. Use the same procedure as for crankcase breather.

Servicing the Hydraulic-Steering System

If your hydraulic system is supplied with oil from the same pump that supplies the implement control, your steering system has already been serviced.

If the hydraulic system is independent of the implement-control system, most manufacturers recommend that it be drained without flushing. However, some recommend against draining. General procedures are as follows:

1. Remove drain plug and drain system.
2. Start engine and turn steering wheel right and left several

times until remaining oil drains.

3. Clean top of reservoir cover thoroughly.
4. Remove cover and filter element.
5. Clean reusable filter or replace the replaceable type.
6. Thoroughly clean reservoir interior with a lint-free cloth.
7. Check gasket and replace if necessary.
8. Re-assemble filter and cover.
9. Refill hydraulic system.
10. Start engine and turn steering wheel from one extreme to the other several times.
11. Check oil level and fill if necessary.

PREPARING THE TRACTOR FOR STORAGE

If the tractor is to be idle for an extended period of time, it should be properly prepared for storage. Select a dry and protected place where it is exposed to neither the weather nor the livestock.

The following procedure has been outlined for the purpose of keeping a new tractor in working condition for many seasons:

1. Thoroughly wash and clean tractor.
2. Remove all rust spots with sandpaper and retouch with the proper color enamel.
3. Remove air cleaner bowl, then clean it and refill cup with new oil and reinstall.
4. Lubricate all pressure fittings. Drain crankcase and remove oil filter element.
5. Install new oil filter element and refill crankcase with recommended grade of oil.

6. Drain transmission, clean plugs and refill with proper grade of new oil.
7. Clean and repack front wheel bearings.
8. Check oil level in steering gear housing.
9. Remove and replace power steering oil filter element (if tractor is with power steering).
10. Drain the fuel tank.
11. (Gasoline tractors only)
    a. Replace dry filter element in air cleaner.
    b. Drain sediment bowl and carburetor, also clean fuel filter.
    c. Remove spark plugs and pour two tablespoons of heavy lubricating oil into each cylinder top.
    d. Turn engine over several revolutions before replacing spark plugs, using crank or starter.
12. (Diesel tractors only)
    a. Drain sediment bowl and primary fuel filter.
    b. Add two gallons of rust proof oil, manufactured especially for diesel engines, to fuel tank.
    c. "Air Bleed" the fuel system.
    d. Start the tractor engine and allow it to run for 15 minutes at a fast idle to insure the rust inhibitor is in the entire fuel system.
13. Drain the cooling system and wash and flush it out with washing soda and water. Refill cooling system with anti-freeze solution.

14. Cover the ends of the exhaust pipe and breather pipe.
15. Remove, inspect and condition the battery as required, then store in a cool place. Keep the battery in a fully charged state. Inspect every two weeks to assure charge is correct.
16. Jack up the tractor and put on sturdy blocks to remove weight from all tires.
17. Inspect the tractor for worn or damaged parts which later may cause costly breakdowns.
18. Cover tractor with tarpariin for protection.

Removing Tractor from Storage:

1. Install the fully charged battery making sure the proper connections are made. The battery is negative-grounded.
2. Fill the cooling system with proper collant.
3. Fill the fuel tank with clean fuel.
4. Check the oil level in the crankcase, transmission and air cleaner.
5. Remove the covering trom the exhaust and breather pipes.
6. Inspect and tighten all the nuts, bolts, and screws.
7. Lubricate all fitting if not lubricated prior to storage.
8. Diesel tractors only - "Air bleed" the fuel system.
9. Start the tractor engine and allow it to operate at a fast idle for 10 to 15 minutes. Note all the instruments, particularly the oil guage to be sure the engine is receiving proper lubrication.
10. Drive the tractor without load and at slow speeds noting the instruments and general operation.

CHAPTER VII

MAINTENANCE OF TRACTOR IMPLEMENTS AND OTHER MACHINERY ON THE FARM

Over the years, capacities of farm implements to do work have been increased by using wider cuts or swoths, by performing several operations at once, or by operating at higher speeds. They have become at the same time more complex pieces of machinery, costing larger sums of money but returning even more than they cost. But for higher return they need proper handling and good maintenance.

With good maintenance you can reduce wear and the cost of repair service; and the rate of depreciation can be slowed down. Also machines kept in good condition do better work. You will lose money-or your costs per bushel will go up - when you use a planter or a drill that has not been properly repaired and adjusted.

