

A TRACTOR MAINTENANCE AND OPERATION PROGRAM  
FOR SCHOOLS OF AGRICULTURE IN NIGERIA

by

ANDREW D. KESWET

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Approved by:

  
Major Professor

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## CHAPTER I

### INTRODUCTION

#### THE FEDERAL REPUBLIC OF NIGERIA

Nigeria, one of the most populous countries in Black Africa is located on the west coast of the African Continent. It is bounded on the south by the Gulf of Guinea (formed by the Atlantic Ocean), to the east by Cameroon Republic, in the north by Niger Republic and on the west by the Republic of Benin.

There are four main topographical areas that can be distinguished in terms of vegetation, altitude, and climate. These are (1) the hot, humid coastal belt of Mangrove Swamp, 16-97 km wide, (2) north of the Mangrove Swamp is the tropical rain forest and oil palm bush, 30-160 km, (3) the high, relatively dry central plateau, of open woodland and Savanna, and (4) the Semi desert in the extreme north.

In Nigeria, there are several navigable rivers, notably the Niger, the Benue, and the Cross. In addition the extensive lagoon of the southern coastal area plays an important role in transportation and economic activities.

Two seasons, dry and wet as they are called, are characteristic of the country. The dry season of the north is from October to April, and is usually made dusty by Sahara winds called "Harmattan" its origin from the Sahara desert. In the south this season extends from November to April, with considerable desert winds and some dust in December and January. The annual rainfall varies from 160 inches on the eastern coast to 30 inches or less in the extreme north.

The annual temperature varies between 70°F and 90°F with high humidity in the southern part and dryness in the north. The highest temperatures occur between February and April in the south and between March and June in the north. Minimum temperatures of about 45 degrees in the north are usually observed.

The vegetation belts of Nigeria are governed particularly by the variations which occur in the rainfall. The humid, tropical forested south with its longer rains is capable of supporting tree crops, whereas in the north with its lower rainfall and shorter rains consisting of Savanna grassland is suitable for grain and leguminous crops, the seeds of which require dry, hot periods to ripen.

#### THE ECONOMY OF NIGERIA

The economy of Nigeria is dominated by two sectors -- Petroleum and Agriculture. Petroleum is accounting for more than one-third of the gross domestic product, while agriculture is one-fourth. Whereas petroleum accounts for 80% of all government revenues, it provides only a small amount of employment. The agricultural sector, despite a continuous exodus, still accounts for 65-75% of total employment.

Several constraints have hampered the growth effect of the boom on the economy. The major factor being shortages in manpower (skilled labor). Oyenuga summed up the effect of this manpower shortage when he said,

"Of those crops in which Nigeria ranked as a major world exporter 10 years ago -- cocoa, groundnuts, and palm products -- only cocoa still earns the country significant foreign exchange."<sup>1</sup>

The present low level of agricultural production and output per unit of cultivated land and per worker, and the resultant low income per farmer, all of which depress the already low level of national income per head,

are the results of a primitive peasant agriculture unaided by the resources which modern science, technology and industry can offer. But these are now changing rapidly with this age of machine power (e.g. tractor) on the farm and agricultural activities in general.

#### MECHANIZATION AND NIGERIAN AGRICULTURE

The introduction of mechanized agriculture in Nigeria since the early sixties is a welcome innovation taken in the right direction because of the great contribution of agriculture in the national economy. Also, the productivity of the Nigerian soil as seen from traditional farming would be increased tremendously with mechanization if carried out very efficiently. Oyenuga states,

The introduction of machines into farm operations in Nigeria would carry many advantages with it. . . . remove the drudgery from an otherwise pleasant farming operation, bring about greater output from the existing farm labor force, facilitate the cultivation of a larger area of agricultural land and increase the food crops available for consumption.<sup>2</sup>

Nevertheless, the fruit of mechanization cannot be economical and effective under present conditions in which all or most of the machines have to be purchased from abroad as all imported machines are invariably unsuitable for the soil they have to work and for the nature of the function they have to perform. Other reasons could be seen from the following report given to the United Nations.

