INSTRUCTIONAL PROGRAM IN TRACTOR MAINTENANCE AND OPERATION FOR AFGHANISTAN

by

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CHAPTER I

IDENTIFICATION OF INSTRUCTIONAL PROGRAM

INTRODUCTION

Afghanistan is located in the northern hemisphere. It lies in the north subtropic zone, between 29 degrees, 21 minutes and 38 degrees, 30 minutes north latitude and between 60 degrees, 31 minutes and 75 degrees east longitude.

The total area of the country is 700,000 square Km., which is larger than France and pre-war Germany, or about the size of the state of Texas. The population is about 17,880,000. The majority of the people live in fertile valleys.

Afghanistan is bounded on the north by the Union of Soviet Socialist Republics (Turkmanistan, Uzbekistan and Tajikistan); on the west by Iran, on the south and east by Pakistan. In the northeast, the elongated narrow strip of Wakkan is bounded by China Jammu and Kashmir and Russia. The country has some 9,195 Kilometers (3,500 miles) of border but no sea coast. Kabul, the nation's capital with 350,000 population, lies 1,830 meters (6,000 feet) above sea level, within sight of the towering Hindukush some 62 Kilometers (fifty miles) to the north. Here the Loghar river, after winding its way nearly a hundred miles northward through its crop-rich valley, joins the Kabul river which begins a rocky descent southeast to the Khyber pass 242 Kilometers (150 miles) away.

Afghanistan has great variations in temperature, the highest recorded being 128°F. (in Afghan Turkestan) and lowest -15°F. (in the Hindukush). At

Kabul the average temperature is 32°F. in January and 72°F. in July. Days are usually clear and nights cool or cold. The country's annual average rainfall is 15 inches. In the mountains, most of the precipitation falls as snow. The rainy season is between October and April, except in the south-eastern mountains where weak penetration of the Indian summer monsoon brings heavy rains for a few days in July or August.

Irrigated agriculture is the mainstay of the Afghan economy. More than 85 percent of the population obtain their living from agriculture. The major part of Afghanistan is mountainous and unsuited for crop cultivation. The potential cultivable areas are estimated to be 14 million hectares--only 22 percent of the total area of Afghanistan, and of this, 5.3 million hectares are presently under irrigation.

Agricultural mechanization is increasing in Afghanistan and every year about one hundred new tractors are being imported and given to the farmer. Last year 152 new tractors were distributed to the farmers by the Agricultural Bank under long term loans as a result of governmental efforts and the farmer's need for rapid tillage. Intensive agricultural cultivation is used and a multi-cropping system is used each year. It is not only necessary to increase the use of machinery for improvement of agriculture but it is also necessary to maintain the machinery which is being used at the present. A machine can give full service for a longer period of time, and at less cost if it is maintained as recommended by the manufacturer.

In Afghanistan usually the maintenance of machinery is neglected. At the government farms no one feels personally responsible for the machinery because no one is the owner. On private farms farmers do not maintain their machinery properly because:

1. Most farmers do not understand an operator's manual, because it is always written in English.

2. Most operators do not understand machinery well, because they never had experience with the operation of machines.

3. Some farmers neglected maintenance because they do not understand the importance of it.

4. Most farmers do not operate the machinery themselves. They hire operators, who are usually illiterate and not interested in proper maintenance.

5. Most farmers do not understand the importance of keeping adequate maintenance records.

6. Most farmers usually do not have their tractors periodically checked by a qualified mechanic unless it becomes inoperative.

There are other reasons also for poor maintenance in Afghanistan but usually it is because the farmers do not feel it necessary. This feeling often results in more breakdowns and it costs more money and time because the repair shops are scarce and are often located a long distance from the farmer. Even if the farmer takes the tractor to the auto mechanic, there is not enough information on how to do the repairs. Moreover, spare parts and repairs cost more. Machinery maintenance practices are easy, save money, and avoid costly breakdowns. Good tractor maintenance practices help maintain the horsepower that the tractor was designed to develop.

The life and service given by a tractor is dependent largely upon the care and treatment accorded it by the operator. Proper tractor maintenance and 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 form should be made. With this type of check-off record, one is reminded of both the daily service jobs and the jobs that come at longer intervals.

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 and how to perform it, information has been summarized in this study.

Tractors are becoming more and more a source of power on the farms of today; their operation and repair are important problems that confront the farmers. Present and prospective farmers working in agricultural experimental stations will be enrolled in agricultural mechanics courses.

It was with the above thought in mind that this study was undertaken. The writer has attempted to determine the extent to which tractor maintenance and operation is important for agricultural mechanization classes in Afghanistan.

This study was developed on the premise that education had become the symbol of hope and confidence in the future of mankind. It was the observation of the author that many of the problems concerning the achieving of world peace, human brotherhood, personal happiness, as well as problems of a political, social, and economic nature, could be solved by education.

STATEMENT OF THE PROBLEM

Determine the importance of selected areas for the instruction of tractor maintenance and operation in Afghanistan.

HYPOTHESIS

There is no difference in the perception of the importance of selected activities for instruction of tractor maintenance and operation in Afghanistan by experienced instructors of tractor maintenance and operation.

REVIEW OF THE LITERATURE

A review of literature was conducted in order to determine the scope of and importance of selected activities for the instruction of tractor maintenance and operation in Afghanistan. The review of literature will include reference to development of the curriculum and the competencies needed for maintenance and operation.

A curriculum in tractor maintenance and operation should include the competencies needed for tractor maintenance and operation. Vocational education curriculum development has centered around performance objectives in the competencies needed by workers in the industry.

According (1967) to the authors of a Guide for Vocational Education Curriculum Development the following procedure should be used:

1. Listing objectives as the desired outcomes in terms of behavioral change.
2. Formulating the hypothesis.
3. Writing the curriculum.
4. Measuring the results in terms of objectives achieved.
5. Evaluating validity and reliability of measurement.
6. Revising all affected curriculum development criteria.
7. Proceeding through the cycle again with adjusted objectives.

Systematic planning for the learning process within education demands the definition and specification of objectives at each level of the total curriculum. Behaviorally defined objectives may be perceived as minimal requirements for the attainment of long-range and less well-defined aims for a curriculum. Defining objectives is a process which must be based upon knowledge of how people learn. Attained capabilities determine the learning of other capabilities in a cumulative fashion. Planning of learning and the design of learning situations demand the definition of objectives in terms of capabilities inferred from human performances. When objective statements are available a designer can proceed systematically to specify what has to be done to facilitate learning. Earl S. Webb and C. Don Knotts (1974) did a research in the department of Agricultural Education at Texas A and M University. What should be taught in courses that will be of the most value to my students, or content priorities for farm mechanics? The five areas of Farm Power and Machinery, Farm Shop, Farm Electricity, Building and Conveniences, and Soil and Water were included in their study. The purpose of their study was to determine the knowledge and skills that should be included in courses designed for students enrolled in production vocational agriculture and to establish priorities (level of importance) for teaching course content. They requested the responses from 50 young farmers throughout Texas who had been recognized by the State Association of Young Farmers of Texas for outstanding farming programs during one of the five years, 1964-1969. In the area of Farm Power and Machinery the following skills were assigned priority level I rating by respondents.

Farm Power and Machinery:

Be able to operate the farm tractor and equipment safely.

Be able to service machinery and equipment according to operator's service manual.

Be able to determine cause of trouble of machinery and equipment.

Be able to select the size and type of machinery and equipment appropriate for farming operations.

Be able to adjust farm implements under field conditions.

Be able to keep records of maintenance and repair on machinery and equipment.

And they recommended that:

1. Teachers should examine courses of study in agricultural mechanics to see if suitable content is included and if appropriate priorities are assigned to subject matter content. Findings show that the most important area is Farm Power and Machinery. It is evident that for a vast majority of farmers, it is far more important to be able to service machinery and equipment according to the operator's service manual than to be able to overhaul an engine.
2. Teachers should determine the knowledge and skills needed by farmers in their school communities and develop instructional content to meet these needs.
3. In diversified farming areas, consideration should be given to individualized instruction in agricultural mechanics in accordance with the type of farming a student plans to enter or type of farming in which he is engaged.

Phipps and Deyo of Illinois in 1952 reported that the farmers included in their study listed the most frequent farm mechanic jobs done on their farm as maintenance, repair and adjustment of farm tractors.

Brasfield of Tennessee in 1955 reported that all of the farmers he surveyed needed to learn new skills and improve others. His survey showed that of the 283 pieces of equipment on twenty farms, 117 needed repair, 76 required adjustment and 145 parts needed lubrication.

Arizona farmers, as indicated by Finley (1952), felt that major emphasis should be directed toward preventive maintenance, adjustment and repair of farm machinery.

Floyd Norman Reece (1959) studied and tested a sample of 50 farm tractors. The tractors were tested for horsepower, output and specific fuel consumption under the condition in which they were being operated and again after a selected number of adjustments to correct deficiencies resulting from improper maintenance were made. It was found that the tractors, under the conditions in which they were being operated, were capable of developing 74.9 percent of maximum power as determined by the Nebraska tractor tests, and were using 1.32 times as much fuel as determined from the Nebraska tests.

After simple adjustment and maintenance to engine governor, air cleaner, spark plugs, carburetor, and timing, the tractor was capable of developing 83.3 percent of maximum power as determined by Nebraska tests.

Simple adjustment and maintenance of the indicated items increased the maximum power by an average of 3.07 horsepower per tractor, or 11.1 percent, and decreased the specific fuel consumption by 0.105 lb/h.p.-hr. per tractor, or 14.4 percent.

It was possible to adjust, to manufacturer's specification, the engine governor on ten of the tractors, resulting in an increase in horsepower of 9.1 percent and a decrease in fuel consumption of 4.8 percent. An additional 10 tractors did not require adjustment or repair of the engine governor. The governors on the remaining 30 tractors were worn so that new parts were needed to operate satisfactorily.

The air cleaners on five, or 10 percent, of the tractors were found to be choked in varying degrees with dirt and chaff. Service of the air cleaner in these cases resulted in an average increase of 7.6 percent in power, and decrease of 11.4 percent in fuel consumption.

Spark plugs were changed on 45, or 90 percent, of the tractors, which gave an average increase of 5.3 percent in power and a decrease of 6.1 percent in fuel consumption. In seven cases, or 14 percent of the tractors tested, the spark plugs were in such a faulty condition that they caused misfiring under full load. On these seven tractors, power was increased 21.5 percent and fuel consumption decreased 14.2 percent by installing new spark plugs. Adjustment of the carburetor was needed on 36, or 72 percent of the tractors. Thirteen of them were found to be set too lean, and 23 were found to be set too rich. On the 23 which were set too rich, the fuel consumption was decreased an average of 9.5 percent.

Ignition timing was changed on 27, or 54 percent, of the tractors. This resulted in an average of 5.3 percent in maximum power and a decrease of 5.3 percent in fuel consumption. On 10, or 37 percent, of the 27 tractors, it was possible to obtain correct timing by merely adjusting the breaker points.

By applying the results obtained in this investigation, it is possible to estimate that improper maintenance and adjustment of the farm tractor and other engines may be costing the Kansas farmers, collectively, up to $8,390,000 annually in wasted fuel. The average farmer in the farm management association may be wasting up to $146 per year because of excessive fuel consumption caused by neglect of the farm tractor.

Weber (1958) in an Illinois study of 60 farm tractors found that maintenance chores were being neglected. The study indicated that: the fact that an operator knew of a certain recommendation did not necessarily mean that he was following it. Many recommendations were not followed because the operator felt that they were unnecessary, time consuming, messy, or expensive. The most frequent maintenance deficiencies were dirty crankcase breather and air cleaners, battery with liquid level below the plates, low tire pressure, improper valve adjustment, pitted ignition points, poorly adjusted brakes, excessive engine speed, and crankcase oil that needed changing.

In summary the related literature indicated that proper adjustment and maintenance of tractors increased maximum power an average of 11.1%, and decreased fuel consumption 14.4%.

Good tractor maintenance practices not only saved money and avoided costly breakdowns, but helped maintain the horsepower that tractors were designed to develop. American Society of Agricultural Engineers (ASAE) (1970) and the Society of Automotive Engineers (SAE) recommended the hourly intervals of 5, 10, 50, 100, 250, 500, and 1000 be the maintenance cycles for tractors.

OBJECTIVES

The objectives of the study are:

1. To survey the areas of tractor maintenance and operation which should be included in the farm mechanic curriculum of vocational agriculture.
2. To determine the importance of tractor maintenance and operation for the farmers of Afghanistan.
3. To formulate guidelines for the development of a curriculum for preparing farm mechanics which would include competencies considered to be essential for all areas of activity in tractor maintenance and operation.

DEFINITION OF TERMS

Certain terms were selected and given special definitions for the purposes of this study. The definitions may or may not be those considered to be of common usage.

Curriculum. A prescribed course of study in a university, school, etc.

Farm Machinery. Mechanical devices used in the production of agricultural products.

Tractor Maintenance. The work of keeping a tractor in proper condition.

Farm Machine Repair. The reconditioning of a machine used in production agriculture.

Skills. In this study, skills refer to manual dexterity plus the facts or knowledge required to do the job successfully.

Farm Power and Machinery Course. A unit of study dealing with engines and machines.

Farm Machine Service. The process of making machines ready for use.

SELECTION OF SUBJECTS

Subjects were selected from those United States citizens who had taught agricultural mechanics in Afghanistan since 1960. One hundred percent of those individuals were surveyed by questionnaire and 100% responded.

DESIGN

This study most closely resembles the criterion-group design in that an attempt was made to ascertain the important facts of tractor maintenance peculiar to Afghanistan tractor operation.

PRESENTATION OF THE STUDY

Purpose: The purpose of this evaluation was to study the feasibility and importance of tractor maintenance and operation for Afghanistan.

Limitation: Due to the shortage of qualified experts in Agricultural Mechanics, five Americans who taught this course in Afghanistan were involved in the evaluation process. The questionnaire was also presented to a group of people who had worked overseas and were enrolled in the Agricultural Education Seminar for the fall term 1973.

Personnel surveyed: Dr. Loyed Pickett, a Vocational Agriculture Professor from the University of Montana. Dr. Pickett worked in Afghanistan for 6 years under the Agency for International Agricultural Development. For 4 years he taught Farm Mechanics and for 2 years Dr. Pickett worked in Agriculture Education organizing publications.

Mr. Ted Louden from the University of Michigan who taught Farm Mechanics and Agricultural Engineering in Kabul University in Afghanistan for two years.

Mr. John K. First, from Michigan who came to Afghanistan under contract of University of Wyoming, and he was involved there for two years.

Mr. Arden G. Fabricius, from Wyoming and he came to Afghanistan under the same contract, and he worked for 4 years teaching Farm Mechanics and Agriculture Engineering courses.

Dr. Lewis C. Saboe, Professor of Agronomy taught in Afghanistan for two years.

METHOD AND PROCEDURES

In an attempt to discover the feasibility and importance of tractor maintenance and operation, the author developed a questionnaire involving various aspects of tractor maintenance and operation. The questionnaires used in this study were sent to the five persons above who reacted to the importance of each item on the questionnaire. The respondents were asked to indicate the degree of importance for each area of tractor maintenance and operation.

Five questionnaires were sent to five respondents, and all five were returned. The results from the respondents were compiled and each degree of importance was given an arbitrary weighted value according to a Likert Scale as follows:

High importance ------- 5 points
Medium importance ----- 3 points
Low importance -------- 1 point
No importance --------- 0 points

After computation of the data there was one area that fell below 3.0 points in importance, and it was discarded. The remaining areas were recommended to be included in the course of study for tractor maintenance and operation. The area which fell below 3.0 points was "stopping a diesel engine" with an importance value of 2.2 points. The other areas were considered to be from medium to high importance.

The questionnaire was also presented to a group of people who had worked overseas and were enrolled in the Agricultural Education Seminar for the fall term 1973. When the ratings were compared to those given by a group of teachers who had caught farm mechanics in Afghanistan there were some differences. The respondents in the Agricultural Education Seminar group responded to all areas of the questionnaire with an importance rating of 5.0.

AGRICULTURAL MECHANICS
TRACTOR MAINTENANCE AND OPERATION

EVALUATION SHEET

Please answer in the appropriate column in the importance scale for each of the following Tractor Mechanics activities.

Instructional Area	Importance High 5	Medium 3	Low 1	None 0	Average
Tractor Maintenance					
I. Maintenance after 10-hour or daily service jobs:					
Servicing the air-cleaner assembly	5				5.0
Checking the crankcase oil level	5				5.0
Checking the cooling system	5				5.0
Doing the 10-hour grease jobs	3	2			3.6
Removing water and sediment from diesel fuel	1	3	1		3.0
Safety checking of clothing	4	1			4.2
Checking miscellaneous items	1	4			3.4
II. Maintenance after 50 hours of operation:					
Maintaining the battery	4	1			4.6
Checking and adjusting v-belt tension	4	1			4.6
Lubricating the clutch-release mechanism	1	3	1		3.0
Maintaining the hydraulic system oil level	4	1			4.0
III. Maintenance after 100 hours of operation:					
Changing crankcase oil	5				5.0
Replacing the oil filter	5				5.0
Servicing the crankcase breather	5				5.0
Maintaining tractor tires	3	2			4.2
Checking and servicing other parts of the tractor	3	2			4.2
IV. Maintenance after 250 hours of operation:					
Making valve-clearance adjustments	3	2			4.2
Maintaining tractor spark plugs	3	2			4.2
Cleaning the battery	2	3			3.8
Cleaning the sediment bowl and fuel filter	5				5.0
Adjusting the carburetor	4	1			4.6
Adjusting the tractor brakes	2	2	1		3.4
Adjusting the engine clutch	3	2			4.2
Adjusting and servicing other parts of the tractor	2	3			3.8

Please answer in the appropriate column in the importance scale for each of the following in Tractor Mechanics activities.

Instructional Area	High 5	Medium 3	Low 1	None 0	Average
V. Maintenance after 500 hours of operation:					
Servicing the distributor	5				5.0
Timing the ignition	5				5.0
Maintaining the starter and generator	3	2			4.2
Servicing the diesel engine fuel filter(s)	4	1			4.6
Servicing the front-wheel bearings	4	1			4.6
VI. Maintenance after a year of operation:					
Cleaning the tractor	3	2			4.2
Servicing the drive mechanism	1	3	1		3.0
Servicing the cooling system	3	2			4.2
Servicing the hydraulic system	3	2			4.2
Adjusting the engine governor	2	2	1		3.4
Preparing the tractor for storage	3	2			4.2
Tractor Operation					
I. Making adjustments to meet operation needs:					
Checking and adjusting seat position	3	2			4.2
Changing rear-wheel spacing	2	2	1		3.4
Adjusting front-wheel spacing	1	3	1		3.0
Adding weight for traction and balance	4	1			4.6
II. Starting the tractor engine:					
Identifying the type of tractor engine	4	1			4.6
Preliminary starting preparations (carburetor or diesel type)	4	1			4.6
Starting engine operation (carburetor or diesel type)	4	1			4.6
Making adjustment during warm up	3	2			4.2
III. Controlling tractor movement:					
Identifying the type of tractor transmission	4	1			4.6
Starting tractor movement	4	1			4.6
Operating a moving tractor	4	1			4.6
Stopping tractor movement	4	1			4.6

Please answer in the appropriate column in the importance scale for each of the following Tractor Mechanics activities.

Instructional Area	High 5	Medium 3	Low 1	None 0	Average
IV. Operating a tractor under field conditions:					
Making adjustments before starting field work	5				5.0
Matching gear selection and engine speed with load	4	1			4.6
Handling overloads without stopping tractor	5				5.0
Checking and correcting tire slippage	3	2			4.2
Operating a tractor on slopes	4	1			4.6
Pulling out of a mud hole or ditch	2	3			3.8
V. Operating a tractor under highway conditions:					
Providing safety warning devices	4	1			4.6
Selecting a suitable speed	3	1	1		3.8
Using right-of-way	3	2			4.2
Slowing or stopping a tractor at road speeds	4		1		4.2
VI. Stopping the tractor engine:					
Stopping a carburetor engine	3	1	1		3.8
Stopping a diesel engine		3	2		2.2
Refueling the tractor	4		1		4.2

CONCLUSION

The results of this study should be adapted according to community needs in Afghanistan. It should meet the individual needs of the students who will be involved in teaching, working at experiment stations, and for those students who will be going back to farming. Afghanistan is on the way to mechanization so this farm mechanics course will give them some background and knowledge about maintenance and operation of farm tractors. The students will be able to repair and maintain tractors and equipment as well as the safe operation of tractors which will avoid tractor breakdown and dangerous personal injury. Emphasis in this course of study has been placed on course content with suggestions for instructional methods, tests, demonstrations, shop procedures, and teaching techniques for better instruction by the teachers. Flexibility should be emphasized throughout the program in order to adapt community need and type of equipment. Vocational Agriculture is basically a "learning by doing" educational program. If too few opportunities for "doing" are provided, the "learning" objective is seriously limited.

RECOMMENDATION

The proposed course of tractor operation and maintenance should be taught in one semester as follows: approximately 40% of the class period should be spent in lecture or classroom activity with the remainder devoted to practical application in the shop.

The course should be flexible to allow students to progress at their own rate according to their interests, aptitudes and abilities.

Demonstrations are useful and are a basic means of instruction through "showing" and "telling." The shop instructor presents demonstrations for each area for basic skill understanding. The teacher should strongly emphasize the safe operation of all power equipment to be operated by student.

Short courses should be offered in the colleges and different areas of the country according to the facilities and equipment available.

Agricultural extension staff members know little about machinery, but should be given instructions during their training period. Because the extension department has workers at all places where farmers may be reached, they could demonstrate each area of maintenance and operation effectively.

All the tractor maintenance and operation materials presented in this study will be translated into local languages and it will be printed into smaller sections and separate parts. The printed material will be distributed through Agricultural Extension to the Colleges and farmers. With the cooperation of the radio station authorities, some programs can be made for presentation in programs for farmers.

JUSTIFICATION

Today in Afghanistan the profitable use of farm tractors is seriously affected by poorly trained tractor operators and their misunderstanding of proper maintenance procedures for their tractor and equipment. This study was undertaken to determine a feasible method of training these tractor operators in proper operation and maintenance procedures.

Previous studies of this problem area have met with minimum success. It is anticipated that this study, due to its objectivity and approach to the problem areas, will be significantly more successful in increasing the usability of the farm tractor in Afghanistan.

CHAPTER II

MAINTENANCE AFTER 10-HOUR OR DAILY SERVICE JOB

SERVICING THE AIR CLEANER ASSEMBLY

Checking and servicing the air cleaner of the tractor is one of the most important service jobs to do. In fact, more tractor troubles result from lack of air cleaner service than any other single cause. The clean air is so important that the common carburetor tractor uses large quantities of air about 9,000 gallons of air for each gallon of gasoline. Even a small amount of dirt in that much air adds up to a considerable quantity during a day's operation. A diesel engine uses even larger quantities of air.

If the air is not filtered out, it passes directly through the intake manifold into the engine cylinders. Here it mixes with oil on the cylinder walls to form a grinding compound. The grinding action takes place on the cylinder walls, piston rings and valves and in the rings, grooves and bearings.

As these parts get worn the tractor engine loses power, starts using oil and takes more fuel to get a job done. It finally reaches a stage where a complete engine overhaul is necessary.

The speed with which this wear takes place depends on the amount and kind of dirt that is reaching the inside of the tractor engine. This depends on how well the air cleaner service is done. "The difference in ring wear between a very efficient type of cleaner and no air cleaner is approximately 100 to 1." "The increased amount of dirt in the crankcase oil when the air cleaner is omitted, or its efficiency reduced as much as 30 times."

Tractor manufacturers equip their tractors with the most efficient air-cleaner units available in an effort to help you prevent this unnecessary wear. They are about 99 percent efficient. Even with that efficiency, about three-quarters of a pound of dirt gets into the engine in a season, yet if the air cleaner was only 50 percent efficient, about 37 pounds of dirt would reach the engine.

Oil bath cleaners must be properly maintained or the oil cup will become filled with sludge, preventing the screens and elements from cleaning the air properly. This will restrict air flow to the engine (the same effect as choking the engine) and may allow dirty air to enter. Restricted air flow through the air cleaner will eventually cause incomplete combustion, increased carbon formation, and crankcase oil dilution.

Leaks in the connecting pipes, loose hose connections, or damaged gaskets which permit dust-laden air to enter the engine, can defeat the purpose of the air cleaner.

To know how an air cleaner works, there are two types of air cleaners used on farm tractors: (1) oil bath type and (2) dry (paper filter) type. It is important that you know the type on your tractor because the frequency and method of servicing each type is different. With either type, when the engine is running, outside air is drawn through a screened inlet or through a pre-cleaner, where large particles are removed from the air stream. The job, with either the screened inlet or pre-cleaner, is to remove coarse particles and relieve the air filter of that much load. After the air passes through the screened intake, or pre-cleaner, it is drawn through a tube called an "air stack" or "duct" into the air cleaner.

1. Oil-type cleaner. Air entering an oil-bath cleaner is directed to an oil cup at the bottom of the cleaner assembly. Dirt particles in the air become coated with oil. As the air moves up through the filtering element, the oil-coated dirt particles lodge in the filtering element and drain back into the oil cup. Here the dirt settles out, and the oil is used again to trap more dirt. The oil-bath air cleaners are always mounted upright (vertically) so the oil will remain in the cup at the bottom of the cleaner. They are often located in front of the radiator immediately behind the grill, or on the side of the engine.

An oil-bath air cleaner, operating under the conditions for which it is designed, is about 99 percent efficient. However, it is not always operating under its design conditions, so the efficiency may be lower at times when the air flow drops below its rated capacity. If the oil in the cleaner cup gets low, or becomes loaded with dirt, its efficiency is greatly reduced.

2. Dry-type air cleaner: This type of air cleaner consists of two stage cleaning: (1) precleaning, (2) filtering.

1. Precleaning: The air is precleaned by directing incoming air against shield causing a cyclone (centrifugal) action that carries the larger dirt particles to the opposite end of cleaner where they are deposited in a dirt cup or dirt unloader. Cyclone action of precleaner is developed by air passing over the tilted fins. This precleaning action removes from 80 to 90 percent of the dirt particles and greatly reduces the load on the filter. Air then enters the pleated filter element for final cleaning before continuing to the engine.

2. Filtering: The partially cleaned air then passes through the holes in the metal jacket surrounding the pleated paper filter. Filtering is accomplished as the air passes through the paper filter. It filters out the remaining small particles.

If your air cleaner has a dust cup it should be emptied daily. If an automatic dust unloader is used in place of a cup, it is usually recommended that it be checked at least once daily to make certain it doesn't become clogged.

Some dry-type cleaners are equipped with a vacuum gauge to show when the filter needs cleaning.

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 over the tractor engine.

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.

Frequency of cleaning the dry-type cleaner varies from 50-hour intervals to 100 hours, according to manufacturers' recommendation, depending on operating conditions. Be sure to check the operator's manual.