Keep equipment in shape. Tightening chains and belts, sharpening cutting edges, and making other necessary adjustments assure you that machines run with least power requirements possible. Keeping machinery adjusted also helps prevent breakdowns.

MAINTENANCE OF MOLDBOARD PLOW

The modern tractor plow is one of the most important items of farm equipment. When we consider the work the plow does - cutting, lifting, turning, and fracturing tons of soil, burying surface trash deeply and completely - it becomes apparent that time well spend in acquainting ourselves with its operation, care, and adjustment.

1. Always lubricate the plow thoroughly before taking it to the field. Use pressure lubricating gun.

   Be sure all fittings are free from dirt and pait so the lubricant is certain to enter the bearing.

   Always force the lubricant through the full length of each bearing until it emerges at the end, carrying with it the worn lubricant and any dirt that may have entered the bearing.
2. When starting to plow with a new plow or one which has been stored, check to see that all bolts and set screws are tight and all casters spread to keep them from falling out. A good practice is to check for loose bolts, screws and adjustment of parts when lubricating the machine.
3. Check and oil weekly, oil trip parts to insure freedom; if rusted apply penetrating oil.
4. Repack coulter and wheel bearings with grease every year.
5. Check and maintain air pressure in tires, every two or three weeks.
6. Apply a light coating of oil on the bright surfaces of the plow bottoms, coulters and jointers whenever the plow is not in use.
7. Keep all the parts adjusted according to the operator's manual.

MAINTENANCE OF DISK PLOW

Disk plows are used in those territories where soil conditions are such that moldboard plows will not operate to the best advantage. Disk plows work well in soil so dry and hard that moldboard plows cannot penetrate, and in sticky soils.

1. Protect the face of the disks and scrapers from rust between plowing seasons or intermittent plowing periods by greasing the polished surface with a coat of grease or hard oil.
2. Repack wheel bearing with grease and check washers each year.
3. The disk bearings should be greased before operating. Grease twice daily through the grease fitting on the bearing.
4. Tighten all nuts, inspect periodically and replace bent bolts or bolts with stripped threads.
5. Keep the tractor tires inflated according to instructions given in your operator's manual for use with disk plow.
6. Keep all the parts properly adjusted.

MAINTENANCE OF HARROWS

Harrows are used for the preparation of refined seedbed.

1. Lubricate regularly the disk harrow bearings. Some disk harrows are equipped with sealed permanently lubricated bearings. They need no lubrication.
2. Keep the cutting edges sharp in all types of harrows. If the points are replaceable, replace when worn with new points.
3. Keep the polished surfaces lubricated when not in use.
4. Check periodically and keep all the bolts tight.
5. Keep all parts adjusted properly.
6. Use tractor wheel weights with disk harrows if recommended.

MAINTENANCE OF GRAIN DRILLS AND ROW-CROP PLANTERS

There are several kinds of drills. Drills equipped for seeding small grain or beans are called plaindrills. When fertilizer or grass

seeding attachments are used, they are called fertilizer grain drills or combination drills. This type of drill completes four operations at once. It pulverizes the soil, plants seed, distributes fertilizer, and covers both.

1. Keep disk bearings well lubricated. Disk bearings must be kept lubricated and dust free. This is difficult because the bearings are working so close to soil. It is important to watch the bearing seals. Make sure they are tight. Lubricate the bearings frequently. Before putting a drill in use, examine the disk bearings. They may need to be removed and cleaned. Make sure the bearings are taking lubricant.
2. Lubricate daily with grease all grease fittings, cross shaft idlers, seed and agitator cranks, press wheels, and depth and press wheel cranks (if equipped with press wheels.)
3. Oil clutch shaft bearings and chain tighteners.
4. Be sure to keep tires inflated to the recommended pressure. Low pressures reduces the "rolling radius" at the wheel. This can cause inaccurate seeding because grain drills are ground driven from the wheels.
5. Before a grain drill or a row crop planter is put into use, inspect carefully for broken or worn parts, replace if necessary. Keep all the parts tight.
6. If some parts are enclosed in housings and operate in a constant bath of oil inside the gear case, inspect the oil level occasionally, and if low, add sifficient new oil

to fill gear case to proper level. Before the planting season opens, remove drain plug, drain old oil, and flush out with kerosene. Refill housing to proper level with clean oil.

7. Inspect the seed dropping mechanism regularly for clogging and proper functioning.
8. Adjustment of the parts is very important in drills and planters. Seed should be deposited by the machines at proper depth, distance and at right rate. Adjust parts, that need adjustment, before every use according to the recommendations in your operator's manual.
9. The drill or the planter should be cleaned, lubricated, and put in condition for the next season's seeding before it is stored. All seed should be cleaned out, the disks or other opener surfaces cleaned and oiled, and the machine put under shelter.