Most of the equipment used in developing countries is manufactured in industrialized countries and is designed to suit conditions in these countries; little attention is given to modifications or adaptations in design and material that could make it more suitable for use in developing countries. Technical studies carried out jointly by local experts and suppliers could result in such modifications. This would increase the reliability, availability and maintainability of equipment and lead to lower cost of maintenance and higher productivity of equipment.<sup>3</sup>

The availability of an initial stock of spare parts, in sufficient quantity and of the right type, and the continuous supply of these spare

parts during the lifetime of the equipment are necessary for proper maintenance and operation. Even though there are two or three tractor assembly plants in Nigeria, their suitability to the climatic and farming practices in the country is questionable. This is because there was no pre-local research for adaptability and suitability. Unless local research and design are done, these tractors being assembled would never be economical and efficient.

Despite the lack of local research and design on agricultural machines and equipment, the innovation to change the cultural way of farming through mechanization in Nigeria is increasing and progressing rapidly, aided by Western education. Every year more than three thousand tractors are being assembled in the country and many are bought from overseas to meet the needs of the people (farmers) who are becoming very enterprising in their farming activities.

The scope of mechanizing agriculture in Nigeria is extremely large and the country has vast and productive farmlands, most of which are now undercultivated or laying fallow. With present emphasis on all-year-round farming, many irrigation projects have been set up in all parts of the country especially in Sokoto, Kaduna, Kwara, Gongola, Plateau and Kano. This increased emphasis and interest would require more trained tractor mechanics and operators to enhance the success of the program.

The federal government of Nigeria in its Fourth National Development Plan has placed greater emphasis on agricultural development, a plan they called "Green Revolution." It is with this new spirit that the agricultural sector was allocated a bigger share of the fourth development plan budget (1980-85). The President of Nigeria said,

Nigeria's Fourth National Development Plan proposes to invest ₦82,000 million. . . . Agriculture is to receive about 13% of the total capital investment to generate annual growth rate of 4% which is expected to eliminate shortages of food and industrial raw materials.<sup>4</sup>

The government's interest and effort to increase agricultural production and the farmers' interest to face the challenge by going mechanized will require more equipment. This determination to be successful can only be achieved through good management. Therefore it is not only necessary to increase farm equipment (tractors and implements) but to maintain and operate correctly the machinery which is being used at the present. Irrespective of the size and type of the farming enterprises, the management of maintenance can make the difference between profit and loss. Proper management of maintenance activities is thus as important as the proper management of production.

A contributing factor for the low service life of farm equipment in Nigeria can be attributed to the fact that it is the federal and state governments who are the greatest purchasers. They are purchased by the Various Ministries of Agriculture and Natural Resources, then distributed to farmers by way of "Tractor Hiring Units" (THU). Most of the mechanics and operators of this equipment don't have even basic education let alone special training in this field. And on private or cooperative farms, farm tractors and implements are not adequately maintained because of these reasons:

1. With high illiteracy rate in Nigeria among farmers, they all appreciate buying farm equipment, but they cannot read the operator's manual as this is written in English.
2. Most farmers do not operate the machinery themselves because they don't know how to.

3. When farmers hire operators, usually they are not qualified because they never had experience with farm machines.
4. Most farmers neglect major maintenance chores because they are ignorant of the importance.
5. Because they cannot read or write, most farmers do not keep maintenance records.
6. Most farmers feel the maintenance chores on their tractors are not essential.
7. Because of cheap labor, most farmers would take their tractors to roadside mechanics for repairs.

These reasons and others already mentioned could attest to the fact why farmers and even government owned tractors are not efficiently used. Most farmers would not agree that all machinery maintenance practices are good and can save money, time and even avoid costly inconveniences in times of breakdown when operating on the farm.

The life and service given by a farm tractor depends largely upon the care and maintenance given it by the owner. It is essential therefore, that proper tractor maintenance and operating records be kept. Modern tractors have made it a lot easier to keep records up to date because of their hour-meters. The completion of the maintenance jobs when they arise is mostly a matter of keeping records and scheduling time to do them promptly. In most cases they only require simple tools and an understanding of what is to be done. However, even when regular maintenance schedules are followed, it is good that owners take their tractors to a qualified person or farm tractor mechanics for inspection and servicing jobs that need very specialized knowledge and tools. The value of farm tractor maintenance and operation, in this study, most of the information has



been summarized. Other books, particularly the operating manual by the different tractor manufacturers, should be studied for detailed information.

#### STATEMENT OF THE PROBLEM

In developing countries such as Nigeria the emphasis for more food production has led to mechanizing agriculture. More tractors are being used that they are becoming the major source of power on the farms. The problem of proper maintenance and operation of tractors is becoming very important. It is essential therefore, that farmers should be taught courses in the care and proper use of their tractors. The purposes of this study were to assess the importance of tractor maintenance and operation which should be included in a curriculum for training tractor operators.