How to Service Air Cleaner

Under normal operating conditions, most manufacturers recommend that either type of air cleaner be checked for dirt accumulation each day. Under very dirty conditions check every 5 hours.

If your tractor is equipped with an oil-type cleaner:

1. Loosen oil cup and remove from filter. Don't try to remove cup with engine running because this allows unfiltered air to enter directly.
2. Check depth of sediment deposit in outer chamber. If sediment is about 1/2 inch in depth, proceed with the remaining steps.
   Some manufacturers recommend cleaning when 1/4 inch of dirt has accumulated. Check your operator's manual for recommendations. If the oil has thickened, even though the dirt depth may not be as high as 1/2 inch, change the oil. Because thickened oil acts as a choke on your engine causing it to use more fuel. There is also a possibility of drawing dirt-laden oil into the carburetor then into the engine, which will act as a grinding compound and causing fast wear. With today's high-detergent oils, dirt may never settle to the bottom of the cup, so watch for thick oil as your signal that the oil needs to be changed.
   If there is water in the cup, you will probably find the air intake cap has been removed, allowing rain to enter, proceed with cleaning the cup and be sure to replace air intake cap. Water interferes with effective air cleaning action.
3. If cup needs cleaning, throw away dirty oil, scrape and then wash inner and outer cups with clean kerosene or diesel fuel. Remove all caked dirt from bottom of cup and also clean dirt from tray if used.

Don't use gasoline or other highly inflammable liquids such as naptha or benzen.

4. Check air intake pipe (air stack) for dirt accumulation. This will not need cleaning often, but if dirty, swab it out with your cleaning material. The more dirt you allow to accumulate in the stack, the more it acts as a choke to air flow and increase fuel consumption.
5. Refill cup with oil to oil level mark.

   Most operator's manuals recommend the same weight oil as used in the engine crankcase. If you use an oil that is too heavy, the washing action is lessened. It also acts as a choke on the engine and increases fuel consumption. If you use oil that is too light it will pull into the engine and this will lower the oil level in the cup and the cleaning action is not efficient. With diesel engines, the oil is used as fuel causing the engine to run wild. When this happens, you have no control of engine speed. Don't use old crankcase oil. It may contain unburned fuel which evaporates quickly and lowers the oil level in the cup. It also contains dirt which limits washing action. Don't overfill oil cup. On spark-ignition (carburetor) engines it increases fuel consumption and causes loss of power.
6. Replace oil cup and screen tray, if included and tighten clamp.
7. Check air duct between cleaner and carburetor or intake manifold on diesel engines for holes or loose clamp connections.

   Air entering the engine here bypasses the air cleaner. Dirt particles pass directly to the engine, causing rapid wear.

8. Check air inlet screen, or pre-cleaner, and remove trash if necessary.

   For best performance at least once each year, completely disassemble and clean the entire air cleaner system. This is a vital service to long engine life, and the recommendations vary from every 1000 hours to yearly.

Servicing Dry-Type Air Cleaner

If the dry air cleaner has a dust cup, empty it daily.

If an automatic dust unloading valve is used in place of a dust cup, check it daily for clogging.

Removing the filter element:

1. Stop engine, if it is running.
2. Squeeze dust unloader if supplied on your air cleaner to make sure the valve is working and not blocked.
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. 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) tapping to loosen dust so it can be shaken out, (2) use of compressed air, and (3) washing with water and a detergent.

The method you are going to select depends on the condition of the filter element and what facilities you have for cleaning.

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 gently enough against the palm of your hand for loosening dirt. Do not tap the element against a firm surface such as a tractor tire or fence post. This will damage the element beyond usage.
2. Rotate element while tapping and shake out dust.

Cleaning with compressed air:

1. Hold the air nozzle about an inch away from the inner screen of the element. 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.

It is helpful if the air nozzle is equipped with a deflector to spread the air to avoid blowing a hole in the filter element.

2. Continue blowing and rotating the element until it is clean.

Cleaning by washing:

1. Clean away as much dirt as possible with clean water from a hose (the water should be applied from inside the filter element), 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 clear water and then shake excess water from element.
4. Allow element time to dry, approximately 24 hours at 70°F. Do not use compressed air to dry the filter element. It will probably rupture the paper filter. Be sure you don't leave the wet element where it will be exposed to freezing weather. Do not oven dry.
5. Inspect element for damage by placing a light inside it.
   Discard any element that shows the slightest damage or rupture in the paper or fails during cleaning.
   Replace the filter element after a recommended service period or six washings.

Installing the Filter Element

1. Replace the filter element in the cleaner.
2. Tighten wing nut that holds element in place. Don't overtighten. Tighten with fingers only.

3. Complete remaining procedures in reverse order from those used to remove the filter element.

CHECKING THE CRANKCASE OIL LEVEL

Lubrication plays an important part in the operation of any type of automotive machine. The life and service given by an automobile or a tractor are dependent largely upon the consideration and care given to its lubrication, both in the design of the system and during its use and operation.

You may think of oil as just a lubricant--a means of reducing friction and preventing wear. But it does other important jobs too: it keeps working parts cool; it cushions the pounding action on piston pins and bearings; and it forms a seal between the piston rings and cylinder walls.

Less effective for all of these jobs and partciularly serious if the amount of oil becomes so small that it overheats. Overheating causes oil to oxidize, which means it gets thicker and flows less rapidly. Oxidized oil may also result in varnish deposits, stuck rings and stuck valves; and, if allowed to continue, will develop corrosive substances that cause rapid engine wear. After the crankcase temperature reaches 180°F., each additional rise of 17° in temperature approximately doubles the rate of oxidation.

If you don't check the oil level daily, it will cause serious problems and it will cost you to overhaul the engine.

How to Check and Add Oil

The dip stick or oil level gauge may be on either side of the tractor depending on the make.

1. Check oil-level position.

Don't check the oil level while the tractor is running except when the dip stick has marks for both (one side is marked to check oil level when the engine is not running and the other side has marks to check the oil level while the engine is running).

2. Stop the engine and after a few minutes check the oil level. If your tractor has been running, oil will be distributed over the length of the dip stick. Wipe dry with clean cloth, then insert and withdraw for checking oil level.

   Note top marking labelled "full" and lower marking lettered "add," "low" or "danger." Some manufacturer's make the dip stick short enough so no oil shows when it is time to add.

3. Add oil if needed.

   It is extremely important that you use a clean container and clean oil if you want your tractor to continue to give good service.

   Don't mix different brands. Add the brand of oil which is in the crankcase.

   Fill to "full" mark with type and grade of oil recommended in your operator's manual.

   Do not overfill; too much oil causes problems in oil consumption and foaming.

CHECKING THE COOLING SYSTEM

Importance of the cooling system:

When fuel burns inside an engine the temperature may momentarily reach 3,500° to 4,000°F. of course, that temperature exists for such a short time that it has no effect, as long as excess heat can be easily removed through the tractor exhaust and cooling systems. Approximately 40 percent of this heat is given off through the cylinder walls. An adequate cooling system must be provided to get rid of it.

How to service the cooling system:

1. Remove the radiator cap and check level of coolant. If the coolant is more than 2 or 2 1/2 inches below the neck of the radiator it is in need of filling. If the engine is hot remove the radiator cap slowly. Give it a slight turn and you will feel it partially release without coming off and then remove the cap completely, but if you remove it at the first time, you may get sprayed with steam and hot water.
2. Check the pressure cap. If there is no buildup of pressure in the radiator, the pressure cap is worn, replace it with a new one. When you buy a pressure cap, be sure that the relief valve is for the right pressure setting. The wrong cap can cause overheating or cause the radiator to burst.
3. Refill radiator to within about 2 inches of radiator neck. Check your manufacturer's recommendations, because it varies from as little as 1 1/2 inches (to bottom of filler neck) to 4 inches (when measured to the top of the filler neck).
4. Check for leaks about radiator, radiator hoses and hose clamps.
5. Remove trash collected on front of radiator or on radiator screen.

If you have air or water under pressure, use a hose and direct the stream against the radiator from the side next to the engine.

Under trashy operating conditions, such as those of corn harvesting, when the radiator should be checked and trash removed several times a day in the field.

DOING THE 10-HOUR GREASE JOBS

There are a number of places on most farm tractors that you should grease daily or after 10 hours of operation. Regular greasing of these points, not only saves wear and protects the bearings, it also makes it easier for you to operate the tractor.

Many of the bearings on today's machines are sealed with lubricant for the life of the bearing. Some bearings still require periodic lubrication.

It is an easy task to grease your machine when it requires it. Your operator's manual recommends how each bearing or shaft should be lubricated and how much.

Some grease fittings require daily or 10 hours service, while others are serviced at 50 or even 250 hour intervals. If you don't lubricate the bearings or shafts when required, these parts will wear out prematurely. Grease is not expensive and repair costs will be saved by keeping the machine properly lubricated.

Greases are semifluid or semisolid lubricants and are used primarily for slow-moving parts when pressures are high and for parts that are concealed or inaccessible such as wheel bearings, spring shackles, axle bearings, universal joints, and water pumps. Many different kinds of greases have been developed to meet the specific requirements of automobile, truck, and tractor chassis lubrication.

A grease is a mixture of metallic soap and a mineral oil. Certain chemicals may be added to provide stabilization, oxidation resistance, rust prevention, tackiness, and other desirable characteristics.

Most operator's manuals refer to "chassis grease," "pressure-gun grease," "No. I pressure-gun grease," "ball-and-roller bearing grease" or "general purpose grease" to use, but when you look for those, you will probably find two different greases: (1) a multi-purpose grease which is relatively new but is satisfactory for both chassis and water-pump use, or (2) the older type chassis grease which is suitable for greasing the chassis but not the water pump. Grease should be kept free of dirt and water. If you open the container and do not close it properly, it usually becomes contaminated.

Most users now recognize how necessary it is to use the right type of grease in the right place and in the right amount, but they sometimes overlook the matter of keeping the grease clean. Two of the most important points of all are keeping the grease clean in all stages of its storage and handling, and in making sure that no abrasive dust or dirt carries into a bearing at the time of grease application. Grease packages should be kept covered and away from dust. Grease fitting should be wiped clean before the grease gun is applied to them. The grease gun itself should be kept clean.

Locating grease fittings:

The grease fittings that need daily attention are usually (a) those located on the steering mechanism, (b) the linkage and shafting connecting to the clutch and brakes, (c) portions of the drive mechanism and (d) the hydraulic-hitch assembly.

If your tractor is fairly old, it probably has more points that need daily greasing than if it is new.

The amount of lubricant required are:

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

3. Clutch-shaft fittings, 2 strokes each.
4. Hitch links and lift-control fittings, 2 strokes each.
5. Steering mechanism fittings, 2 strokes each.
6. Axle pivot pin, 2 strokes.

Using a grease gun:

1. Wipe end of grease fitting with a clean cloth. If you don't, any dirt accumulated on the end is forced into the bearing which makes bearings wear fast.
2. Place gun on fitting and hold directly in line with it.
3. Pump gun slowly.

   If bearing has grease seal, grease lightly. Too much pressure destroys the seal and allows dirt to enter.

   If bearing has no seal, apply lubricant until old grease is forced out and new grease appears at edges.
4. Remove gun by swinging through 30° arc.
5. Wipe excess grease from fitting.

REMOVING WATER AND SEDIMENT FROM DIESEL FUEL

Importance of Water and Sediment Removal

Diesel tractors have a rather elaborate system for removing both water and sediment from fuel.

These have a bad effect on the fuel injection system: (a) sediment grinds away the finely fitted parts of the injection pump; (b) water causes the parts to rust and a very small amount can cause serious damage; (c) water interferes with the proper feeding of fuel and causes rough running of the engine.

Water is more of a problem in diesel fuel than it is in gasoline. Water separates from gasoline rather readily; but the weight of diesel fuel is so near the weight of water thay they mix readily and separate slowly. When you stop the tractor during the night, water has time to separate from the diesel fuel and settle to the bottom of the tank. The trapped water should be removed from the fuel tank each morning.

How to Remove the Daily Deposit of Water and Sediment

1. Check for drain cock on:

   (a) Bottom of fuel tank.

   (b) Bottom of first filter.

   (c) Top of sediment bowl.

   If equipped with drain cock:

   1. Open the cock and drain about 1 pint of fuel. In order to be sure that water and sediment are removed.

   2. Close drain cock.

   If it does not have a drain cock and equipped with water trap and sediment bowl.

   If sediment bowl is more than 1/3 full of water

   1. Close fuel valve under fuel tank.

   2. Loosen thumb nut under bowl and swing bail to one side.

   3. Remove glass bowl, empty, and clean. When bowl is removed, the gasket may be on top of bowl or may remain in top of filter assembly and be careful not to lose them.

4. Wash glass bowl in kerosene to remove dirt and sediment.
5. Install bowl loosely.

   Before installing bowl check the gasket. If it is not good, replace it with a new one.
6. Open fuel valve and allow bowl to fill. Since the bowl is mounted loosely, the fuel forces air out of the top of bowl.
7. Tighten thumb nut under bowl when air is completely removed.

SAFETY CHECKING OF CLOTHING

It is the characteristic of a good operator to take safety precautions into consideration. Although it is important to prepare your tractor properly for day's operation, it is even more important for you to be prepared to operate it safely. This preparation has to do mostly with the way you are dressed and the condition of the surface where you climb or place your weight.

1. Check your clothing to make sure they fit fairly well; they should be free of tears, bulging pockets, frayed edges and heavy cuffs. Clothing which is loose, frayed and bulky can easily become wrapped in the revolving parts and cause many disabling injuries or even death.
2. Wear shoes with heels and tight soles. Heels help prevent slippage; tight soles reduce the danger of tripping and falling.
3. Check the tractor platform steps and pedals for mud, grease or in the winter time for snow or ice. Sometimes a thin layer of ice or grease can cause an injury, and it can be made safe by covering it with sand or soil particles, and be removed later on.

CHECKING MISCELLANEOUS ITEMS

As an operator, you need to watch continually for loose nuts, bent brackets that need straightening, worn parts that need replacing, cuts or worn places in tires, tire inflation, loose or worn fan belts, loose wheel lugs, head lights turned out of position and other points that need attention.

Many of these service problems may be part of your weekly, monthly, semi-annual or yearly maintenance schedule, but not all of them can be put off that long. Watching for the parts that need attention, and caring for them at the time they need it, is part of the difference between your being just a tractor driver or a competent operator.

CHAPTER III

MAINTENANCE AFTER 50 HOURS OF OPERATION

MAINTAINING THE BATTERY

Checking the liquid level in a battery is one of the most simple of tractor maintenance jobs. Maybe 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 tractor because some provide more reserve than others, and also the location of the battery on the tractor is another reason. If the location is immediately back of the engine it will become warmer and water will evaporate faster than if it is under the seat.

To care for a battery, you need to understand its construction and how it works. The battery is made up of a number of individual cells in a hard rubber case. The basic units of each cell are the positive and the negative plates. These plates hold the active materials in flat grids, charged negative plates contain spongy lead (Pb) which is grey in color, charged positive plates contain lead peroxide (PbO_2) which has a chocolate brown color. A plate group is made by welding a number of similar plates to a plate strap. Plate groups of opposite polarity are interlaced so the negative and positive plates alternate. Negative plate groups normally have one more plate than the positive groups. This keeps negative plates exposed on both sides of the interlaced group. Each plate in the interlaced plate group is kept apart from its neighbor by porous separators, the separators allow a free flow of electrolyte around the active plates, the resulting assembly is called an element. After the element is assembled, it is placed in a cell compartment of the battery case. Hard-top batteries have cell connectors which pass through the partitions between cells. The connectors and partitions are sealed so that electrolyte will not transfer between cells. This improves battery performance, since the cell connections are shorter and the cover is more acid-tight. The main battery terminals are the positive and negative posts. The positive terminal is larger to help prevent the danger of connecting the battery in reverse polarity. Vent caps are located in each cell cover. The caps have two purposes: (1) They close the openings in the cell cover through which the electrolyte level is checked and water is added; (2) They provide a vent for the escape of gases formed when the battery is charging. Each cell in a storage battery has a potential of about two volts, six-volt batteries contain three cells connected in series, while 12-volt batteries have six cells in series.

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 percent sulfuric acid (H_2SO_4) and 64 percent water. When you start to use electrical energy, such as for engine starting or lights, 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 do not recharge the battery, a point is reached where so much of the active material has been changed into lead sulfate, the cell no longer produces 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 for 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 then 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. In this case you should maintain the battery liquid level above the level of the plates. Because the portions of the plates and separators which are exposed to air, will dry out. These 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.

There are two important reasons that you should maintain your battery at or near full charge: 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 and shortens its life. Second: the capacity of your battery for cold weather starting is greatly reduced. Even a fully charged battery at 0°F. has only 40 per cent of the capacity it has at 70°F. That is the reason a weak battery may give fair service until the weather turns cold. Then it appears to go all at once.

Charging rate: The rate in amperes at which the current flows when a storage battery is being charged is known as the charging rate. Obviously, the higher the charging rate for a given battery, the shorter the time required to charge it. On the other hand, an excessively high charging rate may cause permanent injury because of the heating effect on the plates and cell content. During the early stages of the charging process, a higher rate of charge is permissible. As the battery becomes partly charged and bubbling or gassing is observed, the rate should be reduced until, near the end and during the last few hours, it is less than one-half the initial rate. A safe rule to follow in the case of a completely discharged battery, if it is in good condition otherwise, is to determine or estimate its ampere-hour rating and start charging it at a rate equal to one-eighth this capacity, continuing until gassing begins and then reducing the rate about one-half and completing the charge. This method will require from 12 to 24 hr. of continuous charging.

Maintaining Battery Liquid Level

Every 50 hours of operation check the battery liquid level. Your battery will require more water when it is overcharged or when the weather becomes hotter. To do this job proceed as follows:

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. While the caps are removed, flammable gas from battery electrolyte is coming out. Do not smoke, keep all sparks and flames away from the battery. If the battery has been charging, hydrogen gas is present. This gas will explode in the presence of a spark or flame and possibly cause serious injury to you or others nearby.
2. Fill each cell to proper level with clean distilled water. Avoid overfilling, fill until the level of the electrolyte is about 3/8 inch above the level of the plates. Never add acid to the battery unless electrolyte is lost by spilling.
3. Replace caps on battery, make certain the vent hole in each cap is not clogged. When operating under dusty conditions, check the vent hole in the cap each time the battery is serviced. If the vent is plugged, enough pressure can develop in the battery to break the seal or case.

Checking the Battery Frame and Cable Connection

Check for loose terminal connections or loose hold down clamp on the battery. In case 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 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.

Cleaning the Battery

1. Remove ground strap or cable from battery terminal post which prevents short circuits caused by accidentally grounding the other terminal with a tool. Use a battery clamp puller if available. Do not pound on terminal,; you may crack the battery top or loosen the post.
2. Remove the other battery cable.
3. Wipe off the clamps with a cloth. Dip the clamps into a mixture of baking soda and water (two tablespoons of soda to a pint of water). This will clean off some of the corrosion and acid.
4. Clean the inside of the clamps with a round wire brush or a small piece of sandpaper around your finger.
5. Use a hollow-brush terminal cleaning tool to scrub the corrosion from the terminal posts.
6. Use a bristle brush to remove loose dirt and corrosion particles from the top of the battery.
7. Brush a fresh mixture of baking soda and water on top of battery and post. This will neutralize the acid. Apply solution until foaming stops and do not allow any of the solution to enter the breather holes in the caps.
8. Flush off residue with clean water and protect battery caps from direct stream of water to avoid flushing dirt into the battery through the vent holes.
9. Dry the top of the battery with clean cloth.
10. Inspect the battery for any damage which may require repair or replacement.

11. Attach non-grounded cable to proper battery terminal. Be sure the correct connection is made or you may damage the generator or alternator. Mostly the positive terminal is wider.
12. Then attach ground cable to the opposite terminal. Do not pound the clamps in place.

Checking Battery Charge

Several devices are available to check the battery more accurately and safely. These include: hydrometer, voltmeter, charger-tester. Since the hydrometer is the most commonly used and least expensive the procedure for specific-gravity (hydrometer) follows:

1. Remove battery caps.

   Check the level of the electrolyte in the cells. If it does not cover the plates, add water; delay checking your battery. Operate your tractor for a few hours to mix the water and electrolyte so that an accurate reading can be taken.
2. Insert the hydrometer into one of the cell openings, squeeze the bulb and slowly release it to draw electrolyte into the 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. The specific gravity should read from 1.215 to 1.270 (corrected for 80°F. electrolyte temperature). To determine a corrected specific gravity reading when the temperature of the electrolyte is other than 80°F. add to the hydrometer reading four gravity points (0.004) for each 10° above 80°F. Subtract four gravity points (0.004) for each 10° below 80°F.

7. Check remaining cells in the same manner.

8. Flush hydrometer with clean water.

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

SPECIFIC GRAVITY READING	WHAT IT MEANS
1.300	Electrolyte level is low, battery is being overcharged or electrolyte has been added instead of water.
Between 1.225 and 1.280	Battery is in good condition. Some batteries are fully charged with a reading of 1.280 while others are fully charged at 1.250 or less. Batteries intended for use in warmer climates may fully charge with the specific gravity as low as 1.225.
Under 1.225	Battery charge is too low. Have it recharged.

The electrolyte in various stages of charge will start to freeze at the following temperature:

Specific gravity reading	Electrolyte freezing temperatures
(Corrected to +80°F.)	
1.250	-62°F.
1.200	-16°F.
1.150	+ 5°F.
1.100	+19°F.

If there are more than 50 gravity points difference between the highest and lowest cell readings. This condition may indicate: short circuits in the battery, unequal losses of acid from the cells; that the battery is worn out due to loss of active plate materials, breakdown of the separators, or accumulation of impurities.

CHECKING AND ADJUSTING V-BELT TENSION

Almost every machine has either belts, chains or both. These drive components must be maintained to keep them from wearing out. Belts can stretch and slip and cause loss of power.

Most tractors are equipped with one or two belts which operate the water pump, fan and generator. 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. If belt is regularly checked the replacement will be less frequent.

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 particularly tight.

If you tighten a V-belt too much, bearing wear increases rapidly and belt life is shortened. The extra tightness causes additional wear on the sides of the belt where they contact the pulleys. When belt riding on the bottom of the pulley groove it is less effective for delivering power.

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 its charge. Slipping also causes the life of the belt to be shortened due to overheating.

Oil or grease allowed to accumulate on the V-belt will soften the rubber and cause permanent damage, so it is very important that the V-belts be kept clean. Always check alignment of belt and sheave. If it is not aligned the belt will wear out very soon.

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 most likely to meet the conditions under which your V-belt must work.

Checking Tension of V-Belt

1. Check your operator's manual to determine amount of deflection required. Deflection is the distance the belt can be pushed (or pulled) from its normal position. These two methods are recommended by manufacturers for checking tension of a V-belt:
   A. depressing the belt between pulleys and measuring the deflection with a ruler.
   B. deflecting with a spring scale using about 10 pounds and measuring the deflection with a ruler.
2. Deflect belt and measure deflection. The amount of deflection recommended in operator's manuals varies from 1/4 inch to 1 inch. The reason for these variations is the difference in distance between pulleys on various tractors, the varying cross-sectional size of belts, and different types of belts used.

Adjusting Tension of V-Belt

If the belt needs adjusting or the deflection increases either more or less than recommended for your tractor, proceed as follows (these same steps apply for removal and replacement of a V-belt).

1. Make certain the ignition switch is turned off especially if you have a spark-ignition engine. This is a safety precaution. When adjusting or replacing a belt you may move the crankshaft enough to cause one cylinder to fire and start the engine.
2. Loosen belt tension adjustment. There are two types of 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 the 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. First of all you have to provide all the slack available with either type of adjustment, then you can slip the belt off the smaller pulleys and over the fan blades. When installing a new belt that fits tightly, provide the maximum slack that is available. Then start one side of the belt over the edge of one of the pulley flanges and turn the pulley slowly. If there is not enough slack provided the belt may be severely stretched or damaged, thus shortening the life of the belt.
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 adjustment nuts securely. A new V-belt will normally stretch during the first few hours of operation and should be adjusted after the first day of operation.

LUBRICATING THE CLUTCH-RELEASE MECHANISM

The clutch provides the means of disconnecting the engine from its load while starting, shifting or idling. 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.

How the Clutch-Release Mechanism Works

A cluth is engaged and power is being delivered from the engine to the transmission. The clutch-release mechanism rides on the drive shaft but does not rotate. When the clutch pedal is pressed down, the clutch-release assembly is forced against the clutch fingers. This disengages the clutch. That portion of the clutch-release bearing in contact with the fingers rotates at engine speed. The rest of the assembly does not rotate.

When foot is lifted from the clutch pedal, the clutch-release mechanism is pulled back by a return spring until there is a small clearance between the clutch-release fingers and the clutch-release bearing. Thus, engine power is again delivered to the transmission.

The hydraulic clutch is similar to the standard clutch except that the clutch plate operates wet in a transmission fluid and the clutch is engaged and disengaged hydraulically. Hydraulic clutches don't normally require free travel or clearance adjustment.

The hydrostatic drive is an automatic fluid drive which uses fluid under pressure to transmit engine power to the drive wheels of the tractor.

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 tractor 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 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 is reached through a hole in the side or bottom of the clutch housing.
2. Apply lubrication sparingly.

   Most operator's manuals suggest either one or two short strokes of a grease gun, always follow the recommendations because overlubrication may force grease onto the clutch facings, causing slippage and rapid wear. Finally it will cause clutch chatter. If it is under-lubricated, or neglected, rapid bearing wear will result and in time it will fail.

MAINTAINING THE HYDRAULIC SYSTEM OIL LEVEL

The hydraulic systems of your tractor provide the "muscles" for controlling various operations. Some tractors have a single hydraulic system to steer, brake, control implements, and supply remote operation of tools. Other tractors may have only one or two hydraulic functions. These functions may use a common oil supply or they may have their own reservoirs.

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 commence to form.

The oil in the hydraulic system is subject to contamination, just as the engine and transmission oil are. Again, dust, rust, moisture and metal particles will damage the hydraulic system.

A well-maintained hydraulic system seldom gives the operator any trouble. Regular checks assure you that the oil level is sufficient.

Checking Hydraulic Oil Level

1. Adjust hydraulic control so that cylinder(s) is in a retracted position. On most tractors the oil level is checked with the cylinder(s) retracted. It means not under pressure. This is especially true with single-acting hydraulic systems. 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 drain check plug and some provide a dip stick on the filler cover or cap. This is very important that you should clean the area around the dip stick before removing it, because a small amount of dirt entering the hydraulic system can cause to overhaul the entire system.
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.
   Do not overfill, because this may cause the hydraulic pump to overheat.
5. Start engine and work hydraulic control lever several times. This is to make certain that all air is removed and the system is full of oil.
6. Recheck hydraulic oil level and add oil if necessary.
7. Replace filler cap.