MAINTENANCE OF CULTIVATORS AND FIELD TILLERS

Like all farm implements, the length of life and the satisfaction given by cultivators and field tillers depend upon the way they are handled and the care given them during operation and storage.

1. Keep shovels and sweeps sharp all the time, with their points properly shaped. A dull shovel will not penetrate easily; it does poor work and causes heavier draft. If the points are too badly worn, new shovels or new points (for the slip point type of shovel) should be obtained. If the shovels have become rusted and pitted between seasons, they should be polished before being taken into the field.

2. Keep all nuts and bolts tight and all the parts well adjusted.
3. Lubricate polished surfaces of the shovels when not in use.
4. Grease the guage wheel bearings daily.

MAINTENANCE OF MOWERS

Mowers require considerable attention and care when at work.

1. See that all moving parts work freely before putting the machine to work. Keep all nuts tight.
2. Use plenty of good grade oil, and never let wearing surfaces become dry. Grease all grease fitting daily.
3. Keep oil level up to the mark in enclosed drive mechanism housing.
4. Be sure mower is correctly attached to the tractor. Check levers and controls often to see that they operate properly.
5. Be sure rubber tires are properly inflated.
6. When moving from one field to another, the cutter bar must be placed in transport position. Be sure power take-off of tractor is disengaged when raising cutter bar by hand.
7. Keep knife sharpened and properly adjusted for clean cutting. Replace knife when worn.
8. Store the mower in a dry place. Clean off all dirt, tighten loose bolts, grease bar and replace worn parts. Take off load of mower off the caster wheel rubber tire or remove it. Do not deflate tire.

MAINTENANCE OF A.C. ELECTRIC MOTORS

1. Proper care of the bearings: There are two tupes of bearings used on motors: (1) sleeve bearings, and (2) ball bearings.

Sleeve bearings should be lubricated with a light grade of machine oil. Avoid the use of lubricants containing animal or vegetable oils. If there is an overflow hole in the oil reservoir, it should be cleaned out each time the motor is oiled. Good bearing care means more than just oiling. It means keeping dirt out of them and it means avoiding unnecessary strains on the bearing materials.

Another thing you should notice on motors with sleeve bearings is the direction of pull of the belt. Motors should not be mounted so that the belt pulls the motor shaft against the window in the bearing. This causes the greatest bearing pressure where the bearing has the least area and interferes with the flow of oil through the window.

Ball bearing motors are more expensive than those with sleeve bearings, but they do not require the care needed by motors with sleeve bearings. Belts can pull on ball bearing in all directions and the motor can be mounted in any position. Bearings which are not pre-lubricated and sealed in manufacturing can be relubricated either by disassembling the motor or through lubrication openings. Clean disassembled bearing, and use the grease that is recommended.

2. Keep the motor clean, dry, and well ventilated. It is extremely important. Where dust and dirt accumulate rapidly, such as around a feed mill or a saw, the area around the motor should be cleaned regularly. The motor should be brushed off or vacummed occasionally. Special attention

should be given to cleaning round the air vents through which the motor breathes. No definite schedule can be set for cleaning inside of a motor, but close inspection will usually show when it is needed.

Dry-clean the inside of motor with rags or a dry cleaning brush. It should be possible to get most of the dirt in this way. If not, wash the metal parts in a cleaning solution. Do not apply cleaning solution to any wires or windings and do not scrape them. Be sure that all the air passages in the frame and through the rotor are clean.

3. Overload protection.

Overloading which causes motors to drain excessive current and overheating of motor. With overheating the insulation deteriorates and the motor burns out. Time delay fuses are available that will allow current to flow at several times their rating for a short period but will open the circuit if the high current continues for a dangerous length of time. Special motor switches incorporate the same kind of time delay and are available in amperage ratings to fit every motor need.

Use delay fuse or switch according to your motor's need.

SUMMARY

As the mechanization is increasing in Pakistan, because of the Governments effort and farmers need for quick tillage after harvest, intensive agriculture, and for bringing more land under cultivation, it is now necessary that the farmers know the proper use, care, and maintenance of the machinery they are using on their farms.

In Pakistan machinery costs more than in the United States also the repair cost is relatively higher. To avoid costly breakdowns and to save money, it is necessary to do all maintenance jobs properly and regularly. The maintenance jobs are easy to do and they require simple tools and an understanding of what is to be accomplished.