#### REVIEW OF LITERATURE

A review of literature was considered necessary because it provided the basic understanding of what farm tractor maintenance and operation is. Also, the review was conducted to determine the length and importance of instructional materials in this study. The materials selected and reviewed herein include those which appeared to be most closely related to the study.

In 1970, the United Nations<sup>5</sup> conducted a symposium on maintenance and repair in developing countries. The members developed a general consensus that developing countries should give special attention to maintenance, planning, and programs of preventive maintenance. They say that only in this way can maintenance problems be dealt with efficiently and economically. It was generally agreed that maintenance planning

reduces greatly the consumption of spare parts and makes it easier to predict when major components will need to be changed. However, they emphasize that only trained personnel will be able to choose maintenance techniques appropriate for local conditions and to implement them efficiently, and that their experience and knowledge should be made use of when new machines are ordered.

In 1955, Weber<sup>6</sup> examined 60 farm tractors in Champaign County, Illinois, for indication of improper maintenance procedures. He found that several maintenance deficiencies which could result in a decrease in maximum horsepower and fuel efficiency were prevalent. Those listed as occurring most frequently were dirty air cleaners, improper valve adjustment, pitted ignition points, and improper engine speeds.

In 1974, E. S. Webb and C. D. Knotts<sup>7</sup> made a research in Texas on content priorities for farm mechanics. In the area of farm power and machinery they found that high priority rating by their respondents were given in the following manner:

- a. Ability to operate the farm tractor safely.
- b. Ability to determine cause of trouble of tractor and equipment.
- c. Ability to service machinery and equipment correctly.
- d. Ability to make adjustment on farm tractor and implements under field conditions.
- e. Ability to select size and type of machinery and equipment appropriate to farm and farming operation.
- f. Ability to be a good manager of machinery and equipment.

They recommended that teachers should determine the skill and knowledge needed by farmers and develop instructional materials to meet those needs.

Also, that individualized instruction should be given in agricultural mechanics in diversified farming areas according to the type of farming.

In 1959, F. N. Reece,<sup>8</sup> in a remarkable conclusion after the results of his investigation, made the following remark that for the sample of 50 farm tractors tested for horsepower and fuel efficiency under operating conditions and after a selected number of adjustments and repairs to correct deficiencies resulting from improper maintenance. (1) The tractors under the condition in which they were being operated were capable of developing 74.9% of maximum power as determined by Nebraska Tractor Test and were using 1.32 times as much fuel as determined from the Nebraska Test. (2) After simple adjustment and maintenance to engine governor, air cleaner, spark plugs, carburetor, and timing, the tractors were capable of developing 83.3% of their maximum power but used 1.13 times more fuel as determined by the Nebraska Tractor Test. (3) Simple adjustment and maintenance of the indicated items increased the maximum power by an average of 3.07 horsepower per tractor and decreased the specific fuel consumption by 0.105 lb/h.p. hr. per tractor or 14.4%. (4) The air cleaners on 10% of the tractors were very dirty with varying dirt, but servicing them increased engine power to 7.6% and decreased fuel consumption by 11.4%. (5) Spark plug service on 90% of the tractors increased power by 5.3% and decreased fuel consumption by 6.1%. (6) On 23 of 72 tractors where carburetor adjustment was done (set too rich) fuel consumption was decreased by 9.5%. (7) Ignition timing was changed on 27 tractors. This gave an average increase of 5.3% in maximum power and decreased fuel consumption by 5.3%.

Elmer J. Johnson and Alvin Hollenberg<sup>9</sup> in the preface of their book pointed out that to keep mechanized power units in good operative condition, and to assure their efficient use when needed, it behooves farmers to pursue a sound farm tractor maintenance program. Such farm tractor maintenance programs should include attention to the daily and periodic service needs which assure the best in performance, the utmost efficiency, and a maximum period of satisfactory operation. That developing and following such a plan of service and maintenance reduces the number of field breakdowns, as well as need for major reconditioning. And that because of farm mechanization, there are many new demands upon farmers. The foremost of these demands is the need for farmers to provide the proper care, operation, and maintenance of power farming equipment, particularly the tractor.