CHAPTER IV

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 oftentimes the period which tractor manufacturers recommend. However, there are rather wide variations in the recommended periods for changing crankcase oil. With gasoline-operated tractors the intervals vary from 90 to 300 hours, with distillate tractors from 75 to 150 hours, with LP-gas tractors from 90 to 300 hours, and with diesel tractors from 60 to 300 hours. It mostly depends on type of work and operating condition of the tractor, therefore it is important that you should check your operator's manual for best results.

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 bearings and cylinder walls, and wear increased.

The engines which are built today, operating at higher compression ratios, higher speeds, under heavier loads and under winter as well as summer conditions, the job expected of an 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. Finally it reaches a point 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.

In summary if engine oil is to fulfill all these requirements the oil must do the following.

1. Keep a protective oil film on moving parts.
2. Resist high temperature.
3. Resist corrosion and rusting.
4. Prevent ring sticking.
5. Prevent sludge formation.
6. Flow easily at low temperatures.
7. Resist foaming.
8. Resist breakdown after prolonged use.

Selecting Engine Oils

Follow these general rules to get the best performance from your engine oil.

1. Use reputable brands of oil of the proper viscosity and service ratings as outlined in the operator's manual. If the manufacturer has a special oil which does a better job, use only that oil in your engine for typical recommendations from one manufacturer.
2. Drain and change oil at recommended intervals. Typical recommendations for off-the-road machines are to change oil for the first time

after 20-100 hours. Subsequent changes are made at least every 100-250 hours with the oil filter being changed at each or at alternate oil changes. For exact intervals, see the tractor operator's manual.

3. Select only oils which have been performance-tested--those having passed MS sequence tests and the machine manufacturer's own tests.
4. Never mix oils of various MIL specifications such as S-I and S-3 or S-3 and MIL-L-2104B. Oils carrying a similar MIL specification can be mixed even though obtained from different suppliers.
5. Use common sense when operating the engine--bring the engine up to normal operating temperature each time it is used. This will help reduce engine wear.
6. Keep oil containers covered, sealed, and protected to prevent contamination by dirt or water.

Changing Crankcase Oil

To change your tractor crankcase oil, proceed as follows.

1. Operate engine until thoroughly heated. Oil will drain more rapidly and completely 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, because it damages the plug and it will be hard to take it off next time.

   If the drain plug is magnetic, strike the plug against a solid object to remove the accumulated particles. Be careful not to damage threads. Gasket helps prevent oil leakage around the drain plug. Try to not lose or damage it.

3. Allow crankcase to drain for several minutes. This way oil will have time to drain from various parts of the engine.
4. Replace drain plug. If drain plug is equipped with a copper gasket, be sure it is in place on the drain plug. If filter element was removed, install a new one. Follow procedures under replacing oil filters.
5. Refill crankcase with new oil. Check 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.
6. 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 stock. Also check the pressure gauge to make sure that the oil pump is working properly.
7. Check for oil leaks.

   Check area around drain plug and around filter element for leak.
8. Check oil level on dip stick. Shut off the engine and after allowing engine to set for a few minutes. If oil is not to the "full" line, add more until it reaches that level. Do not overfill; this can cause oil consumption and oil foaming.

REPLACING THE OIL FILTER

Most tractor engines are equipped with an oil filter. The purpose of the oil filter is to help keep the crankcase oil free of abrasive contamination and to aid in removing other impurities that normally collect in the crankcase oil. The thing that needs to be kept in mind about any oil filter is that it must be serviced regularly in order to function properly. When it becomes clogged with deposits the oil no longer passes through the filtering material but bypasses the filter completely.

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.

If your service manual is for one of the older tractors, it may indicate that the oil filter should be changed when the "oil begins to darken." This was general practice before the time of additive oils. At that time a filter removed soot and dirt particles, that go to make up sludge, as well as hard abrasive particles.

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 yet be loaded with fine abrasive particles. Consequently, the only safe procedure is to change the filter at intervals recommended in your operator's manual. These intervals vary from 90 to 600 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. By-pass oil filter: only a portion of the circulating oil (possibly one out of every ten to thirty quarts) is diverted from the mainstream or pump through the filter element and rest goes directly to the engine bearings. This type is used on some tractor engines.
2. Full-flow oil filter: All of the circulating oil passes through the filter element. This type of oil filter also has a by-pass valve which becomes operative when the tractor is first started and the oil is cold, or when the filter element is clogged.

Replacing an Oil Filter

1. Stop the tractor engine and find location of oil filters. If there is question, check your operator's manual for oil filter location.
2. Wipe dirt from filter and surrounding area.
3. Remove drain plug (if provided) from base of filter and catch oil in pan.
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 and tighten it.
8. Install new filter 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 work. With a "spin-on" filter, apply a light film of crankcase oil to the gasket or sealing ring before installing it. This will prevent tearing the seal as it is tightened.

9. Install new filter cartridge. Do not tighten too much as seals can be damaged. With spin-on filters, turn the filter until the seal contacts the base, then tighten no more than an extra 1/2 turn. This keeps from over-tightening which distorts the seal and causes leaks. Be sure the new filter is an exact duplicate of the one recommended by the manufacturer.
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 oil if needed. Most filter elements require about one additional quart to recharge them.

SERVICING THE CRANKCASE BREATHER

In order to reduce the collection of liquid contaminants which tend to accumulate in an engine crankcase, a crankcase ventilation system is usually provided. When such a system is operating properly, unburned fuel vapors, moisture vapor, etc. are carried out of the crankcase. A crankcase ventilation system that functions effectively will eliminate moisture. Thus it will guard against water sludge and will free the crankcase oil of previous accumulations that could not be prevented, particularly during periods of starting or warm up of a cold engine or operation at low temperature.

Crankcase ventilation has two purposes:

1. To avoid a build up 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 breather cap and (b) by means of a ventilator pump. The latter seldom requires attention.

The breather cap method is mostly used, which can be found on older tractor as well as the new tractor. The breather cap is usually located on the valve cover.

The whirling action of the crankshaft and piston movement causes 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 chamber and enter the crankcase. This is called "blow-by." If these cannot 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 stick because normal blow-by is prevented. If this type of breather cap is used the operator must make sure that it is properly serviced. It should be cleaned by washing with kerosene and then dipped in oil. In some cases where varnish-like deposits accumulate on the element, it may be necessary to use a solvent.

Another type of system uses a vane or impeller pump to circulate the air. The air is taken from the main air cleaner and pumped through the engine. The outlet can be either a vent tube or the intake manifold. Some engines using this system have a filter on the engine side of the vent pipe. But these seldom need servicing except at the time of an engine overhaul.

Servicing the Crankcase Breather

1. Locate crankcase breather (1) check your operator's manual. 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 filler cap over the end of the filler 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 some others it will be removed by taking off a clamp or wing nut.
4. Wash filter element in solvent such as diesel fuel or kerosene. Do not use gasoline. It is an effective cleaner but a serious fire hazard.

   In some cases where varnish-like deposits accumulate on the element, it may be necessary to use a solvent such as a strong solution of lye water for cleaning.
5. Shake out excess cleaning fluid. If you used lye solution, allow time for water to evaporate.
6. Relubricate mesh with light crankcase oil (SAE IOW). Use clean oil. Used oil is not very effective.

7. Remove excess oil.

8. Reinstall breather(s). If a gasket or felt washer was there when you removed the breather, make sure that you reinstall it. If the seal or washer is broken, replace with a new one.

MAINTAINING TRACTOR TIRES

Tire manufacturers 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.

Proper inflation is vitally important to proper service life of the tire. Tires are designed to operate with a certain sidewall deflection or "bulge." Correct air pressure insures proper traction, flotation, support of load, and prevents excessive flexing of the tire which could cause overheating. Correctly inflated tires permit all of the tread to contact the ground, yet are not soft enough to flex excessively.

Overinflation prevents full contact of the tire tread with the ground or road. This subjects the center of the tread to excessive wear. Because the tire is more rigid, it is more liable to damage by striking curbs, rocks, and other objects which can cause breakage of the cord plies. Cords may lose as much as 35 to 40 percent of their tensile strength (resistance to rupture).

Underinflated tires flex excessively at every turn of the wheel, resulting in high internal heat and premature failure. Underinflation is indicated by excessive wear of the sides of the tread while the center is relatively unworn.

Check Tire Inflation

1. Always check and inflate, if necessary, when the tires are cold. This is very important since, as the tires become heated through use, the air expands and the pressure increases. In some industrial tires it may take as long as 24 hours or longer for the tire to return to normal temperature.
2. Remove valve cap and check pressure. Add air (or deflate) as needed to secure proper pressure.
   Never "bleed" pressure from hot tires. This invariably results in the tire pressure being too low when its temperature becomes normal, often resulting in tire damage when put to work. Either reduce the load, the speed, or both.
3. If a tire becomes low while operating, adjust the pressure to the same as that of another tire of the same size. Recheck the pressure after about 30 minutes of operation.
4. Always use a liquid-type pressure gauge when checking pressure in tires with liquid ballast. Check the pressure with the valve stem at the bottom. If it is impossible or undesirable to check the pressure with the valve stem at the bottom, locate the stem at the top. Add about 1/2 pound to the pressure gauge reading for each foot height of liquid in the tire for the actual pressure, depending upon density of ballast.
5. Wash gauge with clean water after using on tires containing calcium-chloride solution.
6. 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.

Modern off-the-road machines are designed with adequate horsepower for their field or job site operation. However, machine weight by itself may not be sufficient for full traction and drawbar pull, resulting in tire slippage. Tire traction can be judged by looking at the tire tread pattern after pulling under load.

When too much weight is used, the tire tracks will be sharp and distinct in the soil and there will be no evidence of slipping. This is bad, as the tires are literally geared to the ground and do not allow the flexibility of engine operation that is obtained when some slippage occurs.

When the tires have too little weight they lose traction. The tread marks are entirely wiped out and forward progress is slowed. Not only is less work done but the tires wear excessively.

When the tires have proper weight, a small amount of slippage occurs. Usually, between 10 and 15 percent slippage is considered ideal in the field. When the tire is properly weighted, the soil between the cleats will be shifted but the tread pattern is still visible in the tire track. Proper weighting allows the engine to perform at its best with maximum flexibility.

Checking Tire Condition

1. Check side walls for cuts or breaks, cracks or "checking" caused by overinflation or long exposure to sunlight. Radial cracks resulting from underinflation and heavy drawbar load. These should be repaired in order 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 THE TRACTOR

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

1. Generator bearings, 8 to 10 drops of SAE-20 oil.
2. Distributor shaft, 8 to 10 drops of SAE-10W oil.
3. Distributor camshaft wick, 2 drops SAE-10W oil.
4. Power-steering oil level--unless it is supplied from the hydraulic-control unit.

CHAPTER V

MAINTENANCE AFTER 250 HOURS OF OPERATION

MAKING VALVE-CLEARANCE ADJUSTMENT

You, as a machine or tractor operator, should understand how the intake and exhaust valves work.

The engine must take in fuel-air and exhaust spent gases at precise intervals. The valves do this job by opening and closing the intake and exhaust ports to the cylinder. The sequence of valve operation for a typical four stroke cycle engine are:

1. During the intake stroke, the intake valve opens, allowing the fuel-air mixture to enter the combustion chamber.
2. During compression and power strokes, both valves are closed to seal in the combustible mixture.
3. During the exhaust stroke, the exhaust valve opens, allowing gases to be exhausted.
4. At the end of the exhaust stroke, the intake valve opens, beginning another cycle.

The camshaft is turned by the engine crankshaft. A lobe (cam) on the camshaft causes the cam follower and push rod to push the valve open. The spring closes the valve when the cam allows the push rod and cam follower to return to the low side of the cam. Cam movements are designed to open or close the valve at the right moment.

How often should you check valve clearance. Manufacturers differ in their recommendation--some say after every 150 hours 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. The engine will use fuel more efficiently.

b. The engine will start more easily.

c. Maximum power will be achieved.

d. Valves will give longer service.

e. Overheating of the engine is less likely to occur.

f. Smoothest engine operation will be provided.

When valves are properly adjusted, there is a small clearance between the valve stem and the end of the rocker arm. (This clearance is sometimes referred to as "valve lash" or "tappet clearance.") Valve clearance allows for the heat expansion of parts. Without clearance, the heated parts would cause the valves to stay partly open during operation. This clearance is small, varying from approximately 0.006 inch to 0.030 inch. Each engine manufacturer recommends a definite clearance for his engine model.

The valve clearance may vary depending on the engine model and whether the engine is hot or cold during adjustment. Some engines run hotter than others.

Too little valve clearance throws the valves out of time. This causes valves to open too early and close too late. Also, valve stems may lengthen from heating and prevent valves from seating completely. Hot combustion gases rushing past the valves cause overheating because the valves seat so briefly or so poorly that normal heat transfer into the cooling system does not have time to take place. This causes burned valves.

Too much valve clearance causes 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 also become damaged. When valve clearance is properly adjusted, the camshaft allows the speed of valve movement as it closes. But with too much clearance, the valves close with great impact, cracking or breaking the valve and scuffing the cam and follower.

Preparing Tractor for Valve Adjustment

1. Read your operator's manual to determine whether you should check valve clearances while the engine is hot or cold.
2. Remove parts as necessary or part that interfere with removal of valve cover.
3. Remove the nuts or cap screws which hold the cover in place.
4. Carefully remove the valve cover. Strike the cover on one side and then on the other with the palm of your hand. Don't worry about damaging the gasket because you should replace it with a new one each time the cover is removed.
5. To prevent accidental starting of the engine during valve adjustment, take these precautions:
   a. Disconnect the center terminal wire to distributor.
   b. Or, remove spark plugs.

   With diesel engines, shut off the fuel supply to the injection pump. If these precautions are not followed, the engine could start during valve adjustment and cause serious injury to you.

Making Valve-Clearance Adjustment

1. Determine from your operator's manual valve clearance, valve arrangement, timing marks and firing order.

2. Be sure the engine is at the recommended temperature before you begin valve adjustment.
3. Check the tightness of the cylinder head nuts or bolts with a torque wrench. Refer to the operator's manual or service manual to determine the proper torque to apply and the sequence.
4. Turn engine over until piston in the No. 1 or first cylinder is at top dead center (TDC) of its compression stroke. Most engines have timing marks on the flywheel or fan drive pulley to mark the "TDC" or other timing point. Check the alignment of timing marks. No. 1 cylinder is the one next to the radiator on upright engines. On horizontal engines, it is the one next to the flywheel.

   A positive way to find when a piston is at "TDC" is to remove the spark plug or injection nozzle and hold your finger over the opening. On the compression stroke, air will be forced out against your finger until the piston reaches the "TDC" position.
5. With the No. 1 piston at "TDC" check the valve clearance by using the recommended feeler gage thickness(es). Adjust clearance if necessary by inserting gage between valve steam and rocker arm of both valves. Turn the adjusting screw up or down until the clearance is proper to the specification. 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. Hold the adjusting screws from turning and tighten the lock nuts.
6. Be sure to determine which are intake and which are exhaust valves because the clearances are usually different for the two.
7. Determine which cylinder fires next. The firing order will tell you

this. Usually the firing order appears on the side of the engine. If it does not, refer to your operator's manual.

8. Set next cylinder at TDC.

   Turn the crankshaft until the next cylinder to fire is at top of its compression stroke. With 2- and 4-cylinder engine, turn the crankshaft 1/2 turn or 180°. With 6-cylinder engine, turn the crankshaft 1/3 turn or 120°. On 8-cylinder engines, turn 1/4 turn or 90°.

9. Set remaining valve clearance. Proceed in the same manner as on No. 1 cylinder with remaining cylinders.

One quick way to set valves is to use the following procedure when the intake and exhaust valves are arranged in a conventional manner, beginning with an exhaust valve followed by two intake valves, then two exhaust valves, and so on, ending with a single exhaust valve.

FOUR CYLINDER ENGINE

With	Adjust valves (engine warm)							
No. 1 piston at TDC compression	1	2	3		5			
No. 4 piston at TDC compression				4		6	7	8

SIX CYLINDER ENGINE

No. 1 piston at TDC compression	1	2	3		5		7		9			
No. 6 piston at TDC compression				4		6		8		10	11	12

Reassembly After Valve Adjustment

1. Clean and install spark plugs or (injection nozzle).
2. Before installing valve cover, start engine to check lubrication of rocker arms. You may have to install some of the parts you removed

if they are required to run the engine. Be certain an ample supply of oil is being delivered to all rocker arms.

3. Position new gasket on the cylinder head.
4. Install valve cover. Be certain that the gasket fits properly under the edges of the valve cover or oil will leak by and increase oil consumption.
5. Install all remaining parts.

MAINTAINING TRACTOR SPARK PLUGS

(Spark-ignition Engine)

Operator's manuals are often not very definite, some manuals stress that spark plugs should be serviced and checked "regularly," "when required," "periodically," or "when not firing regularly." Others suggest definite time intervals such as 150 hours, 200 hours or 250 hours.

The spark plug provides a means whereby a spark can occur inside the combustion chamber. Electric current from the ignition coil travels at regular intervals through the high-tension lead wire to the spark-plug terminal. The current is conducted through the center electrode to the spark gap. High voltage (10,000 to 20,000 volts) pushes the current across the spark gap to the ground electrode. As the current jumps the gap, a spark is formed and the air-fuel mixture in the combustion chamber is ignited by the spark.

The importance of maintaining your tractor spark plugs in proper condition can be judged from an investigation of 50 farm tractor performance.[1] New plugs were installed in each tractor unless new ones had been installed

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[1]Floyd N. Reece, An investigation of farm tractor performance, Master's thesis, Department of Agricultural Engineering, Kansas State University, 1959.

within two weeks preceding the test. An average increase in horsepower of 5.6 per cent and decrease in fuel consumption of 6.1 per cent was obtained by installing new spark plugs in the 45 tractors. In each of seven tractors that misfired under load, new plugs eliminated the misfiring in all seven cases, and their horsepower was increased 21.5 per cent and decreased fuel consumption by 14.2 per cent.

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.

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 trouble developing enough voltage to fire a worn plug. This makes spark plug maintenance all the more important on older tractors.

Selecting the Spark Plugs

Whether you are buying new spark plugs or reconditioning old ones, it is important that you understand the differences in spark plug 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. If you want to substitute the spark plug or you could not find the brand that you already have, see the spark plug manufacturers chart for proper substitute.

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 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 coolant. The longer the insulator tip, the further the heat must travel, and the hotter the plug becomes. For an engine that does not reach relatively high operating temperature a "hot" type of spark plug is needed.

By using spark plugs of suggested heat type, you get longer, trouble-free service from them and from your tractor. The spark plugs become hot enough to 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 expect them to overheat. Overheating will cause blistering, burning of the electrodes and engine knock. Therefore engine knock is caused by the plugs becoming so hot that they ignite the fuel charge before the spark plug fires. The temperature in this case 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 happens at 700°F to 800°F and below.

Engine design affects the length or "reach" of plug recommended. This is especially true in 14 millimeter sizes, which is one of the common sizes used on farm tractors. "Reaches" 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. There are 4 different "reaches" of 14 millimeter plugs, 3/8", 7/16", 1/2" and 3/4".

If you use longer reach plugs in your tractor engine than the ones which are recommended, they will extend into combustion chamber and may interfere with piston or valve action. The exposed threads will collect deposits and the plug will be hard to remove.

If plugs with little or too short reach are used, the spark is shielded, the reach will not extend into the cylinder far enough for proper combustion of the fuel. In this case the exposed threads in the cylinder head fill with deposits to that it is difficult to install a plug with the proper reach unless the threads are cleaned with the proper thread tap.

<u>Removing Plugs from Engine</u>

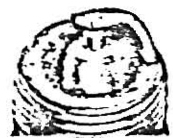
1. Pull the wire from the plug by grasping the terminal, not by pulling on the wire. Position ends of spark plug wires so you can connect them to the same cylinder when they are reconnected.

2. Use a deep-well socket or special spark plug socket with rubber insert to loosen the spark plug. Hold the socket straight to prevent breaking the insulator.
3. After loosening the plug but before removing it, always clean the area around the spark plug by blowing, wiping, or brushing. This will prevent dirt from falling into the cylinder after removal. Be sure to protect your eyes while blowing.
4. Remove the plugs and place them in order to match the cylinder each came from. The condition of the spark plug can tell you a lot about the operation of a particular cylinder. You may be able to detect a cylinder that is using oil or one that is not working properly.

Analyzing Condition of Spark Plugs

Check the condition of all spark plugs removed--even if you are replacing them with new ones. The appearance of the plug's firing end can tell you whether your engine is using too much oil, over-fueling, misfiring, or over-heating. Condition of plugs may also warn you of a wrong grade of fuel or an incorrect spark plug. The chart at the right is for you to become familiar with spark plug conditions and what they mean to you.

SPARK PLUG CONDITION CHART

Condition	Identification	Caused By
 Oil Fouling	Wet, sludgy deposits.	Excessive oil entering combustion chamber through worn rings and pistons, excessive clearance between valve guides and stems, or worn or loose bearings.
 Gas Fouling	Dry, black, fluffy deposits.	Incomplete combustion caused by too rich a fuel-air mixture or by a defective coil, breaker points or ignition wiring.
 Burned or Overheating	White, burned, or blistered insulator nose and eroded electrodes	Engine overheating caused by improper ignition timing, wrong type of fuel, loose spark plugs, too hot a plug, or low fuel pump pressure.
 Normal Conditions	Rusty brown to grayish-tan powder deposit and minor electrode erosion.	Regular or unleaded gasoline.
 High Lead Deposits	White, powdery deposits.	Highly leaded gasoline (premium gasoline).
 Carbon Fouling	Hard, baked on black carbon.	Too cold a plug. Weak ignition, defective fuel pump, dirty air cleaner, too rich a fuel mixture.
 Silicone Deposit	Hard and scratchy.	Formed when fine sand particles combine with anti-knock compounds in fuel. Most common in dusty areas. The plugs cannot be cleaned.
 Splashed Fouling	Splattered deposits.	Deposits from misfiring loosened when normal combustion chamber deposits are restored after new plugs are installed. During high-speed run, these deposits are thrown into plug.

Servicing of Spark Plugs

Spark plug service has three basic jobs:

1. Inspecting.
2. Cleaning.
3. Gap adjustment.

Inspecting Spark Plugs

Closely inspect the plugs, look for the normal or abnormal wear shown in the spark plug condition chart. Then decide whether to recondition or replace the plugs.

It is very important that, if one plug is replaced, all the plugs should be replaced to get the full advantage of new plug performance and economy. This does not apply, of course, if unusual conditions cause premature failure to just one in a fairly new set of plugs. Normally, replace the whole set of plugs after long intervals of use. Check your operator's manual when to replace it. Normal wear can double the voltage requirements of a spark plug even in a short period of time.

Cleaning Spark Plugs

Most spark plug manufacturers do not recommend use of a power wire brush for cleaning the spark plug.

1. Badly fouled plugs should be replaced. It is doubtful if sand blasting or liquid cleaning will remove all the deposits from such 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 removing dirt so the plug will not bind when reinstalled.
4. Remove the rest of 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 seconds 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. To allow room for filing, bend the ground electrode away from the center electrode.
7. File both electrodes until they have flat bright surfaces (like a new plug). However, remove as little material as possible. The flat surfaces help assure against misfiring. About 25 to 40 per cent less voltage is required to fire a spark plug with sharp edges on the central electrode than one with a round end. It is very important that you never bend the center electrode. Doing so you may crack or break the insulator tip.
8. Bend ground electrodes back to original position.
9. Clean or blow metal fillings from plug.

Gap Adjustment of Spark Plugs

1. Whether the plug is new or used, always check the gap before you install the plug. Refer to your operator's manual for the correct

gap, it is usually .020, .025, or .030 inch.

2. Use a wire feeler gage. Do not use a flat gage to check the spark plug gap. A flat gage does not give an accurate indication of the true gap. 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. A wire gage will fit the contour of irregular surfaces.
3. Check the gap with the proper thickness gage. Bend the ground electrode, as necessary, with a gap setter which is usually a part of the spark plug gage.

Installing Spark Plugs

Spark plugs are cooled by the coolant in the passages of the engine head. For this reason, be sure the area around each spark plug post is absolutely clean before installing plugs.

1. Install the plugs and tighten with your fingers. Be sure to use a gasket--unless the plug has a tapered seat. This type of plug does not require a gasket. When installing plugs you should use new gasket, because old gaskets will be flattened by tightening; however they may still be useable. A properly tightened gasket conducts almost 50 per cent of the heat flow from the plug to the engine head and coolant.
2. Tighten plug with a spark plug socket and torque wrench. Refer to operator's manual for proper torque to apply. If the plug is not tight enough against the gasket, the plug will overheat. If the plug is too tight against the gasket, the porcelain insulator may break. Also, the plug could be distorted and change the gap between the electrodes.

3. Check the condition of the spark plug wire before reinstalling. If the insulation is cracked or extremely soft, replace the wires. Defective insulation will allow electrical leaks and misfiring. Check for looseness and not properly fit of the plug connectors. If they are not repairable replace the wires with new ones.
4. Check the polarity of the spark at the spark plug. To do so, hold the metal connector of the spark plug wire about 1/4 inch from the spark plug terminal. Insert the point of an ordinary lead pencil in between. If the spark feathers on the plug side, the polarity is correct.

   If the spark feathers on the connector side, the polarity is reversed. To correct, interchange the primary wire connections on the ignition coil.

CLEANING THE BATTERY

When you operate your tractor, moisture, dirt and acid gradually accumulate on the top of the battery. Gases that develop when the battery is being charged by the generator or alternator carry acid as they escape from vents in battery caps. Acid settles on battery top and may accumulate enough to provide electrical paths to ground. This causes a battery to lose its charge and also causes corrosion of the cable terminals, carrier and the tractor frame.

If a battery is charged but not being used, it has a natural tendency to discharge. At 0°F. a fully-charged battery may last a year before it becomes completely discharged. At 125°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. Remove ground strap or cable from battery terminal posts if they are corroded. This prevents short circuits caused by accidentally grounding the other terminal with a tool, such as laying a wrench or screwdriver on the battery in a way to contact the opposite battery terminal and some part of the frame.
2. Remove the other battery cable.
3. Clean cable clamps and battery post. A wire brush is easiest to use and very effective on outside surface. Clean the inside of the clamps with a round wire brush cleaning tool or sandpaper.
4. Remove loose dirt and corrosion particles from top of battery.
5. Brush soda-and-water mixture on top of battery, on posts and on clamps. Use about two tablespoons of baking soda in a pint of water. Mix thoroughly and apply on the battery. Soda will react with water and cause considerable foaming. Apply until foaming stops. Avoid entering of soda and water into the battery through the breather hole in each cap; it will weaken the acid in the electrolyte.
6. Wash away residue with clean water.
7. Dry top of battery with a clean cloth.
8. Reconnect cable and ground strap. Connect positive or power cable first to help avoid grounding the battery with your tools. Don't pound the clamps in place. Tighten the clamps real good.
9. Apply a coating of petroleum jelly (vaseline) or light-grease to post and cable clamps.