Few farmers have a real plan or system for doing the maintenance jobs. They may be fairly regular with the daily or weekly jobs, but they tend to do the others when the "have time" or when the "feel" they need to be done.

Servicing tractor on a regular schedule, is a matter of: (1) keeping a fairly accurate record of the tractor's operating time and (2) seeing to it that the service jobs are done on schedule. After setting up operating records, the service intervals recommended in the operator's manual for doing the various jobs should be used.

All the instructions about care and maintenance are given in the operator's manuals, but information has been summarized in this report to help the farmers understand their manuals and to use it more effectively.

For tractors all the different operator's manuals recommend different service intervals for different makes and models. The service intervals used in this report are 50, 100, 250, 500 hours and yearly.

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FARM MACHINERY MAINTENANCE PROGRAM FOR PAKISTAN

by

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The total land area of Pakistan is 234 million acres of which only 64.3 million acres are available for cultivation. Out of the area available for cultivation only 54.6 million acres are sown. As 10 million acres are sown more than once a year, the total cropped area amounts to about 64.6 million acres.

In many parts of East Pakistan, it is possible to raise two, and even three crops on same land during a year, provided that in addition to the availability of water, facilities exist for quick tillage of the land immediately after harvest. Intensive agriculture in West Pakistan also require quick plowing where irrigation facilities are avilable. In addition, development of new areas for cultivation, requires mechanized leveling and tillage.

During the Third Plan (1965-70), the number of tractors will be increased. Requirements of wheel type tractors by private individuals will be met increasingly by local manufacturers. An assembling plant has been set up that will be completely converted eventually to domestic manufacturing.

As the machinery is increasing at the farm in Pakistan, there is a need that the farmer should know proper care and maintenance of machinery to get the most out of it.

This program is prepared to teach the farmers the importance of maintenance and how to do it. The program will include teaching, distribution of printed material, demonstration, motion pictures, and programs on radio. These projects will be carried out by Agricultural Colleges, Farm Machinery Dealers, Agricultural Extension Department, and Agricultural Engineering - Agriculture Department.

The maintenance of farm machinery is divided in to tractor maintenance and tractor implements. The tractor maintenance include maintenance after 50, 100, 250, 500 hours and one year of operation.

The following maintenance jobs are commonly recommended to be done "every 50 hours" or "weekly". (Some newer model tractors are recommending longer intervals for these jobs - as long as 200 hours):

1. Maintaining the battery.
2. Checking and adjusting V-belt tension.
3. Lubricating the clutch-release mechanism.
4. Maintaining the hydraulic system oil level.
5. Servicing the dry-type air cleaner.
6. Checking and servicing other parts of the tractor.

The 100 hour maintenance jobs included are:

1. Changing crankcase oil.
2. Replacing the oil filter.
3. Servicing the crankcase breather.
4. Maintaining tractor tires.
5. Checking and servicing other parts of the tractor.

The 250 hour service period includes most of the jobs considered necessary for a tractor tune-up. If they are done regularly, they help keep down the maintenance costs. They are:

1. Making valve-clearance adjustments.
2. Maintaining tractor spark plugs.
3. Cleaning the battery.
4. Cleaning the sediment bowl and filter.
5. Adjusting the carburetor.
6. Adjusting the tractor brakes.

7. Adjusting the tractor engine clutch.

8. Checking and servicing other parts of the tractor.

Many farm tractors are operated no more than 500 hours per year. For such tractors the 500-hour jobs and yearly jobs can be combined and completed at one time.

Jobs included as part of the 500-hour maintenance program include the following:

1. Servicing the distributor.

2. Timing the ignition.

3. Maintaining the starter and generator.

4. Servicing diesel-engine fuel filters.

5. Servicing front-wheel bearings.

6. Maintaining the cooling system.

The yearly maintenance jobs are probably the most neglected of all. Some farmers never get around to doing them. Some do part or all of the jobs every few years when they feel these items have been neglected long enough. Included in this group of jobs are:

1. Cleaning the tractor.

2. Servicing the air-cleaner assembly.

3. Servicing the drive mechanism.

4. Servicing the hydraulic system(s).

5. Preparing the tractor for storage.

In maintenance of tractor implements and other machinery, it is important to keep all bolts and nuts tight all the time. Keep cutting edges sharp, and all the parts well adjusted. Clean and lubricate the implement and apply lubricant on polished surfaces, when storing for few months or longer.