#### OBJECTIVES OF THE STUDY

1. To determine the importance of the competency areas of tractor maintenance and operation which could be included in a farm mechanics curriculum course for the schools of agriculture.
2. To assess the government's encouragement to use tractors for mechanization.
3. To serve as guideline for the development of a curriculum in preparing farm mechanics course which should include competencies essential for all areas of activities in tractor maintenance and operation.

#### SELECTION OF SUBJECTS

Subjects were selected from those Nigerian students studying agriculture in Kansas State University and Fort Hays State University,

who have served with the Ministry of Agriculture in their various states for more than ten years, especially those who have worked in the Agricultural Engineering section.

#### DEFINITION OF TERMS

Farm Tractor Maintenance - The daily and periodic needs of tractors which assures the best performance, utmost efficiency, and maximum years of satisfactory operation.

Farm Tractor Operation - A planned and controlled or skillful movement of the tractor on the farm and/or highways safely and economically.

Curriculum - The content of courses of study and list of subjects to be offered to learners under direction (particularly in schools).

Agricultural Innovation - The process of making or bringing new changes in agriculture.

Agricultural Mechanization - The application of engineering and the use of mechanical power on the farm for agricultural production.

Skill - Great proficiency acquired through learning and experience.

Tractor Hiring Unit (THU) System - A system that operates only in the Ministry of Agriculture and Natural Resources. The government buys the tractors and rents them to farmers for a subsidized rate. The farmer is also given a tractor operator from the ministry. All maintenance that may arise during the period of rental is done by the Ministry's mechanics. The farmer is charged only for the number of acres of work done.

## DESIGN OF THE STUDY

The study is designed in a way as to make it possible to determine the importance of farm tractor mechanics (care, maintenance and operation) peculiar to agricultural development in Nigeria.

## METHOD OF PROCEDURE

An attempt was made to find out the importance of the different competency areas or activities of farm mechanics. Two categories of questionnaires were designed to this effect: (1) involving the mechanics of the farm tractor and (2) involving the importance of the tractor as seen from the Federal and State Governments' activities to mechanize agriculture in Nigeria.

The questionnaires were sent particularly to Nigerian students studying agriculture and agricultural mechanization. These students have worked in their various States' Ministry of Agriculture for ten or more years; and most of them are on in-service training in Kansas State University and Fort Hays State University. There was an 83% return of the answered questionnaires from the respondents.

Part one of the questionnaire was compiled, calculated and weighed on a degree of importance scale as follows:

Essential - - - - -	6
Very important - - - - -	4
Important - - - - -	2
Not important - - - - -	0

The degree of importance was calculated to find out the average degree of importance, thus:

$$\text{Degree of importance} = \frac{\text{Sum of response}}{\text{Number of response}} = \text{Average}$$

THE IMPORTANCE OF SELECTED COMPETENCY AREAS  
FOR THE MAINTENANCE AND OPERATION OF FARM TRACTORS

<u>Competency areas</u>	Ess.	Very Imp.	Imp.	Not Imp.	Average
1. Servicing the air cleaner assembly	14	9	2	0	4.96
2. Checking the crankcase oil level	11	6	4	5	3.92
3. Checking the cooling system	9	9	4	3	3.92
4. Doing the 10-hour grease job	6	12	6	1	3.84
5. Removing water and sediments from diesel fuel	10	8	7	0	4.26
6. Safety checking of clothing	7	14	3	1	4.16
7. Maintaining the battery	10	12	2	1	4.48
8. Checking and adjusting V-belt tension	6	10	7	2	3.60
9. Lubricating the clutch release mechanism	11	8	5	1	4.32
10. Maintaining the hydraulic system oil level	16	6	3	0	5.04
11. Changing crankcase oil	8	9	7	1	3.92
12. Replacing the oil filter	5	12	5	3	3.52
13. Servicing the crankcase breather	8	5	11	1	3.60
14. Maintaining tractor tires	13	9	3	0	4.30
15. Making valve clearance adjustment	15	9	1	0	5.12
16. Maintaining spark plugs	16	2	7	1	4.72
17. Cleaning the battery	9	4	12	0	3.84
18. Cleaning the sediment bowl and fuel filter	8	12	3	2	3.60
19. Adjusting the carburetor	15	9	1	0	5.12
20. Adjusting the tractor brakes	18	5	1	0	5.20
21. Adjusting the engine clutch	13	10	2	0	4.88

THE IMPORTANCE OF SELECTED COMPETENCY AREAS  
FOR THE MAINTENANCE AND OPERATION OF FARM TRACTORS (cont.)