CLEANING THE SEDIMENT BOWL AND FUEL FILTER

Most agricultural machines and tractors are equipped with a combination sediment bowl and fuel filter or strainer. Contamination of fuel is a major cause of excessive engine wear and failures. On some diesel tractor 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 main purpose of a sediment bowl and filter is to trap water and any foreign objects that may contaminate the fuel system and avoid clogging jets of a carburetor. Moisture is a problem in fuel for all types of engines. If it mixes 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 Fuel Filter

1. Shut off fuel supply line, usually this is either located at the fuel tank or the sediment bowl.
2. Loosen the nut which holds the sediment bowl in place and remove bowl and gasket.
3. Remove strainer screen.
4. Wash strainer in cleaning solvent. If screen is difficult to clean, it may have varnish or gum deposits that must be cleaned with a carburetor cleaner solvent.

5. Clean sediment bowl. Use a cloth dampened with the cleaning solution. Wipe the bowl dry and be sure there is no lint remaining in the bowl.
6. Drain sediment from fuel tank at the tank, if possible.
7. Open fuel valve and observe the flow of fuel. Catch the fuel in a container. This should allow any dirt or water to escape from the tank and fuel line. If the vent hole in the fuel tank cap is plugged, the flow will be slow. Close valve. Clean the cap, if clogged, in solvent.
8. Reassemble the sediment bowl, strainer or filter and gasket.
9. Tighten the bowl against gasket. On some systems you must let fuel run into bowl before tightening it air-tight.
10. Open the fuel valve. Start the engine and check for leaks.

ADJUSTING THE CARBURETOR

(Spark-ignition Engines)

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

When the fuel system is operating properly, the maximum in fuel economy and horsepower is achieved. The study of 50 farm tractors by Floyd N. Reece,[1] it was found that 23, or 46 per cent, of the tractors tested were being operated with the air-fuel mixture too rich. The average specific fuel consumption was decreased 9.5 per cent on these 23 tractors by adjusting the

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[1]Floyd N. Reece, An investigation of farm tractor performance, Master's thesis, Department of Agricultural Engineering, Kansas State University, 1959.

carburetors, 13 or 26 per cent with the air-fuel mixture excessively lean, and 28 per cent required no adjustment in carburetor.

Those tractors that were properly adjusted after having too lean a mixture, had an average increase in fuel consumption of 5.3 per cent which was offset by an average increase in horsepower of 5.3 per cent. Another factor to consider is that a lean mixture burns slowly. The slow-burning exhaust gases are extra hot which result in burning of valves.

The Functions of a Carburetor

To adjust the carburetor properly, make sure that you understand how it operates.

The function of the carburetor is to provide the proper mixture of fuel and air to the engine. Under normal operating conditions, the mixture is about 13 1/2 pounds of air to one pound of fuel or an air-to-fuel ratio of 13.5:1. However, an engine will run on ratios varying from as rich as 7:1 to as lean as 20:1.

A common way of stating the proportion of air to fuel is by volume. One gallon of fuel requires about 9,000 gallons of air for combustion in an engine.

Piston movement in an engine creates a vacuum or low pressure area. Atmospheric pressure forces air to flow into this vacuum. 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 or 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." A venturi is a restriction in any passage which causes air to move faster and so lowers the pressure of the air passing through it. The faster the air moves, the lower the air pressure at the venturi. This low pressure is the basic force by which a carburetor works.

To see the relation between the speed of air and its pressure: hold the edge of a sheet of paper to your lower lip, allowing the rest of the paper to hang limp. Now blow across the top of the paper and notice how the paper rises. Air moving across the top of the paper exerts less pressure to the paper than the stationary air under the paper. The pressure difference forces the paper upward. The faster the air, the lower the pressure above the paper, causing the paper to rise still higher.

When the incoming air reaches the venturi 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 low pressure area of the venturi. The fuel supply is kept at a constant level in the nozzle by means of a float valve controlling the supply from the fuel tank into the float chamber.

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. There is addition of an accelerating well in a carburetor 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 hasty demand for power, the governor opens the throttle valve and air moves past the nozzle much much faster, picking up additional fuel. This way of working 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 soon 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 carry out another work that must be done--it must supply a richer idling mixture. This needs an air-fuel ratio of about 12:1. An engine does not operate well at idling speed unless a rich mixture is provided. To make up for this situation, carburetors are built with a distinctive provision to supply the proper idling mixture. When the fuel passes from the accelerating well up through a distinctive passage and is mixed with air where it joins the passage from the idler air bleed. The mixture then passes into the manifold through the upper idle port 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. In this case the air also enters through the lower idle port with the throttle valve completely closed.

While the throttle valve is opened, the lower idle port becomes exposed to vacuum from the manifold. Through it an additional supply of air-fuel mixture is delivered to the engine. About this time the main fuel nozzle begins to supply fuel and continues to do so on an increasing scale as the throttle valve opens.

There are two other special parts on a carburetor that you should know about, they are (a) the choke valve and (b) the pressure-equalizing arrangement to the fuel float chamber.

The choke valve creates a rich fuel mixture for starting a cold engine, it is located at the carburetor air intake. 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 air 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 an opening or a path that connects at the carburetor air inlet and stretches forth around the venturi to the fuel float chamber. This protects the air pressure in the float chamber the same as that entering the carburetor. Since the air cleaner causes a slight drop in air pressure as air passes through it on its way to the carburetor so this is an important provision, without this connection, fuel in the float chamber would have to be exposed to atmospheric pressure. In order to force extra fuel through the nozzle tip to make the mixture extra rich, the atmospheric pressure should be enough more than that of the air entering the carburetor.

This signifies that the float chamber must be air tight and completely sealed opposed to atmospheric pressure. This also avoids dirt and dust from entering the carburetor.

Preparing for Carburetor Adjustment

Before attempting to make carburetor adjustment, it is important that you check the following points.

1. Check the strainer screen in the carburetor for clogging. Find out from your operator's manual whether it has one or not. The screen is

usually located at or near the fuel inlet to the carburetor.

2. Shut off the valve on fuel line and disconnect line at the carburetor. Gasoline is flammable. To avoid injury, do not smoke or allow any flame near the area. Also do not allow gasoline to spill onto any hot surface, such as a hot manifold.
3. Remove screen from carburetor. It is often 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 the manifold connections and around the carburetor gaskets. To do so squirt a few drops of oil over suspicious areas. If oil is drawn into the manifold, air is leaking into the manifold. Tighten fittings and check again. If leaks are still present, replace gaskets. The carburetor cannot be adjusted properly if the screen is clogged or the manifold is leaking.

Adjusting Idling Speed

The idle adjusting screw determines how completely the throttle valve closes. This controls the idling speed of the engine. The idling-speed or bumper-screw adjustment is commonly located on the engine side of the carburetor if viewed from the engine side, you would see that the bumper screw works against a pin. Over a period of time this screw may gradually work out, allowing the engine to idle too slowly and causing it to die when the speed-control lever is all the way down.

1. Start the engine and allow it to warm to operating temperature.
2. Set the speed-control lever at the completely closed position.

3. Adjust to normal idling speed. Turn the idle speed adjusting screw clockwise to increase speed, counterclockwise to decrease speed. Check your operator's manual for proper idling speed. Depending on your engine, this may vary from 300 rpm to as high as 800 rpm. If your tractor does not have a tachometer, you may have to set the speed by sound, which is not a very good way to set it, because you could be off by several hundred revolutions. An electric tachometer can be used for best results.

Adjusting the Idling Fuel-Air Mixture

Adjust the fuel-air mixture while the engine is idling. Some manuals say a setting of so many turns from the completely closed position. These suggestions are usually quite satisfactory if you use the ones that apply to your specific tractor. Use the following procedures to get a finer adjustment.

1. Set the speed-control lever in the idling position with the engine at normal operating temperature. If it is not, operate your tractor engine until it reaches normal operating temperature.
2. Locate idle mixture adjusting screw. If you could not find it, see your operator's manual.
3. Turn the idle-mixture adjusting screw clockwise slowly until the engine begins to "roll" or slow down and shake. This decreases the air flow and causes a richer mixture on some engines and decreases fuel flow on other engines, resulting in a leaner mixture. The engine is not getting the correct fuel-air mixture when it idles roughly.

4. Turn the adjusting screw counterclockwise until the engine begins to run smoothly. Do this slowly so that the engine has a chance to adjust to the changing mixture. You may have to change the direction you are turning the screw several times until you are sure that the best setting has been achieved and the engine runs smoothly.

   Another method is to turn the screw in until the engine runs rough. Then turn the screw out until the engine again runs rough, counting the number of turns. Now turn the screw in one-half the number of turns for the best setting for smooth operation and economy.

   If you find that the engine is not affected by one or two complete turns of the adjusting screw, this may indicate that something is wrong, a leak in the float valve, too high fuel level in the float chamber or deposits in the manifold around the throttle valve which are restricting air flow. For correcting this problem see a mechanic or your dealer.

5. Recheck the idle speed after the idle fuel is set, as the mixture could change the speed. Generally, idle speed and idle fuel should be set together.

Adjusting the Fuel-Air Mixture

The valve which controls the adjusting for fuel-load or high-speed conditions is called "main adjusting needle," "power-adjusting needle," or "full-load fuel adjusting needle." All refer to the same adjustment. Many of the later model engines do not have this adjustment (are preset at factory). Before you do this adjustment make sure the engine is at full operating temperature. To adjust the load fuel-air mixture, proceed as follows:

1. Run engine at full throttle either with or without load. Provide a constant load on the engine, if possible. A dynamometer and flow meter are somewhat more satisfactory to use for this adjustment. Add load until speed decreases slightly from its high idle speed. Do not try to adjust the carburetor while your tractor is in motion (to provide load). You may seriously injure yourself and cause an accident which could injure someone else nearby.
   If you make the adjustments without load, follow up with a final check to make sure the adjustment is satisfactory under load.
2. Turn the load adjusting screw clockwise until engine begins to lose power. This indicates that you have reached the borderline on the lean side of the mixture. At this setting your engine will have high fuel efficiency, but it would not be developing its maximum horsepower. The temperature of the exhaust would be too high, which could cause a burned valve.
3. Turn the adjusting screw counterclockwise (or out) until the engine gives off black smoke from the exhaust. This indicates that the fuel-air mixture is too rich. You will get satisfactory horsepower, but the fuel efficiency of your engine will be low.
4. Turn the screw clockwise until engine runs smoothly and at full speed. Turn the screw slowly so that the engine will have time to adjust.
5. Check this adjustment by accelerating the engine quickly while under load. If you were not able to adjust the engine under load, you should now operate the tractor to determine how it accelerates under load. The engine should accelerate quickly when you move the speed control lever suddenly. If the engine backfires, the mixture is too

lean. If dark-colored smoke comes from the exhaust, the mixture is too rich.

ADJUSTING TRACTOR BRAKES

The recommended intervals for brake adjustment vary from 200 hours to 400 hours of tractor operation. Some operator's manuals do not mention a certain time for adjusting brakes. Most tractors have two brake pedals which may be used for stopping; in this case both pedals are used, or for turning, in this situation, one pedal is used from either side to help turn the tractor.

To keep the tractor safe to operate, be sure to maintain the brakes properly. Brakes that are out of adjustment can cause uneven braking or poor braking which may cause your tractor to overturn or crash into something, injuring you or others and damaging the tractor. If the tractor operates in slow speed, uneven adjustment may not be very serious. But, with top tractor speeds available on most present-day tractors, uneven adjustment between the two wheel brakes could easily cause a serious injury to you and damaging the tractor.

Brakes are not hard to adjust, but the job of adjusting may be quite confusing because brakes are located differently according to different manufacturers design.

Three types of brakes are commonly used 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. The braking action is obtained by pulling the band tightly around a rotating drum. When the force is released, a spring retracts the band so that the drum can rotate freely.

The shoe brake is forced against the inside of the brake drum and slows or prevents the drum from turning. Springs hold the brake shoes off the brake drum until forced against the drum when the brake pedal is pressed. This type of brake is popular on automobiles.

The mechanical disc brake is somewhat more complicated but is coming into more common use. Today disc brakes are commonly used on agricultural tractors. Each brake mechanism consists of two driven brake discs which have friction facings attached to each side and two actuating discs which force the brake discs against a stationary braking surface. The driven brake discs are attached to either differential input shaft or to each driven axle within the differential housing. Between the brake discs are two actuating discs which are held together by springs. Three steel balls are located in tapered cups on the inside of each actuating disc. When the actuating discs are rotated in opposite direction by lever, the steel balls ride out of their cups and force the brake discs apart. As the brake discs are forced farther apart, they bind against the stationary braking surfaces of the housing and slow or stop the shaft from turning.

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 and primarily used on the larger tractors and equipment. 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 supplies the oil under pressure when needed instead of wasting it through the relief valve.

Procedures for adjusting tractor brakes vary, depending on (1) the type of brakes used on the tractor, (2) the location of the brakes and (3) the kind of linkage between the pedals and the brakes. The procedures that follow are general and will serve for adjusting brakes on most tractors.

Adjusting Mechanical Brakes

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 pull rod 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. The brake should 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 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 1 1/2 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. Do not adjust too tight. When the brake does not latch, 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 reassembly, or tightening of lock nuts, to maintain adjustment.
7. Adjust the 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 lightest 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 on 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 Hydraulic Brakes

These three steps should be followed in order to adjust hydraulic brakes: (1) Bleeding, (2) Adjusting push rods, (3) Adjusting brake mechanism.

Bleeding Hydraulic Brakes

1. Locate the brake master cylinder and the slave cylinder. The master cylinder is usually near the brake pedals and slave cylinders are attached near the brake housing.
2. Clean dirt from the cylinder especially the bleed screws.
3. Check the fluid level in the master cylinder. If the reservoir is low fill with the recommended fluid.
4. Have someone sit in the operator's seat to operate the brake pedals.
5. Have your helper slowly depress the brake pedal for the right brake while you crack the bleed valve. Allow the fluid to escape slowly. If air is in the cylinder, bubbles will be noticed as you do this.
6. Before the pedal is released, close the bleed valve. The pedal must be released slowly to avoid churning the fluid and creating more air pockets.
7. Repeat this procedure until no bubbles appear at the bleed valve, and repeat the same steps for other cylinder. Check the master cylinder to be sure that enough fluid still present in the reservoir. If it is low fill it again.
8. Bleed the nearest slave cylinder in the same manner. Repeat for the other slave cylinder.
9. Check the pedal action for a soft or spongy feel. If it does not have a firm feel, bleed it again.
10. Refill the reservoir to the proper level. Replace the cover.

Adjusting Hydraulic Brake Push Rods

1. Loosen the lock nuts on the push rods of the master cylinder.
2. Adjust the push rods until proper pedal free travel is obtained. Each push rod must be adjusted so that the pedals are equal when the brakes are applied.
3. Check your operator's manual for the slave cylinder adjustment. If the manual recommends, do so.
4. Check the brakes for proper braking action. Jack up the tractor so that the drive wheels are off the ground. Be sure to block the tractor securely.

Adjusting Hydraulic Brake Mechanism

If the brakes do not slow at the same rate, adjust the push rods or bleed the brakes again. When one side of the hydraulic system still contains air, it will not apply as much pressure to the brakes as the other side.

ADJUSTING THE ENGINE CLUTCH

A clutch will operate for a long period of time without adjustment unless it is mis-used or 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. This is the reason that most operator's manuals recommend a service intervals after 250 hours of operation.

Once the clutch starts to slip, it will wear rapidly. The clutch should be adjusted immediately; otherwise the wear may become so serious that you will have to take it to a mechanic shop for repairing.

A tractor engine must be able to run free of load for starting, idling, and to permit shifting gears when a conventional transmission is used. It is not only necessary for the engine to be running before a load is applied, but it is desirable to have some means of applying the load gradually through the mechanism of the clutch.

Operation of Clutch

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. In the engaged position, the pressure plate provides pressure against the clutch plate and forces the plate against the flywheel. Power is transmitted from the engine through the flywheel and clutch plate to the drive shaft or transmission input shaft.

The clutch is disengaged by applying pressure on the pedal which pushes the clutch release assembly against the release levers. The levers pull the pressure plate away from the clutch plate so that the clutch plate is no longer forced against the flywheel. In this situation the flywheel and pressure plate are free to rotate independently of the clutch plate and drive shaft.

In the engaged position, there is clearance generally 1/16 to 3/16 inch between the clutch release bearing and the clutch release levers. This is to allow for wear of the clutch plate facings. As the facings wear, the release levers move closer to the clutch release bearing until, eventually, there is no clearance. Adjustment must then be made or the release levers will press continuously on the clutch release bearing and pressure will be reduced on the clutch plate. This will cause the clutch release bearing to fail soon and the clutch will slip which cause a burned clutch and rapid facing wear.

To maintain this necessary clearance between the bearing and the release levers (fingers), the clutch pedal free travel must be maintained. This indicates whether or not the proper clearance is present. The less free travel of the pedal the less clearance between the clutch release parts. Too much free travel can prevent the clutch disengaging completely which will cause difficult shifting of the transmission and overheating of clutch plate. Since the dry type clutch operates by friction, the discs and plates must be kept perfectly dry except the grease fitting of the release bearing which need lubrication.

Adjusting Clutch Pedal Free Travel

1. Determine from your operator's manual how much free travel is needed. Usually the recommendation ranges from 1/2 to 2 inches or more, depending on the make and model of tractor.
2. Check clutch pedal free travel. This is the distance the pedal can be depressed before resistance is noticed. The resistance is caused by the clutch release bearing contacting the release levers or fingers.
3. If the measurement is the same with those specified in your operator's manual, no adjustment is necessary.
4. If the measurement is different compared to those specified, follow the proceeding steps.
5. Locate pedal adjusting mechanism. Usually the adjustment is made near the pedal or it may be somewhere along the linkage leading to the clutch release mechanism.
6. Adjust the linkage, as necessary, until the clutch pedal has proper amount of free travel. Types of adjustment include: set screw and lock nut, adjustable yoke and lock nut, slotted lever and adjustable

cam and lock nut.

7. Tighten lock nut so that it holds adjustment securely.

CHECKING AND SERVICING OTHER PARTS OF THE TRACTOR

Other points that may require lubrication or need checking after 250 hours of operation are:

1. Starter motor lubrication. Many starters used on tractors are pre-lubricated at the factory and require no additional lubrication unless disassembled for repair. But if there is provision for oiling put 8 to 10 drops of SAE-20 oil.
2. Check transmission and differential oil level. Your tractor may have provision like a dip stick or oil-level plugs on the side of the gear case for checking oil level. Before removing the oil level plugs or dip stick, clean the area around them in order to keep dirt from entering the gear case. If gear oil is needed, see your operator's manual for type and viscosity to be used. See your operator's manual for some other jobs to be done after 250 hours of operation.

CHAPTER VI

MAINTENANCE AFTER 500 HOURS OF OPERATION

Most manufacturers recommend that these maintenance jobs should be performed every 500 hours of operation. Some recommend as high as 750 hours and others recommend less than 500 hours. Refer to your operator's manual for this information.

SERVICING THE DISTRIBUTOR

(Spark-Ignition Engine)

Recommendations on how often to service the distributor vary from 200 hours to as long as 1000 hours because of the different make and models of tractors. Servicing the distributor and timing the ignition are often referred to as tune-up jobs. Some operator's manuals state that the breaker points should be cleaned and adjusted "periodically" or when required. Weber[1] in 1958 found that from the 55 farm tractors that he studied 27 had breaker points that were badly pitted. Of this 27 tractors the operators of thirteen tractors inspected ignition points yearly, and nine of them twice a year and others inspected points only when needed or not at all.

Most distributors on farm tractors have a special dust plate or cover located between the rotor and the points. This plate is intended to keep the dirt out of the points and to protect them against the action of ozone, one of the products of high voltage sparking. The distributor is also equipped

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[1] J. A. Weber, Maintenance Inspection of Sixty Farm Tractors, University of Illinois, Agricultural Experiment Station, Bulletin 624, 1958.

with automatic spark advance mechanism. This mechanism consists of weighted levers which revolve with the distributor rotor and act against a set of springs. As the speed of rotation increases, the revolving weights are moved out by centrifugal force, and the timing is advanced. With this arrangement it is possible to have retarded spark for idling and obtain a gradual advance in spark timing as the engine speed increases.

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

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

1. Battery-powered ignition system.

2. Magneto-powered system.

At the present time most of the farm tractors sold are equipped with the battery-powered ignition system.

To understand how a battery-powered ignition system works, it is important to know that the system has only two functions to perform: (1) provide a hot spark at the spark plug which is 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--which is the function of the distributor. This action is performed through two electrical circuits--primary and secondary.

The primary circuit is equipped 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 can which is geared to 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 approximately 250 turns of wire. 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. This situation should be developed before the secondary circuit can build up a spark. At this point, the cam lobe in the distributor turns enough to open the breaker points and break the primary circuit.

As soon as the primary circuit is broken, the magnetic flux lines collapse. In doing so, they cut across several thousand turns of the secondary winding in the ignition coil. This induces high voltage (up to 25,000 volts) in the secondary circuit. Then the secondary winding forces the current into the center terminal of the distributor cap. The distributor rotor picks up this current and delivers it to the proper spark plug. This high voltage is needed to jump the spark plug gap and fire the engine. It takes about 1/1,000th of a second to complete the primary and secondary actions.

The design of distributor are different from engine to engine according to the number of cylinders. The distributor used on a 6 cylinder engine will have 6 lobes on the distributor cam and 6 spark plug-wire terminals in the distributor cap. While the distributor shaft makes a complete revolution, the breaker points open and close 6 times. The rotor fits in the top of the cam, which rotate with the cam. The rotor tip has brushed past but not touched each of the 6 terminals and each of the plugs has received a spark. Four-cylinder engines require 4 lobes and 4 spark plug wire terminals in the distributor cap.

In order to maintain the distributor you should understand the operation of the condenser. The ignition system will not function well without it. The condenser is a small can-shaped unit that is usually in the same compartment with the breaker points. The condenser holds a "charge" of current which stops the current flow in the primary winding of the coil. The field around the winding collapses, inducing voltage in both the primary and second windings.

The voltage induced in the primary winding causes a current to flow in the primary winding. This also helps charge the condenser and creates still more opposition to current flow, producing a further collapse of the field and high voltage. The voltage keeps on rising to try to force the current to flow, but by this time the points are far enough apart so that the voltage never "pushes" current across the point gap. At this time a high voltage is induced into secondary circuit and the current jumps the spark plug gap, producing ignition. The condenser provides a place for current to flow as the contact points separate. This current flowing into the condenser prevents an arc between the points. The distributor may have a centrifugal advance or both a centrifugal and vacuum advance.

Centrifugal Advance on Distributor

Basically, an advance mechanism is a device which times the spark to occur at a certain time as determined by engine speed.

The distributor must deliver the spark to the engine when it is most effective. This is determined by the position of the piston and the time required to ignite the fuel-air mixture in the engine.

The centrifugal advance mechanism is the most popular advance. This device has two weights, a weight base, and two springs. The weight base is part of the distributor drive shaft. The springs are connected to the base, while the weights are placed on the base. The distributor breaker cam has two pins which connect it to the springs and weights. The pins also set in slots in the base.

At idle speeds the breaker cam is "pinned" to the base and rotates with drive shaft. The cam lobes then open the points at a preset time---such as 4 degrees before top dead center. As the engine speeds up, centrifugal force throws the weights against spring tension. This turns the breaker cam so the cam lobes are now striking the breaker lever earlier. Therefore, the contact points open ahead of time. The higher the speed, the further the weights are thrown out. And the further the weights are thrown, the more they turn the breaker cam and the more the spark is advanced. When the engine slows down, the spring returns the breaker cam and weights to their original position, thus retarding the spark timing.

Vacuum Advance on Distributor

An extra advance mechanism is used on some distributors for greater fuel economy, which is the vacuum advance. A vacuum can develop in the engine intake manifold, allowing less fuel and air into the cylinder. Because lean fuel-air mixture will burn slower, ignition must take place sooner in the cycle than even the centrifugal advance can provide, and the vacuum advance is used to advance the spark still further. An air-tight diaphragm is used for vacuum advance which is connected to an opening in the carburetor by a vacuum passage and also the diaphragm is connected by linkage to the distributor housing or breaker plate. When a vacuum at the intake manifold draws air from the diaphragm chamber, it causes the diaphragm to rotate the distributor breaker plate in the opposite direction of drive shaft rotation. This moves the breaker lever to contact the breaker cam lobes sooner and thus advances the spark.

Checking Condition of Distributor

1. Clean outside of distributor housing and cap before removing cap. Use a small amount of cleaning solvent if necessary. Do not use water which may cause short circuits. Do not allow any dirt to enter distributor.
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 holes are open.
3. Inspect the distributor cap for chips or cracks. Replace the cap if it is cracked. If the carbon button in the center of the cap is worn excessively, chipped or cracked, replace with the new cap.
4. Remove distributor arm (rotor) and clean it. Inspect for cracks or excessive burning of the metal strip. Replace the rotor if these signs of damage are present.
5. If a dust cover is used, remove it and check the condition of the felt seal. If the seal is worn, replace the seal.
6. Check the centrifugal advance mechanism. Turn the distributor shaft in the direction of normal rotation. It must rotate freely for a short distance and return 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 surfaces are rough but show only slight pitting and metal deposits, file them

smooth with ignition file. Blow out the dust after you have completed the filing. Do not use sandpaper or emery cloth. Keep the surfaces parallel and flat. If the points are badly pitted with very rough surfaces and worn, replace with a new set.

Burned points may be caused by any one of the following reasons.

a. Oil or foreign material on the contact surfaces.

b. Condenser of improper capacity or defective.

c. Incorrect gap adjustment that is either too wide or too close.

d. Poor alignment of contact surfaces. 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:

   (1) Check tightness of screw that holds the condenser. The screw must be tight in order to prevent sparking at the points.

   (2) If the screw is tight, have condenser checked at a mechanic shop.

   If you want to check the condition of condenser, remove it. If condenser tester is available, it should be tested for ground, short, resistance, and proper capacity for system. Use instructions furnished with the tester units to make the test.

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 the 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. Remove the condenser.
4. Install new condenser and breaker points in the reverse order of disassembly. Be sure electrical connections are tight.
5. Clean, then lubricate cam with petroleum jelly or multipurpose grease. Use enough for a thin film on the cam lobes. Never allow lubricant to get on the breaker point contacts.

Adjusting Breaker Points

1. Check the alignment of the breaker points. If points are not properly aligned or misaligned, the result will be excessive burning, pitting and uneven wear of points. If necessary properly align it.
2. Turn engine until cam opens breaker points to widest position. Crank the engine by "bumping" the starter, by turning the fan by hand. Remove spark plugs to allow the engine to turn easier or by using a heavy screwdriver in the flywheel housing.
3. Check points for proper spacing. Use a feeler gage of the thickness recommended for your tractor. This may vary from .010 to .028 inch. Insert the gage between the points. If the gap is correct, you should feel a slight drag on the feeler gage. If the gap is too tight or too loose, proceed with step 4.