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<u>Competency areas</u>	Ess.	Very Imp.	Imp.	Not Imp.	Average
22. Servicing the distributor	6	17	2	0	4.32
23. Timing the ignition	6	17	2	0	4.32
24. Adjusting breaker points	11	8	6	0	4.40
25. Maintaining the starter and generator	7	12	4	2	3.92
26. Servicing diesel engine fuel filters	18	7	0	0	5.44
27. Servicing the front wheel bearings	20	4	1	0	5.52
28. Cleaning the tractor	8	10	6	1	4.00
29. Servicing the drive mechanism	4	14	6	1	3.84
30. Servicing the cooling system	9	6	10	0	3.92
31. Servicing the hydraulic system	22	3	0	0	5.76
32. Adjusting the engine governor	6	10	8	1	3.68
33. Preparing the tractor for storage	14	6	5	0	4.72
34. Checking and adjusting seat position	11	9	4	1	4.40
35. Changing rear-wheel spacing	3	18	3	1	3.84
36. Adjusting front-wheel spacing	5	12	6	2	3.60
37. Adding weight for traction and balance	10	10	2	3	4.16
38. Starting the tractor engine	7	12	3	3	3.84
39. Starting tractor movement	3	2	20	0	2.64
40. Operating a moving tractor	20	2	3	0	5.52
41. Stopping tractor movement	16	5	4	0	4.96
42. Making adjustments before starting field work	8	14	3	0	4.40
43. Matching gear selection and engine speed	2	19	3	0	3.76
44. Checking and correcting tire slippage	5	5	15	0	3.20



THE IMPORTANCE OF SELECTED COMPETENCY AREAS  
FOR THE MAINTENANCE AND OPERATION OF FARM TRACTORS (cont.)

15

<u>Competency areas</u>	Ess.	Very Imp.	Imp.	Not Imp.	Average
45. Pulling out of mud or ditch	4	8	10	3	3.04
46. Changing fuel filters	2	12	10	1	3.20
47. Operating on slopes and hills	8	10	7	0	4.08
48. Hitching to tractor-operated equipment	3	3	17	2	2.56
49. Providing safety warning devices	23	2	0	0	5.84
50. Using right-of-way	10	6	9	0	4.08
51. Refueling the tractor	4	4	17	0	2.16

Importance Scale:

Essential, six points; very important, four points; important,  
two points; not important, no points.

AN ASSESSMENT OF SELECTED FACTORS IN THE INTRODUCTION  
OF FARM MECHANIZATION IN NIGERIA

PERFORMANCE RATING

	A	B	C	D	E	Average
1. How would you characterize the effort of the government in making tractors available to the farmers?	2	12	5	3	2	3.2
2. How efficient is the Tractor Hiring Unit System?	0	2	8	11	3	2.3
3. What level of interest have the farmers in using tractors to mechanize their farms?	3	8	12	1	0	3.4
4. How would you rate the present qualification of the farm tractor mechanics?	11	3	2	5	3	3.4
5. How would you characterize the maintenance and operation of farm tractors in Nigeria?	0	0	7	14	3	2.5
6. How would you rate the Mechanical Section in the Ministry of Agriculture administratively?	0	3	7	13	2	2.4
7. How would you characterize the technical background of the extension worker in Nigeria?	0	2	15	7	0	2.7
8. How would you rate the publicity given to new agricultural technology in Nigeria?	2	9	12	1	0	3.7

A..... Superior (5 pts.)  
 B..... Excellent (4 pts.)  
 C..... Very good (3 pts.)  
 D..... Good (2 pts.)  
 E..... Average (1 pt.)

## FINDINGS

After computing the data gathered, it was clear from the calculations that all the competency areas in Farm Tractor Maintenance and Operation were very important. The calculations were based on an average of importance for each competency area of tractor mechanics. All averages of importance were weighted on a scale of points. The responses were ranked as essential, six points; very important, four points; important, two points; and not important, no points. None of the competency areas fell below an average of two points. However, an average importance rating below two points would have been considered undesirable or not important and the competency area would not be included in the content of this book.

The importance of fifty one competency areas were assessed. The most important competency area was "Providing safety warning devices" with an importance rating of 5.84 on a six point scale. Other competency areas with importance ratings of five or more points included the following: "Servicing the hydraulic systems" (5.76); "Operating a moving tractor" (5.52); "Servicing the front wheel bearing" (5.52); "Servicing diesel engine fuel filters" (5.44); "Adjusting the tractor brakes" (5.20); "Adjusting the carburetor" (5.12); "Making valve clearance adjustment" (5.12); and "Maintaining the hydraulic system oil level" (5.04).

Nineteen competency areas were included in the four to five points range of importance, and were considered to be very important. Nineteen items were included in the three to four points range of importance and were considered important. Three competency areas were considered of lesser importance but nevertheless important enough to be included in a

curriculum on the Maintenance and Operation of a Farm Tractor. These competency areas were: "Starting tractor movement" (2.64); "Hitching to tractor-operated equipment" (2.56); and "Refueling the tractor" (2.16).

All fifty-one competency areas were rated important by the respondents of the study. These fifty-one competency items became the basis of the content of the Tractor Maintenance and Operation curriculum in this book.

The second part of the questionnaire dealt with activities centered on the government (Federal and State). The researcher asked the respondents to assess the efforts of the Federal and State Governments in introducing mechanized agricultural practices to farmers. The importance of the responses were calculated using a five points scale as follows: Superior, five points; excellent, four points; very good, three points; good, two points and average, one point.

The respondents listed the factor "How would you rate the publicity given to new agricultural technology in Nigeria?" (3.7) as being very good to excellent for the introduction of farm mechanization in Nigeria. Three additional factors were rated as very good and four factors were rated as good. The factor "How efficient is the Tractor Hiring Unit System?" (2.3) had the lowest rating of the eight factors for the introduction of farm mechanization in Nigeria.

The findings indicated that considerable progress was being achieved on the part of the government's effort to introduce mechanization to farmers.

#### CONCLUSION

There is an interest in using tractors for mechanizing farms in Nigeria. With increased services of the government to the farmers to

improve agricultural practices, Nigeria will increasingly become a tractorized farming country. Increased tractor mechanization on the farm can be achieved only when there is good administration in the Ministries of Agriculture in all the States of the Federation, and more qualified extension workers and specialists for advice to aid the farmers.

A well organized Department (Ministry) of Agriculture, having all the facilities to make mechanized agriculture a success, could be the key to the growth and development of agriculture in Nigeria. Such developments are within the reach of Nigeria because it has the financial means to do so. Mechanized agriculture can lead to the growth of the economy because of the stimulus from agriculture to nonfarm sectors. Also, additional agricultural products will stimulate the growth of industry.

The proposed program or curriculum in Farm Tractor Maintenance and Operation should be used in Schools of Agriculture in Nigeria. A distinctive problem of the typical Nigerian farmer is that he is illiterate. He needs education not only in farm tractor mechanics (maintenance and operation), but in all fields of learning to enable him to receive and appreciate new farm technologies. In industrialized nations, particularly where agriculture is practiced most, the farm tractor is the most important piece of machinery on the farm. Therefore, the farmer needs to understand tractor maintenance and operation to enable him to make the best use of it.

#### RECOMMENDATIONS

As a result of the findings of this study, the author would like to make the following recommendations:

1. The farmer should receive more education on how to use the tractor efficiently.
2. The farmer should be taught the importance and the relationship between the tractor and his successful agricultural activities.
3. All the schools of agriculture should include Farm Mechanic curriculum in their courses with more emphasis on Tractor Mechanic curriculum.
4. Agricultural Tractor Schools should be set up in all the local government councils of the states to facilitate quick specialization in Tractor Mechanics and Operation.
5. The proposed course of Tractor Maintenance and Operation in this book should be taught in two semesters in a shop that is very equipped. Field demonstrations are essential. Also, there should be flexibility in the teaching of the course to enable students to comprehend thoroughly what they are learning.
6. Free short courses in Tractor Mechanics should be offered to farmers in all the colleges of agriculture during the schools' long vacations.
7. All students of agriculture should take courses in tractor mechanics at least to know the basics.
8. The author urges the printing of this course content of Tractor Maintenance and Operation into smaller booklets chapter by chapter in the three major languages in Nigeria, namely Hausa, Ibo and Yoruba.

## CHAPTER II

### DAILY OR 10-HOUR SERVICE JOBS

There are many preventive maintenance jobs that are routine and performed daily. Examples are checking the crankcase oil level, checking the water level in the radiator, inspecting the fan belt, removing water and sediment from diesel fuel and checking the air cleaner. These daily jobs are critical because failure to perform them may lead to serious damage to the tractor. A neglected air cleaner can cause the engine to ruin as can a low crankcase oil level or low coolant level in the radiator.