4. Loosen lock screw on bracket that provides adjustment.
5. Adjust points for proper spacing. Some distributors provide an eccentric or adjusting screw which opens or closes the gap depending on which way you turn it. If you set the points too close, they rapidly burn and pit. If you set the points too wide, they will cause a weak spark and higher engine speeds. Improper gap will also affect the timing of your tractor engine.
6. Lock breaker points into position with the lock screw.
7. Recheck the gap and wipe the points clean with a strip of paper or clean cloth.

Checking Cam Angle (Dwell)

The cam angle is the number of degrees that the breaker cam rotates from the time the points close until they open again. As the cam angle increases, the point gap decreases. Too little cam angle can cause engine to misfire at high speed. Too much cam angle allows the points to close for too long, causing burned points.

Use the dwell meter to check the cam angle. Hook up the red-positive clip to the distributor or coil terminal, and block-negative clip to the ground or engine frame, turn test selector to dwell and cylinder selector to number of cylinders in engine.

Turn engine at idle speed and read dwell on cylinder scale corresponding to engine under test. If dwell reading does not agree with specifications, distributor points must be adjusted to proper gap. If the cam angle reading on the meter varies more than two degrees, look for a worn drive shaft or bushings. If the cam angle and point gap cannot be set to specifications, check for the following problem:

a. Improper spring tension.

b. Wrong contact point assembly.

c. Worn breaker cam.

d. Points not following cam at high speeds.

e. Bent drive shaft.

After testing, remove clips and turn tester off.

Reassembling the Distributor

1. Lubricate wick in center of cam shaft. Use two drops of motor oil.
2. Reassemble the distributor in the reverse order of disassembly.
3. Check the condition of the wires leading to the spark plugs and coil. Be sure connections are tight, the nipples seal over the terminal and the insulation is not soft or cracked. If these wires have been exposed to oil and grease or to mechanical wear, the insulation may have become defective, and replace with new high tension wire.

TIMING THE IGNITION

(Spark-ignition Engine)

When you install a new breaker point it is certain to cause your engine timing to be different than it was with the old one. When the rubbing block wears out it also changes the timing of the engine. You should check the timing whenever you adjust the old points or install new breaker points.

There are two methods of timing an engine:

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.

The ignition must be accurately timed so that the spark occurs in the combustion chamber at the correct instant. Incorrectly timed ignition results in loss of efficiency and power. If the spark occurs too early, both fuel economy and power will be sacrificed, and it also can cause the temperature to increase within the cylinder.

If the spark occurs too late, prignition with attendant "pinging" occurs, and if continued, the engine will be damaged.

A study of 50 farm tractors in Kansas[1] showed that retiming caused increased horsepower and 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.

The time that the spark occurs varies considerably in different engines and for that reason factory specifications should be carefully followed. The occurrence of the spark is timed in relation to the position of number one piston, unless otherwise specified, and is listed as so many degrees before top center. This is abbreviated BTC or BTDC, and the top center referred to, is at the end of the compression stroke.

Timing marks are placed on the flywheel, the vibration damper at the front of the engine or on the fan pulley.

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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.

Timing by the Breaker-Point Method

1. Locate the timing marks on the engine flywheel or fan pulley. Your operator's manual should tell you where they are and which ones to use. Usually there are several marks before and after TDC (top dead center). If the marks are hard to see mark over them with chalk or paint to make them more visible.
2. Remove or loosen No. 1 spark plug. If you loosen the spark plug two or three turns, you will be able to hear air escape when the No. 1 piston is on its compression stroke. If you have someone helping you, remove the plug and place your thumb over the spark plug hole so that you can feel the air pressure as the compression stroke begins.
3. Remove distributor cap so that you will be able to see the distributor rotor when you crank the engine.
4. Crank the engine until No. 1 cylinder starts compression stroke. Be certain that ignition switch is off. Look for which way the distributor rotor turns as you crank the engine, by turning the fan by hand or by using a heavy screwdriver in the flywheel housing to pry the flywheel.
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 reassemble the distributor. There is also another way to make sure the timing is correct.

Place the distributor end of the coil high-tension wire 1/8 inch from the engine. Turn ignition switch on. Continue to rotate the crankshaft until the proper timing marks appear aligned with the timing pointer. If the spark jumps the gap between the engine block and wire, the timing is correct. If not, proceed with remaining steps.

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 (or the spark jumps the gap, if the other method is used).
11. Tighten clamps that hold distributor body and reassemble distributor. (If you removed cover from over the timing hole, replace it.)
12. Tighten No. 1 spark plug and attach spark plug wire.
13. Start the engine to see that it operates satisfactorily. If the engine is not firing on all cylinders or is backfiring, make sure your firing order is correct. It is usually written in the engine block. If not see your operator's manual.
    The firing order for four cylinders: 1-3-4-2, also 1-2-4-3.
    The firing order for six cylinders: 1-5-3-6-2-4.

Timing by the Timing-Light Method

1. Locate timing marks on flywheel or pan pulley.
2. Connect timing light as recommended by manufacturer. There are two types of timing light: (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 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 the correct engine operating speed for making timing adjustments according to your operator's manual.

   Some manufacturers will indicate a timing mark that is used for timing at a low idle speed, others will indicate markings for both speeds (high and low).

4. Chalk the proper timing marks so that it is easy to see. (Remove and seal vacuum line at the distributor if applicable.)

5. Start the engine and adjust it to the proper speed, according to operator's manual.

   Be careful that you don't get your hand or the timing light leads caught in any drive belts or the fan blades.

6. Aim the timing light at the marking or pointer near the flywheel or crankshaft fan pulley wherever the timing marks appear.

   If the proper timing mark doesn't align exactly with the pointer, proceed with the following steps.

7. Loosen clamps holding distributor.

8. Turn distributor body slowly back and forth until timing marks are exactly opposite the pointer.

   To retard--rotate in direction of shaft rotation.

   To advance--rotate opposite direction of shaft rotation.

9. Tighten distributor clamps and connect vacuum line and remove timing light from engine.

10. Recheck idle speed, as timing can affect engine speed and shut off engine.

MAINTAINING THE STARTER AND GENERATOR

You may be lubricating your starter and generator at regular intervals, 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 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 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 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 for the tractor. When the tractor is not running, the battery supplies electrical energy. It operates continuously while the engine is running.

The generator has been replaced by the alternator on many of the modern tractor engines. 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. The alternator has two advantages over the generator:

1. Produces a higher output at lower engine speeds.
2. Simple construction requires less maintenance.

Servicing the Starter and Generator

1. Wipe dirt from starter or generator housing.
2. Remove cover band. Some generators do not have cover bands.
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 put new one. Reconnect wire lead to brush holder.
6. Check brushes for binding action in holder. If brush tends to bind in brush holder, remove and wipe brush holder with a clean cloth.
7. Check electrical connection for tightness. If they are loose they will not work properly.
8. Inspect commutator for wear and roughness. If commutator is rough or out-of-round, it will have to be machined or turn down smooth by

an expert service man. If the commutator appears to have dirt and glaze on the surface, proceed as follows.

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. Do not use emery cloth.
10. Seat new brush on commutator. If not properly seated continue the same process, until the brushes fit flush.
11. Blow away dirt and grit, from casing, brush holder, and commutator.
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. Reconnect 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.

Alternator systems do not need to be polarized.

SERVICING THE DIESEL ENGINE FUEL FILTER(S)

Different manufacturers make different recommendations for servicing the diesel fuel filter, but in general 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 tractors 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 stresses two points:

a. Regular servicing of fuel filters.

b. Extreme cleaniness.

The service 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 clearances as small as 0.0001 to 0.0003 inch. These fine parts are necessary to develop and use the high pressure required at the nozzle tips so the engine will operate properly and efficiently.

These parts are so delicately machined, that some manufacturers will not even let their dealers service the injectors or the injection pump. These units should be sent to the factory, or to 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 pumps repaired is quite high and could be discouraging to farmers after operating and using tractor for a few hundred hours.

It is not possible to avoid all moisture and dirt particles from fuel, but wisely handling and proper care in changing filter can reduce dirt and moisture to these points and your tractor will give thousands of hours of service without repair to your injector or injection pump.

From the viewpoint of an operator there are five or six parts to the diesel fuel system. 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 some diesel tractors is located high enough so that it can be fed by gravity from the low-pressure line. In this system, the injection pump will develop some suction on the low-pressure line when the engine is operating. Most tractors are equipped with a transfer pump which develops fuel pressure of about 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 fuel tank are the only parts of the system that need regular servicing which can be done by the operator.

The injection pump job is to apply very high pressure to the fuel (1600 to as high as 3200 pounds per square inch). This high pressure is used by injector nozzles to make a fine mist of the fuel as it is sprayed into the cylinder. This is to provide an immediate and even mixture with the air in the cylinder for even burning. The pump is also responsible for timing the injection so that it performs much the same function that the electrical distributor does on gas engine. Some injection pumps consist of a combination injection pump and injector nozzle which does not need the high-pressure line. Each cylinder has a separate injection which operates by rocker arm. There are 3 rocker 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 injector 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 carefully and regularly service each one. 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 removes most of the water and coarse material. The second-stage filter 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.

See your operator's manual that when the filter should be changed. Some tractors have special gauges which are connected with the fuel line that show when the filter should be changed.

Changing Fuel Filter

The same method and procedures can be used in replacing fuel filters on almost all farm tractors (diesel) 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.

Refer to your operator's manual for filter change. Normally, a first-stage filter should be changed every 500 hours, and the second-stage filter every 1000 hours, or each season. The condition of your fuel will determine whether or not you have to change more frequently.

1. Be sure fuel shut-off valve is turned off. Clean outside of filter and surrounding area of filter, with diesel fuel to remove dirt, then wipe with clean cloth.
2. Drain fuel from filter if the filter has provision for draining.
3. Remove filter or filter bowl. Most filters are held in place with one or more studs or a clip.

4. Clean inside of filter bowl or body (unless it is a self-contained unit). Use a brush or lint-free cloth for cleaning. Make sure that it is absolutely clean.
5. Install cleaned filter or new disposable filter element. Be sure to use new gaskets where separate gaskets are used. Secure filter body. (If the second filter needs to be serviced follow the same procedure.)
6. Complete the filter assembly and tighten it.
7. Replace the drain plug or tighten the drain valve.
8. Open the fuel shut-off valve, and ready to bleed the fuel filter.

Bleeding Air from Fuel Lines

Each time you drain the fuel lines or filters, air is left in them. Unless removed, this air may form an air lock when you try to start the engine. This will prevent a normal supply of fuel from reaching the injection pump, and engine may not start or may run poorly.

If you have changed more than one filter, bleed the one closest to the fuel tank first.

Before bleeding air, be sure the fuel tank is nearly full to provide fuel and pressure enough to bleed the system.

1. Open bleed valve on top of filter. This may be a plug instead of valve. If you changed the first-stage filter, open that bleed valve only.
2. Open fuel supply valve.
   This will force air through the bleed plug and replace the air in the lines and filters with fuel. Some systems are equipped with a hand pump or lever 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 bypass the pump so air can be escaped out of the filter and fuel come out.

3. Close bleed plug after all air is removed from filter.
4. If air lock is still present, the engine may not start or will run poorly. You will also have to bleed the injection lines. Normally, you can bleed half the injection lines and the others will bleed themselves.

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. On some tractors there is a grease fitting which will be greased by grease gun. This type is usually greased daily. As new clean grease is added, old grease comes out around the dust seal and helps remove dirt. The wheel bearings must be taken apart, cleaned and repacked about once a year.

Disassembling the Front-Wheel Bearing

1. Raise front wheels off the ground.

   Make sure your tractor is in gear or block the rear wheels to prevent from moving.
2. Clean dirt from wheel and hub cap and remove hub cap. Most hub caps are either threaded and screwed on hub or are held in place by three bolts.

3. Remove cotter pin and adjusting nut. Use diagonal pliers for straightening cotter pin and for removing it. Lay other parts on clean cloth or in a pan.
4. Remove thrust washer and outer 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 other tractors the grease-seal retained 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 from the hub-cap side of the hub. Do not tap the cage that holds the rollers, you may ruin the bearing.

Cleaning the Front-Wheel Bearings

1. Wash bearings thoroughly. "Swish" the bearing in the cleaning solution (kerosene or diesel) and use a stiff brush to help loosen old grease deposits.
2. Remove solvent from bearings and other parts. If dry compressed air is available, it may be used for drying the bearings but hold the bearing cone so the air blast won't spin it. If the air contains

moisture do not use 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. If inner bearing is tight on the spindle loosen with a wood dowel and hammer, and tap lightly.
4. Examine grease-retainer ring and seal. If it has been ruptured, distorted or cracked replace it, because this is the seal that keeps the grease in and keeps out dirt and moisture.
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 in 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. Then use diagonal pliers and pull one leg of pin outward and up over the end of the spindle. Cut excess off from the other cotter pin leg and bend leg backwards against nut.
8. Replace hub cap.

CHAPTER VII

MAINTENANCE AFTER A YEAR OF OPERATION

CLEANING THE TRACTOR

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.

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. It helps protect paint and parts that are affected by tractor dirt. In addition to oil, grease and dirt particles, the tractor is also exposed to materials such as fertilizers, agricultural sprays and antifreeze. If this mixture is allowed to remain on the tractor indefinitely, the paint may soften or scale; rubber parts such as hydraulic hose lines and the rubber insulation on wiring will soften.
3. There is less chance for dirt to enter the air-cleaner oil cup, fuel filters, and cylinders.
4. Cleaning helps reveal leaks in the cooling system, cracks in the distributor cover, or engine block or any 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. Either method is effective, but the de-greaser is somewhat faster and does a better job of cleaning the hard-to-reach places. Do not use gasoline. It is an extremely bad fire hazard. 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. If you are using a de-greaser apply it with a paint sprayer or insect spray gun in order to get a thin well-distributed film. Apply until the surface has a moist appearance.

   If you are using kerosene or diesel fuel without a de-greaser, apply with a paintbrush to help get penetration.
5. Let solvent set approximately 15 minutes, in order to do an effective job of penetrating and loosening the grease and oil.
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, then flush it with water.
7. Check for areas that have been missed.
8. Replace hood and panels that were removed originally.
9. Start engine and run at idle speed for 10 or 15 minutes for quick drying.

SERVICING THE DRIVE MECHANISM

To help understand why maintenance is important, you should know the operation of the components of the drive mechanism. The parts included in the drive mechanism of a tractor are a clutch, transmission, differential, final drive and power take-off.

Operation of Clutch

The clutch provides the means of disconnecting the engine from its load while starting, shifting or idling.

In the engaged position, the pressure plate provides pressure against the clutch plate and forces the plate against the flywheel. Power is transmitted from the engine through the flywheel and clutch plate to the drive shaft or transmission input shaft. The clutch is disengaged by applying pressure on the pedal which pushes the clutch release assembly against the release levers. The levers pull the pressure plate away from the clutch plate so that the clutch plate is no longer forced against the flywheel. Now the flywheel and pressure plate are free to rotate independently of the clutch plate and drive shaft.

In the engaged position, there is clearance from 1/16 to 3/16 inch between the clutch release bearing and clutch release levers. The clearance allows for wear of the clutch plate facings. As the facings wear, the release levers move closer to the clutch release bearing until, eventually, there is no clearance. Adjustment must then be made or the release levers will press continuously on the clutch release bearing and pressure will be reduced on the clutch plate. The less free travel of the pedal--the less clearance between the clutch release parts. Too much free travel, however, can prevent the clutch from disengaging completely which will cause difficult shifting of the transmission and overheating of clutch plate.

The standard clutch is a dry disk type and no lubricant is found in the clutch compartment, except for grease fittings to the release bearing. The clutch operates by friction and the disks and plates must be kept perfectly dry.

The hydraulic clutch is similar to the standard clutch except that the clutch operates wet in a transmission fluid, and the clutch is engaged and disengaged hydraulically. Hydraulic clutches do not normally require free travel or clearance or adjustment.

Operation of Mechanical Transmission

The mechanical transmission is a train of gears that transfers and adapts the engine power to the drive wheels of the tractor. The job of the transmission is to:

1. Select speed ratios for various travel speeds.
2. Reverse the travel of the tractor.
3. Power a special drive such as a PTO.

Normally the transmission is located to the rear of the engine and clutch and in front of the differential or ring gear. Mechanical transmission are of three major types:

1. Sliding gear: The sliding gear transmission has two or more shafts mounted in parallel or in line, with sliding spur gears arranged to mesh with each other and provide a change in speed or direction.

2. Collar shift: The collar shift transmission has parallel shafts with gears in constant mech. Shifting is done by locking free-running gears to their shafts using sliding collars.

3. Synchromesh: The synchromesh transmission also has gears in constant mesh. However, gears can be selected without clashing, by synchronizing the speeds of mating parts before they engage.

In all three cases, the transmission is shifted by hand, so they are called mechanical transmissions. The gear train for all these transmissions normally operates in a bath of gear oil.

Operation of Hydraulic Assist Transmission

The hydraulic assist transmission is a train of gears which can be shifted without interrupting the flow of power. The gears are kept in constant mesh while two or more hydraulic clutches control the flow of power "on the go" or movement.

The following parts work together:

1. Hydraulic clutches--control the power flow.
2. Gear trains--transmit the power flow.

When the operator shifts gears, hydraulic oil engages the clutches that route power to the selected gears. A hydraulic clutch is normally an alternating pack of friction disks and plates.

The clutch is engaged when pressure oil is sent to push the piston against the disks and plates, clamping them together. The disks are splined to the drum, while the plates are splined to the hub. As a result, input power through the hub is sent on through the hub to the output by the engaged clutch.

The clutch is disengaged when oil pressure is released and the piston moves away from the clutch pack. This frees the disks from the plates and the power flow is stopped. Spring action or oil pressure on the other side of the piston may be used to help release the disks and plates. The hydraulic clutch unit replaces the standard clutch used on mechanical transmission.

The gear train is usually either a countershaft or a planetary unit which feeds power to the output or drive wheels. The gear train normally operates in an oil bath. This oil is usually the reservoir for the hydraulic circuit which operates the clutch units, so special transmission-hydraulic fluid must be used.

Operation of Hydrostatic Drive

The hydrostatic drive is an automatic fluid drive which uses fluid under pressure to transmit engine power to the drive wheels of the tractor.

Mechanical power from the engine is converted to hydraulic power by a pump-motor team. This power is then converted back to mechanical power for the drive wheels.

The hydrostatic drive can function as both a clutch and transmission. The final gear train can then be simplified, with the hydrostatic unit supplying infinite speed and torque ranges as well as reverse speeds.

Hydrostatic transmissions use fluids at high pressures but relatively low speeds. Basically, energy is transferred by the fluid itself in a closed circuit between the pump and motor. While the fluid does move through the lines, it is still considered as being at rest or under static pressure. The rise in pressure of the fluid--which will not compress--is what transfers the energy.

Operation of Torque Converter

A torque converter is also an automatic fluid drive. It transmits engine torque by means of hydraulic force, shifting smoothly through an infinite number of speeds. Actually a gear train is used with the torque converter to give extra speed ranges. But no gear train could give the infinite variations in speed and torque of a torque converter.

Acting as a clutch, the torque converter connects and disconnects power between the engine and the gear train. As a transmission, the converter gives many more speed ratios than are practical with a strictly mechanical gear box.

Here is a rule of thumb to be used to compare a torque converter with a hydrostatic drive. Hydrostatic drives are driven by fluids at high pressure but at relatively low velocity, while torque converters are driven by fluids at low pressure but at high velocity.

Hydrostatic drive = High pressure + Low velocity

Torque converter = Low pressure + High velocity

A fluid at high velocity strikes a turbine and forces it to turn, driving the wheel. Thus, torque is transmitted by a fluid.

To change this torque, the velocity of the fluid is changed. At low velocity, the fluid will not even move the turbine. At high velocity, the turbine starts turning and the wheel picks up speed.

The inside of an oil-filled housing is composed of two parts: the driving half, or pump, and the driven half, or turbine. When the pump is turned by the engine, centrifugal force causes oil to be forced radially outward, crossing over and striking the vanes of the turbine. This rotates the turbine in the same direction and so couples the power. The torque or power from the turbines then flows through the gear train to the power output.

Operation of the Differential

These two jobs are accomplished by the differential:

1. Transmits power "around the corner" to the drive axles.
2. Allows each drive wheel to rotate at a different speed and still propel its own load.

The ring gear and bevel gears direct the power to the axles, while the bevel pinions give the differential action. When the tractor is moving straight ahead, both wheels are free to rotate.

Engine power comes in on the pinion gear and rotates the ring gear. The four bevel pinions and the two bevel gears are carried around by the ring gear and all gears rotate as one unit. Each axle receives the same rotation and so each wheel turns at the same speed.

When the tractor turns a sharp corner, only one wheel is free to rotate. Engine power comes in on the pinion gear and rotates the ring gear, carrying the bevel pinions around with it. But the opposite or other axle is held stationary and so the bevel pinions are forced to rotate on their own axis and "walk around" the bevel gear.

Since the bevel pinions are in constant mesh with both bevel gears, the bevel gear which is forced to rotate because it is subjected to the turning force of the ring gear which is transmitted through the bevel pinions.

When the drive wheels have unequal resistance applied to them, the wheel with the least resistance turns more revolutions. As one wheel turns faster, the other turns slower by the same amount. However, both wheels still propel their own loads--but at different speed.

In some cases the differential action can be a disadvantage when the wheels slip. When a tractor is plowing, one wheel may lose resistance on slick ground and start spinning while the other wheel holds. Then the driving power is limited by the "wasted" power sent to the wheel that slips. The differential locks are often used to prevent this power loss.

Operation of Final Drive

The final drive is the last phase of the power train. It gives the final reduction in speed and increase in torque to the drive wheels. The final drives are mounted near the drive wheels to avoid the stress of long axle shafts and it is used on most large tractors.

By reducing speeds, the final drives lower the stress and simplify the transmission, since extra gears and shafts can be eliminated. Most final drives support the weight of the tractor as well as withstanding torque and shock loads.

Operation of Power Take-Off

The power take-off (PTO) is an attachment in the power train of a tractor. It drives auxiliary equipment. PTO's are normally gear-driven from the transmission and send power through a shaft to the PTO outlet where the driven equipment is coupled. Most modern units are adjustable to drive equipment at either 540 or 1000 rpm. The PTO is operated by a clutch release which is sometimes part of the main engine clutch.

An Illinois study shows that only 15 of 44 operators thought it necessary to change oil as often as once a year. Thirty-nine of 59 operators never changed transmission oil. Most operators or tractor owners do not understand how important it is to change oil in the transmission. 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.

For the proper gear oil, SAE viscosity numbers and type of oil to be used in your tractor, see your tractor operator's manuals.

Most of the lubrication for gears and bearings in the drive mechanism comes from the lower gear 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. In most tractors the drive mechanism lubrication is completed with the changing of gear oil in each compartment by the following procedure:

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:

   a. Add flushing oil, kerosene or diesel fuel as indicated in your operator's manual.
   b. Drive tractor for several minutes. Don't try to pull a load.
   c. Drain, allowing plenty of time for flushing fluid to drain out.
   d. Replace drain plug(s).
7. Clean filler plug and surrounding area.
8. Refill with proper lubricant. Use the grade and type recommended for your tractor.
9. Pour oil until it comes out from the oil level plug(s), or check the dipstick for proper oil level and then replace the oil level plug or dipstick.
10. Replace filler plug(s).
11. Clean breather(s). Service in the same manner as crankcase breather.

SERVICING THE COOLING SYSTEM

Recommended maintenance intervals for your tractor cooling system varies from 400 hours of operation to once a year. If a liquid-cooled engine were run without its coolant, the pistons and bearings would soon weld to their matching parts and the engine would be damaged beyond repair. A tractor cooling system does two things:

1. Prevents overheating.
2. Regulates temperature.

Overheating could burn up the engine parts. Some heat is necessary for combustion, but if the engine generates too much heat the cooling system must carry off the excess heat.

Regulating temperatures keep the engine at the best heat level for each operation. Just after starting, the engine must be warmed faster. During peak operations, the engine must be cooled and kept at a constant temperature. Running the engine too hot can cause preignition, detonation, knock, burned pistons and valves. Running the engine too cold can cause unnecessary wear, poor fuel economy, accumulation of water and sludge in the crankcase.

Operation of Cooling System

The radiator is one of the major components of any liquid cooling system. It is here that heat in the coolant is released to the atmosphere. The radiator also provides a reservoir for enough liquid to operate the cooling system efficiently. Coolant from the engine enters the radiator by way of the top tank, then passes down through a series of small tubes surrounded by fins and air passages. Cooled liquid reaching the bottom tank is picked up by the water pump to repeat the cycle.

The radiator cap provides pressure control of the cooling system. With a pressure cap, the boiling point of the coolant can be raised (a 7 psi cap raises the boiling point of water from 212°F. to about 230°F.). This allows the engine to operate at higher temperatures for better efficiency. A pressure valve in the cap permits the escape of coolant or steam when the pressure reaches a certain point. The vacuum valve in the cap opens to prevent a vacuum in the cooling system when the system cools. The forces cooling air through the radiator core to more quickly dissipate the heat being carried by the coolant into the radiator.

The fan is generally driven by a V-belt from the engine crankshaft.

The coolant pump (water pump) circulates the coolant through the cooling system. The pump draws hot coolant from the engine block and forces it through the radiator for cooling. When the pump fails to circulate the coolant, heat is not removed from the engine and overheating damage may occur. The water pump is normally a centrifugal type and might be called the "heat" of the cooling system. Some pumps turn at 4,000 revolutions a minute and pump as much as 125 gallons of coolant per minute. Most pumps today have self-lubricated, sealed ball bearings.

The thermostat provides automatic control of engine temperature at the correct level. This is necessary in order to get the best performance from an engine. During warm-up the thermostat remains closed. The water pump circulates the coolant through the engine coolant jacket only, by way of the bypass. This quickly warms the engine to its operating temperature before the thermostat opens. When the thermostat opens (usually at 180°F. to 190°F.) hot coolant flows from the engine to the radiator and back.

There are two types of thermostats in general use on tractors. One of these is the bimetallic strip type and has a coil of two different metals pressed together. Each metal has a different expansion rate and when heated the radius of the coil changes, thus moving the valve.

In the other type of thermostat there are bellows. The bellows may be filled under vacuum with a liquid such as alcohol which has a narrow boiling range or it may be filled with wax. When the temperature reaches the boiling point of the liquid or wax, the bellows expends and opens the valve. Should the bellows crack, it will lose its vacuum and the valve will stay open.

Failure to use thermostats and keep them in good working condition causes many engines to run cold and give trouble. If thermostats have been removed during warm weather operation, they should by all means be replaced before operating in cool weather. If a tractor engine equipped with a thermostat is found to warm up slowly, the thermostat should be checked to make sure it is not stuck in the open position. One means for making a quick check is to start a cold engine and then remove the radiator cap and note if water is circulating. A good thermostat stops most of the circulation until the engine has warmed up. A faulty thermostat should be replaced. When replacing a thermostat, care should be taken to use one of the correct temperature range. Some manufacturers have thermostats of different temperature ranges, so the one best suited to the local operating conditions should be used. Always use the thermostat designed specifically for the make and model of engine being used.