### SERVICING THE AIR-CLEANER ASSEMBLY

#### IMPORTANCE OF CLEAN AIR

An efficient air cleaner is a necessity for any type of tractor engine. "The modern tractor engine must breathe in a lot of air. Automotive Engineers have estimated that it requires about 9,000 gallons of air to burn a gallon of gasoline".<sup>10</sup> Because engines consume so much quantity of air, it is essential that the air be cleaned and free of dirt before it enters the engine. The air cleaner will remove practically all the dust from the air, if it is serviced and maintained regularly.

Air cleaner servicing is one of the most important jobs in the routine care of the tractor. The dust entering the tractor working under very dusty conditions without an efficient air cleaner may cut out the cylinder walls, piston, valves, ring grooves and bearings to such an extent that new parts will have to be supplied and replaced or the tractor is put out of use. The dirty air gets into these places by passing directly through the intake manifold into the engine cylinders. As these parts get worn out, the tractor engine loses power, starts using

more oil and fuel to get a job done. The difference in ring wear between a very efficient type of cleaner and no air cleaner is about 100 to 1. Also, the increased amount of dirt in the crankcase oil when the air cleaner is omitted or its efficiency reduced is great as much as thirty times. Tractor manufacturers have always equipped their tractors with the most efficient air cleaner units to help prevent the unnecessary wear caused by dirty air.

#### TYPES OF AIR CLEANERS

There are many air cleaners in use on engines, but the two most common ones found on farm tractors are (1) the oil-bath type and (2) the dry paper filter type. It is therefore important that you know the type used on your tractor because the frequency and method of servicing each differ. With either of the two mentioned, outside air is drawn in through a screen inlet or a pre-cleaner, whereby large particles are removed from the air stream. The screen or pre-cleaner is to remove coarse particles and relieve the air filter of much load. After the air passes through the screen intake or pre-cleaner, it is drawn through a tube called an "airstack" or duct into the air cleaner.

**OIL-BATH AIR CLEANER:** Most tractors use an oil-bath air cleaner. It is very efficient and reliable. It has a screen that is automatically washed with oil. The air coming down through the air intake stack passes through the surface of the oil held in a small cup. Some of the oil is carried up into the separating screen and then drains back into the cup. This process keeps the separating screen oiled and washes the dirt back into the cup. The fine dust particles not trapped when the air passes over the surface of the oil will be caught by the oil film in the separating screen. The cleaned air then flows to the carburetor into the engine



as atomized fuel-air mixture.

**DRY TYPE AIR CLEANER:** There are two stages usually in cleaning the air by way of pre-cleaning and filtration.

The pre-cleaner is often found first at the entry end of the intake stack. It is used to remove most of the heavier dust particles and lighten the load on the main cleaner. It can be as efficient as to removing 80 to 90 percent of the dirt particles before entering the filter element for final cleaning to be used by the engine.

The most common type of pre-cleaner has vanes or baffles that swirl the air causing the heavier particles to be thrown outside where they are trapped in a glass or plastic collector.

The filtering stage consists of a special paper made for the cleaning. The air is cleaned by filtration. The following are some advantages of dry-type air cleaners:

1. It is easier to service
2. Requires less frequent servicing
3. Fuzz and chaff cause less restriction to air passage
4. More efficient at a wide range of engine speeds.

The frequency of cleaning an air cleaner depends on the different types and recommendations of the manufacturers. Also, it varies with the condition under which the tractor is operated. A dirty air cleaner causes power loss and increases fuel consumption. On a diesel engine type tractor, a dirty air cleaner will cause smoking and loss of power.

To maintain the air cleaner, it consists mainly of removing the cup, cleaning it and refilling with new oil or replacing paper element. However, during this process the intake stack, cap, pipes and hose connections need inspection. A leak in the pipes or hose connections can allow dust to be

drawn into the system and bypass the air cleaner to the engine. You must make sure all connections are tightened and damaged hoses or pipes replaced.