Cooling system hoses: Flexible hoses are used in connecting cooling system components because they stand up under vibration better than rigid pipes do. However, hoses have weak points, too.

Radiator hoses can be damaged by air, heat and water in two ways.

1. Hardening or cracking--destroys flexibility, causes leakages, and allows small particles of rubber to jam the radiator.
2. Softening and swelling--produces lining failure and hose rupture.

Replace hoses often enough to be sure they are always pliable and able to pass coolant without leakage. Examine hoses at least twice a year for possible replacement or tightening. When hoses are removed, check them for wear. Hoses may harden and crack, allowing the system to leak, or they may soften and then collapse. A softened hose may also collapse during high speed operation or restrict circulation enough to cause overheating.

When installing hoses, clean the pipe connections and apply a thin layer of non-hardening sealing compound. Locate the hose clamps properly over the connections to provide a secure fastening. A pressurized cooling system will blow off an improperly installed hose.

Coolants

1. Water is the universal coolant--plentiful, cheap, harmless, absorbs heat, circulates freely. But it will freeze, it can evaporate and will also corrode metals.
2. Water needs added inhibitors to prevent corrosion and antifreezes to prevent freezing.
3. Use clean soft water in the cooling system--rain water is best.
4. "Permanent" only means that an antifreeze will not readily boil away; the inhibitors will still "wear out" in a season or two.
5. Alcohol antifreeze boils at 180°F., while ethylene glycol (permanent) antifreezes do not boil until 223°F. (compared to water, which boils at 212°F.).
6. Never overfill the cooling system. It needs room for heat expansion.
7. Two precautions:
   a. Never pour cold water in a hot engine, or vice versa.
   b. Never remove the pressure cap all at once on a hot engine.
8. Watch for all kinds of leaks: coolant out of system, coolant into crankcase, and air and exhaust leaks into coolant.
9. Corrosion of metal surfaces in the system reduce heat transfer and cause overheating. Use inhibitors both summer and winter (in most antifreezes).
10. Flush the system before installing antifreezes. If rusted or limed up, clean the system with an acid-base cleaner, then neutralize and flush it.

11. Check water pump and fan for proper lubrication. Some are greased; others must be lubricated by the coolant.

12. Allow a hot engine to idle for a few minutes before stopping it.

The cooling system absorbs about 1/3 of the heat energy developed by the engine fuel. Another 1/3 of the heat energy is used for power, and the remaining 1/3 is dissipated through exhaust gases and crankcase oil. If the cooling system fails to remove its share of the heat, the engine may be severely damaged and it is likely to have such troubles as: sticking and burned valves, a cracked engine head or block.

<u>Flushing or Cleaning the Cooling System</u>

If you are using one of the commercial flushing or cleaning compounds follow the directions 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 engine is still warm. Some tractors have only one drain cock but most have two or three--one on the radiator and one or two on the engine block.
      (3) Close drain cocks.

(4) Refill cooling system with water. If engine is hot, allow it to cool, then add water slowly. Adding water to hot engine will cause cracking of engine block or head. Allow enough space to add the flushing compound or cleaner.

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 for leaks.
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.
   a. Use clean soft water and rust inhibitor or new antifreeze solution with soft water. (A 50 percent solution will provide protection to -34°F.).
   b. Do not use old antifreeze with a new can of rust inhibitor.
   c. There should be about a 2 inch space between the radiator water level and the neck of the radiator. This allows room for the coolant to expand as it heats without overflowing.

SERVICING THE HYDRAULIC SYSTEM

Hydraulic may be defined, in a strict sense, as the science of fluid forces. In modern usage, hydraulic has come to mean the use of fluid to transfer power, or to change a power source into useful force.

While modern farm and industrial equipment hydraulic uses are relatively new, the use of hydraulic forces--water power, for example--dates back to early times. In the seventeenth century, Pascal discovered the fundamental law upon which modern tractor hydraulic is based. Simply stated, Pascal's law is that pressure applied at any point in a static fluid is the same in all directions and acts with equal force on equal areas.

A well-maintained hydraulic system seldom gives the operator any trouble. Regular checks assure you that the oil level is sufficient. Changing the oil and filters regularly also helps prevent problems.

The oil in the hydraulic system is subject to contamination, just as the engine and transmission oil are. Field dust, rust particles, moisture from condensation and metal particles cause contamination. 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.

Selecting Hydraulic Fluids

The fluid in a hydraulic system serves as the power transmitting medium. It is also the system's lubricant and coolant. Selection of the proper oil is a requirement for satisfactory system performance and life. Oil must be selected with care and from a reputable supplier. Be sure to follow the manufacturer's recommendations.

Depending upon the system, these types of oils may be suitable:

1. Crankcase oil meeting API service classification MS or SE. The most severe classification is the key to proper selection of crankcase oils for mobile hydraulic systems.
2. Antiwear-type hydraulic oil--There is no common designation for oil of this type. However, they are produced by all major oil suppliers and provide the antiwear qualities of MS or SE crankcase oils.
3. Certain other types of petroleum oils are suitable for mobile hydraulic service if they meet the following provisions:
    a. Contain the type and content of antiwear compounding found in MS or SE crankcase oil or have passed pump tests similar to those used in developing the antiwear-type hydraulic oils.
    b. Meet the viscosity recommendations for expected temperatures.
    c. Have the chemical stability for mobile hydraulic system service.

When selecting hydraulic fluids, check the recommendations in the operator's manual. The manufacturer has picked a fluid which meets all the needs of the system, which may vary from simple cylinders to precision hydraulic pumps.

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. For faster drainage loosen the filler plate or the filler plug.
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.
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. This is important to keep dirt from entering the hydraulic system.
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 as necessary.
13. Replace filler plug or plate.
14. Clean hydraulic breather. Not all tractors have a breather on the hydraulic housing. If there is one, use the same procedure as for crankcase breather.

Servicing the Hydraulic-Steering System

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

If the steering 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. Some also have a screen that requires cleaning.
6. Thoroughly clean reservoir interior with a lint-free cloth.
7. Check gasket and replace if necessary.
8. Reassemble 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.

Bleeding Brakes

When the brake system is part of the hydraulic system, the brakes must be bled whenever the hydraulic oil is drained and replaced. Also, whenever the pedals feel spongy or have excessive pedal free travel, you must bleed the air from them.

The tractor may be equipped with either hydraulic brakes or power brakes. Follow the procedure for each type.

Bleeding Hydraulic Brakes

1. Start the engine and run it at fast idle for two minutes to make sure the brake reservoir is filled with oil.
2. Locate the bleed screws, usually they are located on top of the axle housing near the differential.
3. Attach a transparent plastic tube to the bleed valve.
4. If possible, insert the other end into the transmission oil filler hole. Be sure the end of the tube is submerged in oil.
5. Unscrew the bleed valve 3/4 turn.
6. Slowly depress the brake pedal and allow it to return slowly.
7. Continue operating pedal in this manner until oil in the transparent tube is free of air bubbles.
8. With the brake pedal still depressed, close the bleed valve securely.
9. Remove bleed tube and repeat this procedure for the other brake.

Bleeding Power Brakes

1. Start the engine and loosen the bleed screw lock nut on both sides of the tractor at the drive axle housing.
2. Turn each bleed screw out two turns and tighten the lock nut. Tightening the lock nut prevents oil from leaking around the bleed screw.

3. Depress the brake pedals for a few minutes to bleed air from the brake system.
4. While holding the pedals down, loosen the bleed screw lock nuts and tighten the bleed screws.
5. Tighten the lock nuts, release the pedals and stop the engine.
6. Discharge the accumulator (if used) and check the pedal free travel. (The accumulator supplies oil pressure to apply the brakes for a short time after the engine has stopped.) If the travel is excessive (refer to your operator's manual), repeat the procedure again.

ADJUSTING THE ENGINE GOVERNOR

The governor is a device which automatically controls the speed of the engine under varying loads. Governors do these jobs:

1. Maintain a selected speed.
2. Limit the slow and fast speeds.
3. Shut down the engine when it overspeeds.

When the throttle is in fixed position, the governor keeps the engine at a constant speed when the tractor is going uphill or downhill. The governor on the engine automatically regulates speed at whatever setting you select on the speed control (throttle) lever.

Most operator's manuals give detailed instructions on how to adjust the governor for high no-load speed. However, some manuals have no governor adjustment and others warn against making any adjustments. Some engines have governors with adjustments sealed inside the governor housing to discourage operators from making adjustment. The purpose of this information is to help you understand how a governor works, and the importance of proper governor adjustment. This understanding will be helpful whether you service it, or have it done by a competent serviceman.

Tractor manufacturers test their tractor engines and select a maximum speed for each model that provides satisfactory power in relation to fuel consumption, wear and other factors. The speed selected varies with different makes and models. The maximum idle speed recommended for your tractor engine is given in the operator's manual. It is the one you normally use for checking your governor.

Your operator's manual may also give a full-load speed. It will be less than the high-idle speed even though the speed control lever is in the same position. As load is added, there is some loss of engine speed that the governor does not recover. For example, an engine that has a high no-load speed of 2700 revolutions per minute (rpm) may have a full-load speed of 2500 rpm. The speed loss is different with different engines.

If a tractor engine is operated much faster than the top speed specified, wear increases rapidly. If the engine is operated much slower than the manufacturer recommends, there is less power available and operating costs increase.

If only one high no-load is given, the governor is usually considered as being in satisfactory adjustment if the top engine speed is within 20 rpm (faster or slower) of that speed. However, some manuals will indicate a speed range such as 2500 to 2600 rpm. The governor is considered to be in proper adjustment if the idle speed is within this range.

Operation of Governor

After you set the speed control lever, the job of the governor is to adjust the amount of fuel-air mixture (fuel only for diesel engines) that the engine receives so that the engine speed remains approximately the same even though the load varies. Consequently, the governor must be sensitive to speed changes.

The governor is mounted on the engine camshaft where it is directly affected by any slight change in engine speed.

On carburetor (spark-ignition) engines, the governor controls the fuel-air mixture by opening and closing the throttle (butterfly) valve. When you open the speed-control lever, tension is exerted on the governor control spring. The spring tension turns the governor lever clockwise, opening the throttle valve. More fuel-air mixture can enter the engine, causing it to speed up.

When the engine speeds up, centrifugal force acts on the flyweights pushing them outward. They are hinged so that when they move outward, the governor drive plate is pushed out. This rotates the governor arm which, in turn, moves the governor lever in a counter-clockwise direction. As a result, the butterfly valve tends to close. This would slow the engine speed except for the tension of the governor control spring. But a balance is reached immediately between the force of the flyweights and the tension of the governor control spring. This balance holds the throttle valve at the proper position to maintain a constant engine speed.

Suppose more load is put on the engine. The engine speed slows, centrifugal force is reduced on the flyweights and they pull in. This removes some of the pressure on the drive plate against the governor arm, allowing spring tension to turn the governor lever in a clockwise direction. The throttle valve opens further, allows more fuel-air mixture into the engine and increases horsepower output (lugging power) without increasing engine speed.

With the throttle valve open further, more fuel-air mixture is fed to the engine. Engine speed tends to increase but any increase in speed causes the flyweight to move out, overcoming enough spring tension to set up a new balance between the governor and the governor control spring which keeps the engine speed constant.

At higher engine speeds your tractor has the capacity to meet a wide range of power demands. This is why it is important to set the speed control lever at high enough speed to take care of the maximum power needed for a job. When you do this, the engine is ready to start lugging the instant the governor action feeds more fuel into it. If your setting is too low, there is not enough tension on the governor spring to allow the engine to come up to full power.

On a diesel engine the operating principle of the governor is the same as the spark-ignition engine, except the diesel engine governor controls only the fuel going to the engine. This is done by various means, such as: an arrangement that shortens or lengthens the stroke of the injection pump to meet varying load conditions, or a master valve that meters the fuel supply to meet the varying power demands.

Governor Adjustment

Because of possible change in center-to-center distance governor and carburetor, due to removal and replacement of manifold, carburetor or governor assemblies, the linkage between the governor and carburetor must be adjusted to establish the throttle position in relation to governor weight position. This adjustment insures the full power response of a wide open throttle when the governor weights are collapsed by reduction in rpm by application of heavy load. This governor-to-carburetor linkage must be free from binding throughout its range of movement.

1. With engine stopped, advance the operator's engine speed control lever to about half speed position; sufficient to create tension on the governor spring.
2. Disconnect governor-to-carburetor control rod (either end). Hold carburetor throttle against its stop in wide-open position. Move governor rockshaft lever to rear of its travel and adjust length of governor-to-carburetor control rod so that it may be reconnected freely without moving throttle lever or governor lever.
3. Lengthen control rod one turn from the above condition, to compensate for wear, and reconnect.
4. After tightening the control rod clevis lock nut, check to be sure that both ends of the control rod are in the same plane, to eliminate possibility binding on levers.
5. Move operator's engine speed control lever a few times between half speed and low speed position, checking the governor-to-carburetor control rod in all positions for interference or binding.

PREPARING THE TRACTOR FOR STORAGE

If your tractor will not be used for an extended period of time (three or four months or longer), it pays to prepare it for storage. It should be properly prepared for storage. Select a dry and protected place where it is exposed to neither the weather nor the livestock.

Check your operator's manual for procedures that apply particularly to your make and model of tractor.

In general the procedures are as follows:

1. Clean and wash exterior of tractor.
2. Use sandpaper, remove rust spots and repaint it with proper color.
3. Remove air cleaner, then clean it and refill cup with new oil and reinstall.
4. Operate tractor until the engine is thoroughly heated.
5. Drain crankcase oil and remove oil filter element.
6. Install new oil filter and refill crankcase with proper grade of oil.
7. Start engine and run for several minutes to lubricate engine parts. The oil protects surfaces that are inclined to rust.
8. Drain transmission, clean plugs and refill with proper grade of new oil.
9. Service the hydraulic system(s).
10. Clean and repack front-wheel bearings.
11. Drive tractor to storage location.
12. Drain the cooling system and wash and flush it out with washing soda and water. Refill cooling system with antifreeze to proper degree of protection, then fill with water. Be sure to run the engine for several minutes in order to mix antifreeze with water thoroughly. If you are storing your tractor without coolant, be sure to drain the radiator and engine block completely. Leave the drain valves open. Replace the radiator cap loosely and put a tag "cooling system drained." Put another warning tag on the steering wheel or ignition switch.
13. Drain the fuel tank.

14. (Gasoline tractor only.)

    a. Replace dry filter element in air cleaner.

    b. Drain sediment bowl, fuel line and carburetor.

    c. Remove spark plugs, clean and regap then pour two tablespoons of heavy lubricating oil into each cylinder.

    d. Turn engine over several revolutions before replacing spark plugs, using crank or starter.

15. (Diesel tractor only.)

    a. Drain sediment bowl and primary fuel filter.

    b. Add two gallons of rust proof oil, manufactured especially for diesel engines, or half and half SAE-10W engine crankcase oil and white kerosene, 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.

16. Plug ends of exhaust pipe and breather pipe. Use a large cork, or a rubber or wooden plug. This is much better protection against moisture than the use of a rag.

17. Remove and store battery. Place the battery where it will be kept cool but not exposed to freezing temperatures. This keeps down the rate of self-discharge. Inspect the battery every two weeks to assure charge is correct.

18. Jack up the tractor and place wood blocks under the axles to remove weight from all tires.

19. Remove water from tires.

If you are using calcium-chloride solution in your tractor tires, it is not necessary to do so.

20. Order any parts that need to be installed.
21. Cover tractor with tarpaulin if it is not being stored in a building.

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 coolant (if not).
3. Fill the fuel tank with clean fuel.
4. Check the oil level in the crankcase, transmission and air cleaner.
5. Remove the (plugs) covering from the end of exhaust and breather pipe.
6. Inspect and tighten all nuts, bolts, and screws.
7. Lubricate all fittings if not lubricated prior to storage.
8. "Air bleed" the fuel system in diesel tractors.
9. Start the tractor engine and allow it to operate at a fast idle speed for 10 to 15 minutes. Note all the instruments, particularly the oil gauge 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 VIII

MAKING ADJUSTMENTS TO MEET OPERATING NEEDS

CHECKING AND ADJUSTING SEAT POSITION

Seat adjustment which provides for the most comfort and relaxation also provides most freedom from weariness. Seat adjustment and its relation to weariness is that the vibrations absorbed by your body while driving a tractor are much faster (higher frequency) than vibrations caused from running or walking--the ones to which our bodies are best adapted.

Seat position should be checked, and adjusted if necessary, whenever there is a change of drivers.

If you have to strain to reach levers and foot pedals, you will tire faster, be unable to control your tractor properly and will greatly increase your chance of having an accident. All tractor seats provide for adjustment backwards or forwards (horizontal). Some provide for height or weight adjustment, and some for back adjustment.

Horizontal Seat Adjustment

The horizontal seat adjustment is the most important of the three adjustments you can make while the tractor is not running. It provides the right distance between you and the steering wheel, and the pedals. Follow these steps for proper horizontal seat adjustment.

1. Place one foot on the brake pedal(s), one on the foot clutch and depress one at a time. When properly adjusted with either pedal completely depressed, your leg(s) should be straight and your back

braced against the back of the tractor seat. The ideal situation is when your leg angles slightly before depressing the pedal and is straight after your foot has traveled a distance of 3 1/4 to 4 inches.

2. If the seat is not properly positioned for you, adjust the seat by
   a. Loosening the cap screws.
   b. Use of a lever on the side or bottom of the seat.
   c. Releasing the seat latch and adjusting with selector lever.
3. Check seat position for comfortable steering. The ideal position is when your elbows are at an angle of 90° as you sit with both hands on the steering wheel. This enables you to react quickly and to turn the steering wheel through a wide angle. If the horizontal adjustment doesn't provide the proper angle for your arms, you may be able to secure it through height adjustment.

Height or Weight Adjustment

This adjustment is largely a matter of feeling. The position you select should be the one where you feel most comfortable and have best control of the tractor. Adjustments are of two types:

1. With one type you remove bolts from the seat supports and raise or lower the seat to the desired position.
2. The other type is a shock-absorber seat which adjusts automatically to your weight. With the same adjustment, a heavier person sits lower than one that weighs less; consequently, persons of varying weight need to reposition the weight adjustment which is provided by a device on the side of the seat mount.

   Provisions for adjusting weight-adjusting seats:

a. Nut should be loosened and moved forward for light-weight operator.

b. Adjustment with a weight-adjusting knob.

c. Adjustment with a wing-nut screw.

Back Adjustment

Not all tractors provide a back adjustment, but where one is provided, adjust the back rest so it is approximately 9 1/2 inches above the seat. This height provides proper support for your back without having to hold your spine rigid to secure proper backing.

CHANGING REAR-WHEEL SPACING

On most farms it is necessary to change the rear wheel spacing several times a year to meet the needs of various farming operations. For plowing, the wheels should be spaced so the right rear wheel runs in the furrow, not on the landside or on the plowed ground. The other wheel must be spaced the same distance from the center of the tractor so that it pulls evenly. For cultivating the wheels may have to be re-spaced to keep them in the center of the rows. For mounted equipment, the spacing may need changing to allow space for equipment. Close wheel spacing allows more clearance when driving between buildings and through doors and gates. On hills, wide wheel spacing helps avoid overturning.

Adjustable rear wheels can be spaced from widths as narrow as 46 inches to more than 100 inches. Adjustments vary with the make and model of tractor.

Manufacturers provide two means of changing wheel spacings:

1. Manual adjustment.

2. Power adjustment.

Spacing Manually-Adjusted Rear Wheels

With manual methods the spacing of rear wheels can be adjusted in five basic ways. They are as follows:

1. Positioning rear-wheel clamps, either inside or outside of wheel disc.
   a. Close wheel setting; clamps inside disc and attached to outer rim bead.
   b. Widening by moving clamps from inside disc to outside mounting.
2. Placing rim in different position on wheel disc. Widening by changing clamps from outer rim bead to inner rim bead.
3. Changing dish-shaped wheel discs so wheel will either dish in or dish out. Widening by exchanging wheels. Changes wheel disc from dish-in to dish-out.
4. Sliding wheels on axles to any position desired. If tractor has extended axles.
5. Using offset or extended hub. Widening by turning extended hub from outside to inside position.

Most tractor manufacturers use a combination of two or more of these methods. Your operator's manual shows which combination to use to get the width you desire.

The following general procedures will work with most tractors:

1. Place tractor on a level area.
2. Place blocks in front and back of front wheels to avoid tractor movement after it has been jacked up.
3. Jack up the rear wheels. Place jack under axle housing not under axle shaft, because the wheel and axle may be rotated enough to

throw the jack out of position and let the tractor fall to the ground. If you have plans to exchange rear wheels or the tire-and-rim assembly, jack up both sides. (There are some jacks which can be used with your tractor hydraulic system.) An overhead hoist is excellent to use if one is available.

4. Examine wheel assemblies to determine which of the following methods, or combination of methods, you will need to use for changing wheel spacing.
   a. Changing wheel-clamp positions.
      (1) Lock wheel brakes.
      (2) Remove all wheel clamps and let tire rest upright against wheel disc.
      (3) Reinstall wheel clamps in upper position of wheel disc first.
      (4) Place tire-and-rim assembly on newly-positioned wheel clamps.
      (5) Install remaining wheel clamps and tighten evenly.
   b. Changing rim position on wheels.
      (1) Turn rear wheels until clamps are on upper side. Tractors equipped for changing rim positions usually have two special clamps that guide the rim as it is being moved from one position to the other. Most rims have a bead on each side of each drive clamp that extends crosswise. They act as a guide to keep the rim in position on the drive clamps.
      (2) Remove mounting clamps (do not remove drive clamps).

(3) Use pry bar to move rim to desired position on wheel.

(4) Replace mounting clamps and tighten securely.

c. Exchanging rear wheels.

(1) Remove wheel bolts on one wheel.

(2) Remove wheel and leave in upright position. Lean wheel against a building, post or tree or hold with an overhead hoist. Tie top of wheel to the support. This will prevent accidents. Do not lean the wheel against the back or side of the tractor. Do not try to lay the wheel down. Most of them are very heavy and you may be injured.

(3) Remove second wheel and place on hub or axle of first wheel.

Be sure to exchange wheels. (Don't remove a wheel, give it a 1/2 turn and replace it on the same hub.) Look for a "direction-of-rotation" arrow molded on the side of the tire.

With offset tractors the engine is mounted to the left side of the tractor chassis, the right wheel is cast-iron to balance the engine weight. With this type remove the tire-and-rim assembly from the disc, remove disc and turn so it will dish in the opposite direction, mount on axle and replace tire-and-rim assembly.

(4) Tighten wheel bolts on both wheels.

d. Sliding wheels on extended axle.

(1) Rotate wheel until keyway is on upper side of shaft.

One make of tractor uses a rack and pinion. In this case rotate the wheel until the rack is in the upper position.

(2) Loosen hub-clamps bolts.

(3) Slide entire wheel assembly to desired position on axle. With rack-and-pinion adjustment, loosen three cap screws, turn jack screws clockwise until outer groove in each screw is flush with outer surface of wheel hub.

(4) Measure distance from center of tractor to center of tire tread.

Some mounted implements may require one wheel to be set closer to the tractor than the other, but for general use, each tire should be an equal distance from the center of the tractor.

(5) Tighten hub bolts securely. With rack-and-pinion design, loosen jack screws and tighten cap screws.

e. Using the offset hub to get an extra-wide wheel spacing.

(1) Use steps (1) and (2) under (d).

(2) Follow steps (2) and (3) under (c).

(3) Follow steps (3), (4), and (5) under (d).

(4) Tighten bolts again after a few hours of operation.

This is important. Every year farmers ruin wheels, hubs, rims and axles because they do not tighten wheel bolts and nuts sufficiently.

Spacing Power-Adjusted Rear Wheel

Even though a tractor has provisions for power adjusting its wheel spacings, it usually has provision for manual adjustment also. Once the wheels are set for your minimum and maximum spacing needs, you will usually have enough selection of wheel spacings in the power-adjustment range to meet all conditions. There are two types of power-adjusted rear wheels:

I. Spiral guide-rail: Although the two types look different, they work on the same general principle. Both depend on some provision for the wheel disc to rotate inside the rim.

In the spiral guide-rail type, the guide rail which sometimes is called a "shift" rail is welded to the rim. There may be 4 to 6 guide rails on a rim. Between each rail and the wheel disc is a jack screw. Each jack screw is equipped with a saddle fitting that rides the guide rail. When the jack screws are loosened the wheel disc is free to slide on the guide rails. Since the guide rails are spiral shaped, rotating the wheel disc forces the tire-and-rim assembly in or out, depending on which direction the wheel disc moves on the guide rail.

Instead of a jack screw, some tractors are equipped with eccentrics which can be loosened or tightened against the rail to perform the same function as a jack screw. On each wheel there is one guide rail with holes in it and the stop fittings are used to control the wheel-spacing setting.

Check your operator's manual for detailed procedures but in general, the following procedures apply for the spiral guide rail type. Adjust one wheel at a time as follows:

1. Determine which way saddle fitting must move on rail to secure desired adjustment.
2. See if there is enough remaining space on guide rail to provide the adjustment desired.

   Each wheel has 10 to 12 inches of lateral adjustment from one extreme position to the other. Locate guide rail with adjustment holes and count number of spaces left in the direction you want the wheel to move. Most wheels provide 2 inches of lateral movement, but some provide 2 1/2 inches.

3. Remove stop on rail to permit movement in desired direction.
4. Replace stop in rail hole providing desired wheel spacing and tighten set screw.
5. Loosen nuts on the two (or three) upper jack screws an equal number of turns. If eccentrics are used in place of jack screws, loosen all of them. Some tractors have four jack screws, while others have six. Some tractor manuals suggest that all jack screws be loosened. The principal advantage of the above suggestion is to avoid working against the weight of the tractor. With either method, loosen the screws until the wheel disc is free to rotate.
6. Start tractor and shift into gear.
   Use first gear or reverse, depending on which way you want the wheel disc to rotate.
7. Apply brake on side not being adjusted, and slowly engage clutch until jack screw (or eccentric) contacts the stop you reset on the rail. This may require about 1/4 turn of the disc.
8. Move second stop against jack screw or eccentric and tighten securely.
9. Tighten the two (or three) jack screws which were loosened, or if equipped with eccentrics tighten all of them. Most manuals recommend a pull of approximately 150 to 160 pounds on end of wrench provided for jack screw adjustment.
10. Start adjustment on the second wheel in same manner.

II. Slotted channel-bar type: This type is adjusted somewhat differently. When the wheel spacing is changed, the disc is loosened from the rim. As power is applied to the disc it rotates and threads through the slotted channel bar in the same manner as bolt threads into a nut. For each 2-inch adjustment the wheel makes a complete turn.

General procedures for using this type of power adjustment are as follows:

1. Rotate tractor wheel so spacer clamp is at the top. The spacer clamp has a small bolt in the arm that projects from it. It is designed for two uses:
   a. It serves as a driver clamp to hold wheel disc and rim together except when wheel spacing is changed, then
   b. It is used as a stop.
2. Loosen large nut that holds the spacer clamp on wheel disc.
3. Loosen small knurled nut in spacer-clamp arm. Turn bolt so special head will pass through opening in wheel disc.
4. Loosen nuts on remaining lock clamps, slide away from rim and retighten to wheel disc.
5. Place spacer clamp in channel bar at desired wheel spacing. Insert oval-headed bolt (in spacer clamp arm) into channel-bar slot and turn to secure bolt head in channel. Tighten knurled nut securely.
6. Start engine and shift into first gear or reverse depending on which way you want wheel disc to rotate.
7. Engage clutch and at same time brake opposite wheel lightly in order to let tractor move ahead slightly.
8. Disengage clutch when wheel disc strikes spacer clamp.
9. Rotate tractor wheel until lug for spacer clamp is at top.

10. Remove spacer clamp from channel bar and replace on lug for use as a fourth wheel clamp.

11. Loosen nuts on remaining lock clamps, position in rim channel bar and tighten against rim.

12. Use the same procedures in changing tread width on the other rear wheel and check the jack screws, eccentrics, or clamps after a few hours of operation for tightness.

ADJUSTING FRONT-WHEEL SPACING

There are three different types of front wheel arrangements on tractors.

1. Single front wheel.
2. Dual front wheel.
3. Adjustable front axle.

Of the three, only the adjustable-axle type needs to be matched with the spacing of the rear wheels.

The single-wheel type has no spacing adjustments. The dual-wheel type is normally run with a narrow setting to provide easy steering. However, the wide setting is an advantage under 2 conditions:

1. In mud there is less tendency for balling up between the wheels.
2. With listed crops it is easier to keep the front wheels on the ridge. Wider spacing is provided either by reversing the disc-shaped wheels or by changing the rim position from one side of the wheel disc to the other.

If you have a tractor with an adjustable front axle, there are several front-wheel spacings you can use to match the spacing of the rear wheels. The spacing between the front wheels can be changed in units of 4 inches (some provide 5-inch spacings) to the width desired to match the rear wheel width. If only a small amount of width increase is needed, the front wheels can either be reversed (if of the disc type) or mounted on the opposite side of the wheel disc. This will supply from 4 to 8 inches of additional wheel spacing depending on design.

The adjustable front-axles of different tractors may appear quite different in design. But in general, the procedures for extending or shortening axles are similar.

Look in your operator's manual for exact procedures for your particular tractor. In general the following applies to all farm tractors:

1. Be sure tractor is on level ground.
2. Lock brakes on rear wheels or place blocks in front and back of rear tires.
3. Jack up front end of tractor. (Use a good jack with a wide base.)
4. Loosen both extension axles. The extension axle may be fastened to the center axle with bolts or clamps, or the two axles may be telescoped and bolted or clamped in position.
5. Loosen steering linkage (tie rods or drag links) that attach to extension axle. Loosening a tie rod or drag link is usually a matter of backing off a set screw and lock nut or removing clamp bolt.
6. Slide axle to desired position and fasten. Usually the inside face of the front tire is aligned with the inside face of the rear tire. Hole positions in the axles are 2-inches apart on most tractors, so it is easy to determine how many inches you are moving each extension axle. Tractors with 2 1/2 inch intervals on rear wheels, have same intervals on front axle.

   Fasten and replace bolts or tighten clamps that you removed or loosened in step 4. If extension axle is being bolted to center axle, leave at least one hole between the two bolts to make axle more rigid.

7. Adjust tie rods or drag link(s) and tighten. In the front or rear type tie rods of the tractor the telescoping members have punch marks, holes, or ring grooves to mark 2- or 2 1/2-inch adjustment. Move tie rod or drag link the same number of notches as the extension axle and tighten.

   If your tractor has an angular axle, check to see if the front end of the radius rods is in line with the front of the drag link. If in line, no adjustment is required. If out of line, proceed as follows:

   a. Center the steering wheel so the front wheels point straight ahead. The marking can be found on the steering-gear housing and on the Pitman arm.

   b. Turn adjustable drag link (turnbuckle) to secure proper toe-in adjustment and tighten. Note alignment marks on steering arm and spindle. Adjust drag link until these marks are in line.

   c. Repeat procedures with drag link on opposite side of tractor.

ADDING WEIGHT FOR TRACTION AND BALANCE

It is general practice with farm tractors to use additional weight on the rear wheels and often on the front wheels. The need increases as tractors become more powerful in relation to their weight. No matter how much power your tractor has, its power cannot be used to advantage when the rear wheels spin.

Weight is needed on rear wheels to:

A. Give added traction for pulling.

B. Maintain traction with a heavy load on the front.

Weight on front wheels is used:

A. To offset lifting affect from mounted equipment on rear of tractor.

B. To keep front wheels on ground when pulling up a slope.

The drawbar pull of your rubber-tired tractor is usually considered about equal to half the weight carried on the rear wheels. This includes not only the tractor weight but also the weight of the driver and mounted equipment.

A tractor may have ample power but not be able to pull a load because of insufficient traction. Adding weight to rear wheels helps overcome this problem. For each 100 pounds added, drawbar pull is increased about 35 to 40 pounds on dry sand or green alfalfa, 50 to 55 pounds on dry clay or sandy loam, and 65 to 70 pounds on concrete.

Under normal heavy-load operating conditions there is about 15 percent slippage of the rear wheels. This is considered the maximum allowable under most surface conditions. But as the load increases, wheel slippage can increase (beyond 15 percent) enough to greatly increase tire wear, add engine load and result in a waste of fuel without supplying the extra pull needed. This is when more weight is needed.

There are three methods of adding permanent weight to rear wheels:

1. Pumping water, or calcium-chloride solution, into the tires. They are usually filled to the upper-rim level.
2. Attaching cast-iron weights to the rear wheels.
3. Using both liquid in the tires and cast-iron wheel weights.

Of the three methods, the use of calcium-chloride solution in the rear tires is common and best because:

A. It provides protection against freezing.

B. The solution weighs up to 30 percent more per gallon than water, which helps provide more weight. It does not damage the tube or tire. Its use is approved by the tire manufacturers.

When the liquid is at the level of the upper rim it is approximately 75 percent liquid filled. Filling to this level is common practice because there is still enough air in the tire to absorb shock and avoid tire bruising. The tires with this much liquid lose only about 7.5 percent of their resistance to bruising as compared to air-filled tires. Weight is increased in each tire from around 200 pounds with the average size small tire to as much as 550 to 600 pounds for large tires.

Cast-iron wheel weights may be added to each wheel and can be used alone or in addition to liquid in the tires. They are usually available in units of 100 to 150 pounds each. Sometimes they are split to make them easier to mount. As many as two or three weights (or sets of weights) may be added to each wheel. Each manufacturer supplies cast-iron weights that fit their own tractors. To install, the weights are simply bolted into place.

Adding Weight to the Front Wheels: You can recognize whether or not you need more weight on the front wheels by the way they tend to skid sideways while turning with heavy loads. If the front of the tractor tends to rise off the ground when pulling up a slope, you should add weight to the front. Weight for front wheels vary from 50 to 65 pounds each. Frame weights usually run from 100 to 120 pounds each.

Tire pressure may have to be increased above normal inflation pressure under the following circumstances:

1. Adding weight, such as: mounted equipment, wheel weights or frame weights.
2. Operating the tractor on paved roads for several hours.

Even if tire pressures are checked regularly and are kept properly inflated, it is important to recheck tire pressure when weight is added. Some farmers neglect their tires and let the air pressure run low much of the time. Under-inflation causes buckling. It is a common condition with tractor tires. Over-inflation is less common except when weights or mounted equipment are removed from the tractor without deflating the tires. Proper inflation provides good tire contact with the ground and gives good traction with less wear.

If you are increasing the weight on your tractor tires, or are planning to operate it on hard surfaces for several hours, proceed as follows:

1. Remove valve cap and check pressure with gauge. Liquid-filled tires can be checked with the valve stem in top position if pressure of liquid is added to air pressure. Add 1/2 pound per foot of liquid height as measured from lower valve-stem position. Use a special low-pressure tractor-tire gauge with one-pound pressure marking.
2. Add air (or deflate) as needed to secure proper pressure. Use the tire pressures recommended in your operator's manual.
3. Wash gauge with clear water after using on tires containing calcium-chloride solution since calcium chloride will cause corrosion if it isn't completely washed out.
4. Replace valve cap. Caps help prevent air (and liquid) leaks and at the same time prevent dirt and moisture from entering the valve stems and cores.

CHAPTER IX

STARTING THE TRACTOR ENGINE

To start a tractor engine the operator needs to know more than what levers to pull or push, what valves to open or what buttons to press. The operator needs to know what makes an engine run; what safety precautions to take in starting one; how to protect the battery and starter from overloading; and how to warm an engine properly to keep down rapid wear.

IDENTIFYING THE TYPE OF TRACTOR ENGINE

In starting a tractor engine the operator needs to know whether it is a carburetor-type or a diesel-type engine. The two engines are similar in appearance. The visible difference is in the way fuel is supplied to the cylinders. The engine which has a carburetor mixes fuel and air to draw into the cylinder through an intake manifold. This engine also has a coil, distributor, spark plugs, and wiring.

The diesel engine has a pump mounted on the side instead of a carburetor. The pump forces fuel through separate tubes to each cylinder. Now you have to understand the operating principles of these two types of 4-stroke engines.

The term "4-stroke" is shortened from "4-stroke cycle." These terms mean that 4 strokes are needed to complete each cycle of operation. This is also called "4 cycle." "Stroke" refers to piston movement. One stroke is completed when the piston moves from top position in the cylinder to the lowest position; or when it moves from the lowest position to the top position.

How a 4-Stroke Carburetor Engine Develops Power

1. Intake stroke: Piston moves down, develops suction. Intake valve opens. Outside air is drawn past carburetor nozzle where it picks up fuel spray. Air and fuel mixture passes through open intake valve into cylinder chamber.
2. Compression stroke: With both valves closed piston rises and compresses trapped air-fuel mixture to a pressure of approximately 70 to 160 pounds per square inch.
3. Power stroke: Spark plug fires and ignites air-fuel mixture causing combustion. Piston is forced down. Temperature inside the cylinder is reaching approximately 1300°F.
4. Exhaust stroke: Exhaust valve opens. Piston moves up and forces exhaust gases from the cylinder.

How a 4-Stroke Diesel Engine Develops Power

1. Intake stroke: Descending piston develops suction. Outside air (without fuel) is drawn through open intake valve.
2. Compression stroke: With both valves closed, piston rises and compresses trapped air to about 500 pound pressure. This raises air temperature to 1200°-1500°F.
3. Power stroke: Fuel is sprayed into hot compressed air. Fuel ignites spontaneously (no plug needed). Piston is forced down.
4. Exhaust stroke: Exhaust valve opens. Rising piston forces exhaust gases from cylinder.

PRELIMINARY STARTING PREPARATION

(Carburetor or Diesel Types)

The preliminary procedures for starting a tractor engine are much the same for all makes and types of tractors. Check the operator's manual for the particular tractor. The steps given here are the ones needed before getting on the tractor seat:

1. Provide ventilation if tractor is started inside of a building because carbon monoxide is a poisonous gas.
2. Check fuel supply.
3. Turn on fuel supply from tank. The fuel valve should be opened completely to avoid leakage around the stem.

STARTING ENGINE OPERATION

(Carburetor or Diesel Types)

Although the starting procedures are similar for either carburetor or diesel-type engines, the sequence varies slightly. For that reason the starting procedures for each are given separately.

The difference between a tractor throttle and an automobile foot throttle (or accelerator) is that with an automobile throttle the engine speed and power is directly controlled as the throttle (butterfly) valve opens and closes. The more the air fuel valve is opened, the faster the automobile engine runs, or the more power it supplies.

But the throttle on the tractor controls the engine speed indirectly through a "governor." The governor is designed to maintain a constant engine speed under different load conditions so it is not necessary to reset the throttle lever after the desired speed has been attained. With a diesel engine the governor works in the same manner except that it works with the fuel-injection pump and metering valve to control the amount of fuel injected into the cylinders.

Starting a Carburetor-Type Engine

1. Check to see that the shift lever is in neutral or park. Make sure it can be rocked to left and right crosswise of the tractor. On the new types of transmissions the "park" position is indicated on the face of the speed selector quadrant.
2. Set speed-control lever to the desired position. For carburetor-type engine set lever about 1/4 to 1/3 open.
3. Disengage clutch or depress clutch pedal. Press the clutch down as far as it will go. By disengaging the clutch you relieve the drag on the starter caused by cold oil in the gear case and the drag caused by the gearing to the power take-off shaft or belt pulley.
4. Set choke at desired position.

   The choke control is usually pulled out all of the way in order to provide a rich gasoline mixture for easy starting of a cold engine. If the engine has been running and is warm, don't use the choke.
5. Turn ignition switch to "on" position.
6. Crank engine (manually or with starter). Most tractors are now equipped with electric starters. If your engine fails to start on the first try, wait until the engine and starter have stopped rotating before engaging the starter again. Don't operate the starter longer than 30 seconds. Running the starter continuously for longer than this period is hard on the battery, causes the

starter to overheat and can cause the starter switch to heat and fuse together.

If you attempt to start your tractor by towing, use one of the higher gears. Don't try to tow the tractor too fast; it is hard on your tractor and dangerous for you.

Tractors with power-shift transmissions cannot be towed to start the engine. The transmission in these tractors is controlled hydraulically. When the tractor engine is not running there is no hydraulic control of the planetary units--power cannot be delivered from the rear wheels to the engine.

Starting a Diesel-Type Engine

1. Check to see that the gearshift lever is in neutral.
2. Turn on fuel supply at the fuel-stop control, but do not open throttle.

   The fuel-stop control is a means of shutting off the fuel supply when stopping a diesel engine. On some tractors the fuel-stop control is part of the throttle control. By tripping a latch the throttle lever can be extended past idling position for shutting off the fuel supply. With this type, you automatically turn the fuel supply on when you set the throttle for idling.

   On other tractors the fuel-stop control is separate. If the control was pulled out and left the last time the tractor was stopped, it must be pushed in before fuel can be supplied to start the engine. This control operates independently of the fuel valve under the tank.

3. Turn starter switch to "on" position. The starter switch simply energizes the circuit to the starter which differs from the ignition switch on the carburetor tractors.
4. For cold-weather starting (below freezing) use provisions on the tractor for easy starting. See operator's manual for proper cold weather starting procedures.

   Do not add gasoline to diesel fuel in hopes of making the engine easier to start. Gasoline has:

   a. No lubricating qualities so there is a chance the injectors will be damaged.
   b. The auto-ignition temperature of gasoline is higher than for diesel fuel which makes starting more difficult.
5. Depress clutch to ease starting load.
6. Crank engine several revolutions then open throttle from 1/2 to completely open while engine is rotating.

   The starter is usually controlled by a switch button (not by the key-operated switch). Limit starter operation to 15 or 20 seconds. Do not open throttle until starter has engine rotating. If the fuel enters the cylinders too soon, it will cause the engine to "kick back" and damage the starter.

MAKING ADJUSTMENTS DURING WARM-UP

1. Adjust choke for smooth operation (carburetor engines). As engine warms, push in the choke control gradually. If choke is pulled out too far or pushed in too fast, the engine will miss.
2. Adjust throttle to moderately fast idling speed. In general a moderately fast speed is for carburetor engines at 1/4 to 1/3

throttle and for diesel engines at approximately 1/2 throttle. This speed may seem too fast for a cold engine, but the extra speed makes oil available to bearings quicker than a slow idle.

3. Release foot clutch slowly.
4. Check oil-pressure gauge or warning light. In cool or cold weather the gauge will show high pressure at the start. As the engine warms the pressure will gradually lower to its working pressure. If the gauge shows zero or slightly above zero, stop the tractor and check for cause. Some tractors are equipped with a red warning light on the instrument panel in place of a gauge. If it glows red, stop the engine.
5. Check ammeter or warning light, to see if battery is charging. If the ammeter shows discharge while the engine is warming up, check for the cause of trouble. If warning light--labeled "GEN"--glows, this also indicates discharge.
6. After one or two minutes adjust to higher idling speeds. Carburetor engines are adjusted at 1/2 to 3/4 throttle and diesel engines are adjusted from 3/4 to full throttle.
7. Watch indicator to determine when engine is warmed enough. At proper operating temperatures engine wear is considerably less and the tractor will give much more power with less fuel.

CHAPTER X

CONTROLLING TRACTOR MOVEMENT

When driving a tractor regularly habits are developed. Habits may be good or bad. Whether good or bad, they are the ones which will be used in emergencies. When an individual does not have time to think it is important that the right habits were developed when learning to drive a tractor.

IDENTIFYING THE TYPE OF TRACTOR TRANSMISSION

The transmission is part of the power train that helps deliver power from the engine to the drive wheels. It provides a selection of ground speeds, and one or more reverse speeds. It enables the tractor to match the drawbar pull needed with ground speed and engine speed. In tractors gears cannot be shifted in the same way automobile gears are shifted. Some tractors have gears that can be shifted on-the-go without using a clutch.

From an operator's standpoint there are two types of transmissions:

I. Hand-shift transmissions: Gears are disengaged or engaged manually to get the speed desired, or to secure forward or reverse movement. This is accomplished by means of a lever. The forward gears are labeled "1, 2, 3, . . ." and the reverse is labeled "R." These shift positions are labeled on the transmission casing or elsewhere close to the shifting lever. When the shifting lever is moved according to the labels within the various slots and notches of a quadrant to provide forward or reverse movement the gears are moved along a splined shaft into position to mesh with other gears. When this is done, the tractor is shifted into gear.

With this type of transmission, the gears must be at a standstill if they are to be shifted without causing them to clash. Consequently, it is impossible to shift on-the-go.

II. Power-assist shift transmissions: This is a newer type of transmission which consists of an assembly of planetary gear units. A planetary unit differs from a sliding-gear unit in that it does not require engaging and disengaging gear teeth in order to secure changes in speed or a change in direction.

The planetary gear consists of a sun gear, a ring gear and a carrier. Power applied to the sun-gear causes the whole unit to turn. But if the ring gear is held, the small gears on the carrier "walk" around the ring gear and provide a reduced output speed at the carrier shaft.

Tractor manufacturers use a combination of planetary gears to secure different forward and reverse speeds. When the gear-selecting lever is moved, a hydraulic mechanism provides the holding action needed on the various planetary units to secure the proper forward or reverse movement. It is this arrangement that provides for shifting on-the-go. It is not necessary to stop tractor movement before you shift into a faster or a slower gear. However, if you change from forward to reverse, or reverse to forward motion, stop the tractor to avoid gear damage.

STARTING TRACTOR MOVEMENT

1. Reduce engine speed to a slow idle.
2. Check foot brakes and unlatch if in latched position. On most tractors both brake pedals are on the right hand side of the engine. The latch release may be a lever, pull rod, toe-trip or arranged so you can flip it out of position.

3. Disengage clutch if tractor has a hand-shift transmission. It cuts off power to the transmission shaft and allows the gears to stop rotating. The gears must be stopped if you are to shift without clashing them.

4. Move shifting lever into gear position that fits speed and power desired.

   Small tractors often have 3 speeds forward but most farm-size tractors have at least 4 to 5 forward speeds. The operator should select one of the low speeds until familiar with the tractor and controls.

5. Check to make certain that there are no riders and that all persons, livestock and obstructions are out of the way.

6. Increase engine speed and gradually engage clutch on hand-shift transmissions.

7. Gradually open throttle to desired speed.

OPERATING A MOVING TRACTOR

Many tractors are manually steered, but on some models power steering is standard equipment; on others it is optional. Steering the tractor is about the same as steering an automobile. Tractors with the hydraulic mechanisms lessen the amount of pull needed on the steering wheel to turn the front wheels. With heavy tractors, or when tractors are operating in soft fields or in close quarters, the steering effort is greatly reduced. Applying individual wheel brakes will also help tractor steering, especially when making a short turn, by pressing on the brake which causes the wheel to be slowed or stopped, so the front of the tractor turns with little or no forward movement. This is excellent assistance for short turns at the end of cultivated rows, or when operating a tractor in a barn or in close quarters. Be sure to keep your speed down when making turns. Turns can upset a tractor at 8 miles per hour or less on level ground.

Adjust your brakes so the same amount of pedal travel will give equal braking on both wheels, then interlock them when traveling at higher speeds. If you do not, and press on one wheel brake to make a quick turn, you will probably upset the tractor. When one rear wheel is braked, the other speeds up. If one wheel is completely braked, the other turns twice as fast. This greatly increases the chance of overturning the tractor.

After the clutch is engaged completely remove the foot from it. When the operator rests his foot on the clutch during the operation which is called "clutch riding" it may cause the clutch to wear out. It shows up in two ways:

1. The clutch facings slip, causing fast wear and an early repair job.
2. The thrust bearing will wear rapidly due to oil being wholly or partially scaled off as long as there is some pressure against the clutch pedal.

When going downhill, leave the tractor in gear. The engine acts as a brake as long as the throttle is in the idling position. It helps save wheel brakes.

STOPPING TRACTOR MOVEMENT

1. Reduce engine speed by retarding throttle setting.
2. Disengage clutch and move gear-shift lever to neutral position.
3. Re-engage clutch (if using a foot clutch). If a power-assist shift is used downshift (one gear at a time) to neutral or park without using the inching pedal.

Removing foot from a foot clutch automatically re-engages it.

4. Press foot brake down and lock for parking. Do not depend on leaving your tractor in gear for holding it on a slope. In the higher gear there is relatively little resistance to movement.

5. If engine is to idle, set speed-control lever at fast idle.

   For carburetor engines, set at 1/4 to 1/3 throttle.

   For diesels, set at 1/2 throttle.

CHAPTER XI

OPERATING A TRACTOR UNDER FIELD CONDITIONS

MAKING ADJUSTMENTS BEFORE STARTING THE FIELD WORK

The operator's manual will give definite procedures to follow according to the make and type of tractor. In general, these are the checks and adjustments which need to be made.

Checking the Power Take-Off

When power take-off is not to be used:

1. Disconnect power to power take-off shaft. This is usually done by moving a shifter lever, moving a lever to neutral, or throwing a clutch out of engagement.
2. Be sure the guard is in place over end of power take-off shaft.

If the power take-off will be used:

1. Determine if power take-off is set for the speed you wish. Besides the standard 540 and 1,000 rpm take-off speeds, some tractors are equipped with another power take-off speed. When the shifter lever is positioned to "GROUND PTO" the power take-off speed is related to the rate of ground travel rather than engine speed. Its use is limited to such equipment as a side-delivery rake or planter that needs an operating speed in constant relation to ground travel. The power take-off shaft makes one revolution for each 9 to 20 inches of ground travel, depending on the tractor make and/or model.

2. Recheck to make sure shields are in place over the power take-off shaft.
3. Engage power-shaft shifter lever.
4. Check operation of power shaft and equipment at approximately half speed.

Checking the Hydraulic System

Present-day tractors do not provide a means for disconnecting the pump. Hydraulic power is needed continuously for implement control and to supply power for brakes, steering, and hydraulic motors. There is provision in most hydraulic systems to automatically relieve the pumps when hydraulic demands are low. This helps provide efficient operation of the system. If an old tractor or the hydraulic system is not used the pump should be disengaged.

If the hydraulic system will be in use, proceed as follows:

1. Move hydraulic-control lever through "raise" and "lower" positions to make certain system is operating satisfactorily. There are 2 different control actions for operating the hydraulic control of different tractors.
   a. Limit control: movement of the control lever in either direction from neutral, will cause the implement to continue rising (or lowering) until the lever is returned to neutral. The implement remains fixed in that position until the control lever is moved again.
   b. Proportioning control: movement of the control lever in either direction will cause the implement to be raised or lowered in proportion to the distance the lever on the quadrant is moved. The control lever has no neutral.

2. Set supplement hydraulic controls as necessary.

   a. If the tractor is connected to a trailing implement which is equipped with a remote cylinder, set stop on piston rod for approximate stroke desired. For plows this limits the plowing depth. For grain drills, combines and equipment where the cylinder is used for lifting, it determines the height of lift.

   b. If the tractor is connected to mounted equipment, it may have a similar cylinder and adjustable-stop arrangement as used on the remote cylinder.

      The direct manual control of the hydraulic unit is sometimes called position control, implement position control, or uniform depth control. When the soil engaging equipment has reached the proper depth, you can set the stop so the lever can be returned to the same position to assure the same depth when the implement is again raised and lowered.

   c. If a mounted implement has its own gauge wheel, set the hydraulic control lever in free-floating position. The gauge wheels control implement depth and need to be free to rise and lower in accordance with the charges in surface condition. Check the operator's manual for proper positioning of control lever.

      Some tractors are equipped with automatic draft control. The draft control is known by such trade names as constant draft control, load control, traction booster and traction amplification. This is a weight-transfer device built into the tractor hydraulic system. It is used with mounted equipment of the soil-engaging type such as plow and disc harrows. The draft control lever may be found on the gear case or on the quadrant assembly along with the hydraulic-control lever. Draft controls vary somewhat in the way they are adjusted, so be sure to use the operator's manual for your tractor for exact instructions.

3. Check rate of lowering and raising of implement, or hitch. A flow control valve, commonly called a response control governs the speed with which an implement is lowered for ground engagement. For plowing or cultivating a fast drop is desirablé, while a slow gentle drop is recommended for a planter.

4. Check implement hitch.

   Some implements provide two positions for the tongue, or draw pull. One position is for transporting, to center the implement back of the tractor. The other position is for field use and provides for positioning the implement to one side of the tractor hitch. These are common on field balers, combines and corn harvesters.

MATCHING GEAR SELECTION AND ENGINE SPEED WITH LOAD

Some tractor operator's manuals give suggested speeds for various farm jobs. If you have four speeds forward on your tractor, your selection can be approximately as follows:

1st -- For extra-heavy or slow-speed work.

2nd -- For plowing.

3rd -- For cultivating plants that are so large that they don't cover easily.

4th -- For light work.

If there are five speeds forward, the first and second gears are used for heavy work.

These are good general recommendations, but the conditions under which a tractor operates vary widely. An operator needs to know what is involved in selecting a gear that will get the field job done effectively and still use an engine speed that will give satisfactory engine efficiency.

Carburetor Engine

1. Heavy load: The greatest efficiency is attained when the speed-control lever is completely open. On a job that requires full horsepower occasionally, select a gear that will allow operation with the speed-control lever completely open--this will keep the reserve horsepower of the engine available for times when it is needed.
2. Light load: If operating a carburetor engine at light load, the operator will get the greatest efficiency by using the highest gear at which the tractor will still have the necessary pull. It is generally accepted that an engine should not be operated on continuous pulls with the speed-control lever much less than 1/2 open.

Diesel Engine

1. Heavy load: A diesel engine will operate with the most efficiency when fully loaded with the speed-control lever completely open. If the tractor is about to stall under heavy load, it may start running backwards. When this happens, air is drawn in through the exhaust valves and forced out through the air cleaner. Besides getting an oil bath from oil blown out of the air cleaner stack, it is extremely dangerous. Diesel engines will develop almost full speed when the engine reverses if the speed control lever is completely open.

2. Light load: Follow the same procedures as with a carburetor engine. A diesel engine has the advantage of higher efficiency at part load than a carburetor engine and has better lugging ability at slow engine speeds, but it is important to keep the engine speed high enough to avoid excessive exhaust smoke.

Do not overload either type of engine, or load it so heavily there is no reserve for momentary overload. The reserve power of a carburetor engine can be checked with the tractor in motion, and the throttle half open. Then quickly pull the throttle fully open. If the tractor speeds up rapidly, the engine is not overloaded.

When using a power take-off, set the speed control lever to supply the proper power take-off speed, then adjust ground speed with gear selection.

If the tractor has a tachometer or an instrument which indicates engine speed in revolutions per minute, the proper engine speed for the power take-off is marked on it. If it has no tachometer, check the operator's manual. Some tractors provide proper power take-off speed when the speed-control lever is fully open. Another method is to check a slow moving part such as the straw rack on a combine in order to find out the proper speed of a tractor engine. Speed may also be checked at the end of the tractor power shaft with a speed counter.

HANDLING OVERLOADS WITHOUT STOPPING TRACTOR

You can get the greatest efficiency from your tractor if you can operate it near its full-load capacity. The problem is that any extra demand of power creates an overload which if continued can be very harmful to the tractor. Also, it may cause you to kill the engine at a time when it is difficult to start the load again from a dead stop.

Tractor manufacturers have developed a number of ways to down shift while your tractor is still moving. This supplies the extra drawbar power needed to meet most temporary overload conditions. Tractors with power-assist shift transmissions already have provision for down shifting on-the-go. Tractors with standard gear transmissions--those which must normally be stopped to change gears--use overload units to advantage. The units enable the operator to slow ground travel without stopping and at the same time increase drawbar pull from 40 percent to as much as 100 percent. These units are also useful for starting extra-heavy loads. They are of three different types.

1. A planetary gear unit called by such names as "ampli-tore" and "torque amplifier" and it is located between the engine clutch and transmission. When you are operating a tractor equipped with this unit and encounter an overload, you simply pull back on the planetary drive lever. This is done without stopping the tractor or disengaging the clutch. When this is done you immediately get a slower forward speed and an increase in drawbar pull. When the overload condition is past the planetary-drive lever is pushed forward so the tractor again travels at its original speed for more economical operation. This unit can be used in any of the forward or reverse speeds.

2. A double-clutch unit goes by such commercial names as "power director" "hydra-power" and "multipower" and it is located between engine clutch and transmission. From the operator's standpoint it works the same way as the planetary unit. The principal difference is that some have a neutral position. Neutral is used to stop forward movement of the tractor. When the control lever is in neutral both clutches are disengaged. The tractor has no forward movement.

When the control lever is pushed forward, the high-range clutch engages. Power flows from the engine directly to the transmission shaft. The rest of the mechanism rotates but transmits no power. When an overload develops, the control lever is pulled back. This automatically disengages the high-range clutch and engages the "low-range" clutch. Power from the engine feeds through the speed-reducing gears to provide slower speed to the transmission shaft. Ground speed is slowed, but more pull is provided at the drawbar to meet the overload condition.

3. Torque converter is located between the engine and engine clutch. It operates differently from the other two units, and is a completely hydraulic unit. The power is transmitted by oil being forced at high speed from the engine-driven pump to the blades of the turbine.

When the tractor first starts to pick up its load the turbine is moving slowly compared to the pump; thus oil strikes the turbine blades with tremendous force. As oil circles off the turbine blades, it moves inward toward the center of the converter. There it strikes a stationary blade called a "diverter" or "stator." The purpose of the diverter is to make the oil change direction (from a backward to a forward movement) before re-entering the pump.

As the tractor load begins to move, the turbine increases in speed until it approaches the speed of the pump. On some torque converters, the diverter is then automatically released so it will turn with the pump and turbine. All 3 parts then rotate at about the same speed. On others, the diverter or stator remains stationary. There is no lever to move when you use a torque converter for overloads. As an overload develops, the turbine speed and tractor ground speed slows in approximate proportion to the overload. At the same time, drawbar pull increases. When the overload is past, tractor ground speed increases to normal and drawbar pull becomes less.

CHECKING AND CORRECTING TIRE SLIPPAGE

There is some slippage with the rubber tires but if the slippage becomes greater than 15 percent during normal field operations you should either add weight to the rear wheels to provide more traction or reduce the tractor load. If you operate your tractor on hard surfaces such as concrete, this percentage increases which results in rapid tire wear. It is difficult to see slippage until it reaches about 15 percent. Slippage can cause: rapid tire wear, waste fuel, and waste valuable time.

How to Check Tire Slippage

1. Disconnect tractor from load.
2. Put chalk mark on tire directly below axle.
3. Mark ground or set stake in ground next to chalk mark.
4. Drive tractor straight ahead until tire makes exactly 10 revolutions.
5. Stop when the chalk mark is directly under the axle.
6. Measure distance between starting and stopping points and call it (A).
7. Connect tractor to load.
8. Repeat steps 2 through 4.
9. Measure the distance between starting and stopping points and call it (B).

Figure percent of slip as follows:

$$\frac{\text{(distance to) A} - \text{(distance to) B}}{\text{(distance to) A}} \times 100 = \text{percent of slip.}$$

When there is heavy drawbar pull and traction conditions are poor, one drive wheel may start to spin. This often occurs to the land wheel while plowing because most of the weight is on the furrow wheel due to the tilt of the tractor. You can reduce slippage by one of these methods:

1. Additional weight: Add more weight to the land wheel only when plowing and the weight should be removed when not needed.

2. Differential lock: If your tractor has a differential lock, and one wheel starts to slip, engage the hand or foot lever that controls the lock. The locking device is located in the differential. It engages both rear axles so they drive as a solid shaft. Power is applied evenly to both wheels, regardless of slipping or turning conditions. The wheel with the best traction will then increase its pulling effort without the opposite wheel spinning.

Check the operator's manual to learn how the unit works. When turning make certain the differential lock is released. Because when a tractor turns, the outside wheel must rotate faster and travel a greater distance than the inside wheel. If the differential lock is still engaged both wheels are forced to rotate at the same speed which causes excessive strain on the differential and rapid tire wear. These units may be either mechanically or hydraulically operated.

3. Braking action: Apply braking action on the spinning wheel to slow it down. Greater pulling effort is transferred to the wheel that has good traction. Under most conditions tractor travel will continue. But, the wheel braking causes rapid brake wear, wastes engine power, strains the drive mechanism and may even stall the engine. Use this method for emergencies or short periods of time.

Do not try to reduce tire slippage by lowering the pressure of tire which can cause the possiblity of slipping a tire on its rim and ruining a tube, and crackling and ruining the sidewall of a tire from buckling.

OPERATING A TRACTOR ON SLOPES

When driving your tractor around slopes, the wider the spacing between rear wheels the more you reduce the chance of tipping sideways. If the front wheels can be widened to the same width as the rear wheels, it helps the operation of the tractor to be safer, by taking care of unexpected holes or low spots you hit on the lower side of the tractor; or stumps, stones or ridges on the upper side. When pulling a load up hill, it is a good safety precaution to add weight to the front wheels or to the frame. This is especially important if part of the load is carried on the rear of the tractor. If it is a quite steep hill and you have no load, back the tractor up the slope.

Engage the clutch easily. This is particularly important when starting up a hill with a load. Quick engagement of the clutch greatly increases the chances of the tractor tipping over backwards. There is little danger of a tractor overturning backwards when pulling a properly-hitched load up hill. The front wheels may lift off the ground so you cannot steer the tractor, but the forces exerted on the tractor by load help keep it from turning over backwards. Hitching the load to the rear axle, or attaching to a high drawbar hitch, greatly increases overturning tendencies. It can also be dangerous if the rear wheels start spinning and you let them dig in. The load becomes less effective in holding down the front of the tractor and at the same time traction increases on the wheels which may cause it to rotate backwards on its axle.

When going down hill, keep the tractor in gear and let the engine compression help brake the load. Do not depress the clutch. If the tractor speeds up press on both brake pedals. If your tractor has a power-assist shift transmission, you can shift to a lower speed while on the go if more braking action is needed. Do not let the tractor be out of gear when you are going down hill, because you are totally dependent on the tractor brakes. They may not have good braking action or not apply it evenly enough to avoid side slippage. You cannot shift tractor gears with the tractor in fast motion so it is too late then to get braking action from the engine. Do not drive too close to the edge of ditch banks which is a common cause of accidents. It will help if you understand that the normal shear angle of soil without vegetation is about 45° for ditches 6 feet or less in depth. If you keep your tractor wheels as far away from the top of the slope horizontally, as the ditch is deep it is likely to be a safe distance. Also the kind of cover, moisture content, and type of soil will give you an idea how much closer you can drive.

PULLING OUT OF A MUD HOLE OR DITCH

Conditions that make a tractor turn over backwards when the rear wheels become completely mired in a mud hole or lodged in a ditch, and a plank is fastened to the wheels this keeps the wheel from turning. High engine speed, plus quick clutch engagement, causes front of tractor to rise. When the rear wheels of your tractor mire down or lodge in a ditch, proceed as follows:

1. Try backing out.

   If not pulling a load, this may be enough to free your tractor.

   If you are pulling a load, you may not be able to back very far, but even with a small backward movement you may be able to move ahead slowly by shifting to first gear, setting your engine at moderate speed, and letting the clutch engage slowly. If it doesn't work, try step 2.

2. Try digging out in front of the rear wheels, shift into first, use moderate engine speed, and let the clutch engage slowly. It will probably help to dig out in front of the front tires too unless they are already on solid ground. If this procedure doesn't free your tractor, try step 3.
3. Get another tractor to pull out the tractor which is stuck. Be sure to attach a chain, cable or heavy rope to the drawbar of the tractor used for pulling and attach the other end to the frame of your tractor. When the pulling tractor has tightened the tow line, provide help with power from the tractor which is stuck. The mired tractor cannot turn over backwards as long as the other tractor is pulling.

CHAPTER XII

OPERATING A TRACTOR UNDER HIGHWAY CONDITIONS

Farm tractors and other farm vehicles, road maintenance and construction equipment and horse-drawn vehicles, designed for speed of no more than 25 miles per hour, have been classified by national safety council as "slow-moving vehicles." They are frequently referred to as SMV's.

The tractor operators are in great danger. It is evident that in case of accidents, the unprotected driver of the tractor will be seriously injured or killed. If you are careless an accident could happen anywhere on open highways, on hills and curves, any time daylight or night. It is a good policy to be safe. In order to be safe safety warning devices are needed on tractors and trailing implements when operating them on a road or highway regardless of the time of day or night. This is true even when visibility is unlimited and the road surface dry. When visibility is limited by dust, fog, hills, trees, blind intersections or nightfall, or when the highway is slick because of ice, snow or rain, warning devices are an absolute necessity.

It is important for highway travel that you interlock the two brake pedals and inflate your tires to a maximum pressure, if you plan to operate your tractor on the highway for several hours.

PROVIDING SAFETY WARNING DEVICES

The warning devices such as slow-moving-vehicle emblems, flags, reflectors, and lights on the farm tractors and implements for highway travel should be used in order to give early warning to the driver of fast-moving vehicles to avoid collisions between them.

The slow-moving-vehicle emblem is designed to be visible for a distance of one-sixth mile or more. This symbol is of standard size and color and it should be mounted at the center of tractors or trailing implements at a height of two to six feet from the ground. This emblem does not take the place of light or lights or other safety devices required by law, and it is not intended for use on motor vehicles.

Warning-light standards: For night use or for limited-vision conditions have been developed by the American Society of Agricultural Engineers and the Society of Automotive Engineers which are based on these standards.

Recommended use of safety warning lights:

For tractor only:

1. Two head lamps.
2. At least one tail lamp.
3. At least one flashing warning lamp, and should be mounted as high as practical to the farthest projection to the left.
4. A second flashing light on a towed or mounted implement:

    If it extends more than 4 feet to the left of the center of the tractor.

    If it extends more than 15 feet to the rear of the tractor hitch point.

In addition to warning light, two amber reflectors or two pieces of amber reflective tape are recommended for implements that extend more than 4 feet left from the center of the tractor, or 15 feet to the rear of the hitch point on the tractor. This is to help outline the left extremity of the implement.

A special safety light developed which is very convenient for the operator to use. This movable safety lamp can be stored on the steering-column bracket until needed. Lamps can be mounted on towed equipment on special bracket. Cord connects to outlet on tractor.

SELECTING A SUITABLE SPEED

It is very important for the operator to know which speed to select in order to travel on highways. It mainly depends on the climatic conditions and type of road whether you are driving up hill or down hill and also it is up to the type of load you are pulling or towed implement. Use your judgment. But the highest gear on your tractor is intended for highway travel. With most of the loads you are likely to pull on a highway, you can probably use high gear without overloading your engine.

Top speed on most tractors, in high gear with throttle completely open, is around 10 to 12 miles per hour. However, there are some that go no faster than 6 miles per hour and others as high as 18 miles per hour or faster. Some tractors are equipped with a foot-operated accelerator. This provides more flexible speed control than when you depend on a hand speed control lever.

USING RIGHT-OF-WAY

Be doubly careful when entering a highway with tractor and equipment. Do not gamble with fast moving traffic. Cars traveling at 60 miles per hour require a total stopping distance of 565 feet--this allows a reaction time of 4 seconds for the driver to see you, realize the situation and apply brakes. If the road is wet, still more distance is needed.

If you have a curve or crest of a hill closer than about 700 feet, use a high flag on your tractor to warn the oncoming motorist. It is safest to send someone far enough up the road to signal when it is safe to enter. For greatest safety, use the road shoulder if possible. If you cannot use it completely, use one lane of the highway. In doing so, do not use part of the lane. This encourages traffic or motorists to pass you when road width may not be enough to allow three vehicles to pass if a third one should approach from in front. But when the equipment you are pulling extends into the second lane move your equipment over the shoulder far enough so that it will not occupy more than one lane.

If you are traveling on one lane of a highway and cars begin to gather behind you, pull off to one side of the road and let them pass. Do not try waving them past. Use standard road signals by hand for a left turn or right turn. If you plan to stop, you should pull off the road.

SLOWING OR STOPPING A TRACTOR AT ROAD SPEED

Before trying to stop your tractor, retard the throttle so the engine will take most of the braking action until the speed of the tractor and equipment has decreased. This is the best and safer manner than using your tractor brakes, because a slightly uneven pull of the brakes at high speeds will throw your tractor sideways.

Use the same precaution in going down hills. Select a lower gear if the pressure of towed equipment advances tractor speed to where it is unsafe.

CHAPTER XIII

STOPPING THE TRACTOR ENGINE

Regardless of the kind or type of tractor or the kind of fuel it uses, the tractor engine if it has been heavily loaded should run a few minutes before stopping. An engine will usually run safely because of the continuous circulation of the water and lubricating oil and the draft of air blowing over the engine from the radiator fan. When you suddenly stop a heated engine, the water and oil pumps and the fan come to a sudden standstill. The temperature of the engine rises rapidly. This sharp temperature rise may cause expansion of engine parts and may result in a warped head or engine block in severe cases. Overheated exhaust valves which may be left off their seats when the engine is stopped may also become warped.

Check your operator's manual for proper procedure for your particular tractor.

STOPPING A CARBURETOR ENGINE

If your tractor engine runs on gasoline only, use the following procedures:

1. If the engine has been heavily loaded, idle at about half throttle for two or three minutes.
2. Retard throttle and turn off ignition switch. Do not choke the engine to stop it. This leaves the cylinder with excess fuel which gets to the oil and causes dilution.

3. If the tractor is to remain idle overnight or longer, shut off fuel valve under the tank. Cover the end of the exhaust pipe with a can to keep out rain. This will make it easier for you to start next time. Some tractors have caps on the end of the exhaust pipe. When the engine is stopped the cap automatically closes.

REFUELING THE TRACTOR

Most operator's manuals suggest that the tractor fuel tank should be filled at the end of the day, or anytime when you finish using your tractor. The reason for this is to keep moisture from accumulating in the tank.

How a fuel tank collects moisture: Warm, moist air replaces gasoline used from the fuel tank. As air cools moisture deposits on side of tank and runs into the fuel. When this fuel gets into the carburetor, any sulfur present in the fuel combines with water and attacks the metal parts. During the winter, when the weather is cold, this water which has collected in the sediment bowl or fuel line may freeze and cause starting troubles. In the diesel engine when this water gets to the injection pump, it causes galling and sticking of the pump part which is very expensive to repair. If the fuel tank is filled immediately after the tractor is used, there is no room for moist air.

Dirt has a bad effect in a carburetor. It usually closes or partly closes the small openings or orifices that allow the right amount of fuel to mix with incoming air. In diesel engines, it speeds the wear of the plungers in the injector pump.

Fire hazards: If your tractor is hot and you haven't time to wait for it to cool, wait and refuel the next morning. The risk of water in your tractor fuel becomes less important than the risk of fire or explosion which might result from spilling of gasoline on a hot manifold or other hot surfaces during refueling of a hot engine.

Use the following procedures when refueling the tractor:

1. Check against fire hazards.

   Shut off the engine and turn off all electrical switches to lessen the danger of a spark.

   Allow engine to cool if hot. Be sure that no one is smoking.

2. Check mouth of container or hose nozzle for dirt. Remove any dirt with a clean cloth.

3. Remove dust and loose dirt from fuel tank cap and area around tank opening.

4. Fill fuel tank almost full.

   Leave space in neck of opening for fuel to expand if heated; this helps avoid overflow and possibility of fire.

   With diesel fuel, leave about 3 inches of fuel in the bottom of the storage tank as a safety precaution against moisture and dirt.

5. Replace fuel tank cap tightly.

   Check the opening in the fuel tank cap. If it is clogged, a vacuum tends to develop in the fuel tank and avoid properly feeding of fuel into the carburetor.

BIBLIOGRAPHY

1. A Guide for Vocational Education Curriculum Development, Oregon State University, Cawalis, Oregon, 1967.

2. Knotts, C. Don and Webb, Earl S., "Content Priorities for Farm Mechanics," Agricultural Education Magazine, 46:10, April, 1974.

3. Mcilvain, Clarence L., "A Farm Mechanics Program for the Hoxie, Kansas High School," Unpublished Master's Report, Kansas State University, 1962.

4. Brasfield, Eugene D., "Determining Some of the Farm Mechanics Jobs and Skills Needed by Farmers of the Hornboak High School Service Area that Should Be Included in an Instructional Program," Unpublished Master's Thesis, University of Tennessee, 1955, p. 84.

5. Finley, Charles S., "Repair Jobs Performed on Farm Machinery and Shop Tools and Equipment Used by Arizona Farmers," Unpublished Master's Report, University of Arizona, 1952, p. 38.

6. Reece, Floyd Norman, "An Investigation of Farm Tractor Performance," Unpublished Master's Thesis, Kansas State University, 1959.

7. Weber, J. A., "Maintenance Inspections of Sixty Farm Tractors," Agricultural Experiment Station, Bulletin 624, University of Illinois, 1958.

8. ASAE Power and Machinery Technical Committee; Format for periodic lubrication and service charts for tractors and farm machinery, 1970.

9. Edson, Da Silva, Jose, "Suggested Plan for a Course of Study in Agricultural Mechanics for Northeast Brazil," Unpublished Master's Report, Kansas State University, 1971.

10. Evans, Rupert N., Foundations of Vocational Education, Charles E. Merrill Publishing Company, Columbus, Ohio, 1971.

11. Agricultural Equipment Technology, "A Suggested 2-year Post High School Curriculum," U.S. Department of Health, Education and Welfare, Office of Education, Washington, D.C., No Date.

12. Gordon, Gemmill and Carl, Eicher, "The Economics of Farm Mechanization and Processing in Developing Countries," A Seminar Report held at Michigan State University, March 23-24, 1973.

13. Jones, Fred R., Farm Gas Engines and Tractors. New York: McGraw-Hill Book Company, Inc., 1966.

14. Moses, Ben D., and Frost, Kenneth R., Farm Power. New York: John Wiley and Sons, Inc., 1962.

15. Farm Tractors. Standard Oil Division Oil Company, Engineering Bulletin, No. FT-53, Chicago, Illinois, 1968.

16. Weber, J. A., Importance of Air Clean Service. Tractors and Machinery No. 9, Department of Agricultural Engineering, University of Illinois.

17. Reece, F. N., and Larson, G. H., A Study of the Performance of Fifty Farm Tractors, Agricultural Experiment Station Technical Bulletin 99, Kansas State University, May, 1959.

18. Fundamentals of Machine Operation Preventive Maintenance, Deere & Company, Moline, Illinois, 1973.

19. Fundamentals of Service Engines, Deere & Company, Moline, Illinois 61265, 1972.

20. Fundamentals of Service Tires and Tracks, Deere & Company, Moline, Illinois, 1970.

21. Fundamentals of Service Fuels, Lubricants and Coolants, Deere & Company, Moline, Illinois, 1970.

22. Promersberger, William J., Bishop, Frank E., and Priebe, Donald W., Modern Farm Power. Prentice-Hall, Inc., Englewood Cliffs, N.J., 1971.

23. Tractor Maintenance, Southern Association for Agricultural Engineering and Vocational Agriculture, Coordinator's Office, Agricultural Engineering Building, Athens, Georgia, 1964.

24. Tractor Repair and Maintenance, Department of Agricultural Education, Lincoln, Nebraska.

25. Brown, Arlen D., Tractor and Small Engine Maintenance. The Interstate Printers & Publishers, Inc., Fourth Edition, Danville, Illinois, 1973.

26. Engine and Fuel System, International Harvester Company, Chicago, Illinois, No Date.

27. The Tractor Electrical System, American Association for Vocational Instructional Materials, Engineering Center, Athens, Georgia, No Date.

28. Selecting and Storing Fuel and Lubricants, Published by the American Association for Vocational Instructional Materials, Revised July, 1973.

29. Tractor Tips, Champion Spark Plug Company, Toledo, Ohio, No Date.

30. Engineering Manual (Spark Plug), Champion Spark Plug Company, Toledo, Ohio, No Date.

31. Long, Melvin E., "Weights, Dual Wheels, High-flotation Tires, Future Trends," Implement and Tractor, April 21, 1969.

32. Things to Know About Engine Wear, Standard Oil Company, Technical Bulletin No. 55-1, September, 1955.

33. How to Get Extra Service From Farm Tires, The Rubber Manufacturers Association, Inc., New York, No Date.

34. The Engine Cooling System, National Carbon Company, New York, 1960.

35. Long, Melvin E., Engine Ignition System, Implement and Tractor, October 21, 1963.

36. White, Robert G., "Transistorized Ignition Systems," Extension Agricultural Engineer, Michigan State University.

37. Care and Operation of Hydraulic Systems for Tractors and Other Mobile Equipment, AAVIM, Athens, Georgia, 1974.

38. Zimmerman, Mark, "Transistorized Ignition Systems," Implement and Tractor, March 21, 1969.

39. Fundamentals of Semiconductors, Delco Remy, Anderson, Indiana.

40. Farm Tractor Tune-up and Service Guide, American Association for Agricultural Engineering and Vocational Agriculture, Agricultural Engineering Center, Athens, Georgia.

41. Tractor Operation and Daily Care, American Association for Agricultural Engineering and Vocational Agriculture, Agricultural Engineering Center, Athens, Georgia, 1970.

42. Hall, Raymond C., "Demonstrate Farm Tractor Safety," Better Farming Methods, October, 1956.

43. Farm Tractor Basic Principles, Operation, and Maintenance, American Oil Company, Engineering Bulletin No. FT-53, New York, 1956.

44. Fluorescent Reflectorized Triangular Emblem to Identify Slow-Moving Vehicles on Highways, Harkness, K. A., Agricultural Engineering Journal, 44:7, July, 1963.

45. Agricultural Engineers Yearbook, American Society of Agricultural Engineers, Saint Joseph, Mich., 1966.

46. Tractor Transmission, American Association for Agricultural Engineering and Vocational Agriculture, Agricultural Engineering Center, Athens, Georgia, 1966.

INSTRUCTIONAL PROGRAM IN TRACTOR MAINTENANCE AND OPERATION FOR AFGHANISTAN

by

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AN ABSTRACT OF A MASTER'S THESIS

submitted in partial fulfillment of the

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Agricultural mechanization is increasing in Afghanistan and every year about one hundred new tractors are imported and sold to the farmers on a long-term basis. In 1973 there were 152 new tractors which were distributed to farmers in Afghanistan by the Agricultural Bank. It is not only necessary to increase the use of machinery for improvement of agriculture, but it is also necessary to maintain the machinery which is being used at the present time.

The purposes of this study were to identify the competencies needed to perform the tractor maintenance and operation functions needed in Afghanistan, and to develop the instructional materials to be used by the author in teaching a course to Afghan students on tractor maintenance and operation.

The author developed a questionnaire involving various aspects of tractor maintenance and operation with the assistance of professors from Kansas State University. The questionnaires were then trial tested by persons experienced in the instruction of tractor maintenance and operation. The revised questionnaires were then sent to five Americans who had taught Tractor Maintenance and Operation courses in Afghanistan.

Five usable returns were received responding to the importance of tractor maintenance and operation. The results from the respondents were compiled and each degree of importance was given an arbitrary weighted value according to a Likert type scale as follows:

High importance . . . . 5 points

Medium importance . . . . 3 points

Low importance . . . . 1 point

No importance . . . . 0 points

After computation of the data instructional materials were developed for all areas receiving an importance rating of 3.0 or more. One area "stopping a diesel engine" with an importance rating of 2.2 was discarded. Instructional materials were developed for all other areas which were included in the questionnaire.

Instructional materials were developed for the following categories in tractor maintenance:

Maintenance activities after 10 hours or daily service

Maintenance activities after 50 hours of operation

Maintenance activities after 100 hours of operation

Maintenance activities after 250 hours of operation

Maintenance activities after 500 hours of operation

Maintenance activities after a year of operation

Instructional materials were developed for the following categories in tractor operation:

Making adjustments to meet operation needs

Starting the tractor engine

Controlling tractor movement

Operating a tractor under field conditions

Operating the tractor under highway conditions

Stopping the tractor engine

The instructional materials developed in this study will be used in teaching Afghan students tractor maintenance and operation skills. The instructional materials will be used by the author in preparing students for teaching, working at experiment stations, and those who will return to farming. The instructional materials developed in this study will also be used in short courses offered by the college, and by agricultural extension staff members working in rural communities.