#### HOW TO SERVICE THE AIR CLEANER

##### OIL-BATH TYPE:

1. Before any work proceeds, stop the engine and turn off ignition key.
2. Wipe off dust on surface of cleaner parts.
3. Remove air cleaner oil cup by removing clips.
4. Empty oil and clean the cup.
5. While the cup is off, check the intake stack.
  - a. Remove cap and clean the stack
  - b. If stack is bent, straighten it up
6. Clean the cup after throwing away dirty oil, then wash cup with kerosene or diesel fuel.
7. Check the pipe between cleaner and carburetor.
  - a. Check for holes
  - b. Check hose connections for holes, replace any damaged hose
  - c. Retighten hose clamps if loose
8. Check and clean wire mesh of cleaner for trash.
9. Refill cup with new oil of the recommended type.
10. Refill only to the mark level. Never fill too full especially on diesel tractors, as this will cause engine to run wild.

**DRY-TYPE AIR CLEANER:** There are three ways to clean the paper element type: (1) tapping, (2) compressed air, (3) washing with water or diesel fuel.

##### Procedure:

1. Stop engine and turn off ignition key.

2. Wipe off dirt on cleaner parts.
3. Unscrew nut that holds filter in place and carefully remove the filter element.
4. Clean the dust cup and baffle.
5. Clean the element.
  - a. Tap the element gently on the palm of your hand to loosen dirt.
  - b. If you are not satisfied with tapping, use dry compressed air and blow on cleaner at low pressure from the inside toward the outside.
  - c. It may need washing. Flush the element from the inside with clean water and a detergent, then rinse and flush with clean water to remove detergent.
6. Inspect for leaks. Insert a light bulb on the inside and look from the outside for holes or cracks. Throw away bad element.
7. Install the element. Make sure gasket is good and in place.
8. Tighten wing nut that holds element in place with fingers only.
9. Make sure everything is in order before starting your tractor.

QUALITIES OF AIR CLEANERS: Any type of air cleaner to give maximum satisfaction must fulfill the following requirements.

1. It must have high cleaning efficiency at all engine speeds and under all operating conditions.
2. It should offer very little or no restriction to the air flow, since that will reduce the power and fuel economy. Also, it should not interfere otherwise with the satisfactory operation of the engine.
3. It should require very little or only infrequent attention.
4. It should be compact, rigid, not too heavy and noise proof.

## THE COOLING SYSTEM

The cooling system of a tractor has two jobs to do. It must keep the engine from overheating and it must also keep a uniform temperature in the engine. In any internal combustion engine, the main function of the cooling system is to maintain an optimum engine operating temperature. To maintain this temperature, the rejected heat during the combustion process and the heat generated by engine friction and compression of gases must be removed.

The proper design and maintenance of a cooling system is important because the amount of heat to be dissipated is great. The engine must be cooled to maintain proper lubrication, to prevent overheating of the engine parts, and to ensure proper combustion. Also, the engine temperatures must be high enough to ensure vaporization of the fuel and prevent dilution of the oil. The heat distribution in an internal combustion engine varies according to the efficiency, design, speed, load, and size. At full load, about 28% of the fuel energy is passed on to the cooling medium, 26% is lost as exhaust heat, 35% is converted into useful work, and the rest is lost by radiation. Also, heat can be transferred by convection and conduction. It is important to know that the rate of heat transfer is affected by the material in the cylinder wall.

A diesel engine fires by injecting fuel into hot, highly compressed air. Thus, the engine has to be kept warm to prevent overcooling the air. If the diesel engine is run cold, the injectors will foul and cause excessive wear. Remember to always bring an engine to proper operating temperature before you apply a heavy load.

## TYPES OF COOLING SYSTEMS

The two most common types of cooling systems in use are: (1) air

cooling and (2) water cooling.

#### AIR COOLING:

Air cooling is used on some power units (balers) and other field machines e.g. lawn machines. The cylinder wall temperature of air-cooled engines is higher than water cooled engines because of the low value of the heat transfer (coefficient between metal and air). A strong blast of air from a fan is directed by shrouds around the engine, so as to avoid hot spots. The hottest parts in a cylinder head are the exhaust valves and exhaust ports. Some advantages of the air cooling are:

1. eliminate water jackets
2. has no pumps
3. has no radiator
4. has no water connections.

#### WATER COOLING:

There are two general systems used in water cooling. The simplest is thermo-syphon system in which the hot water rises to the top of the water jacket and on up to the radiator. As air is drawn through the radiator by the fan, the water is cooled.

The forced circulating system is the most common type on modern tractor engines. A pump forces the water to circulate through the water jacket and radiator. A thermostat is usually located in the system to block the flow of water to the radiator until the block is warmed up.

#### HOW TO SERVICE THE COOLING SYSTEM

1. Remove the radiator cap and check the level of coolant in the radiator.
2. Check the pressure cap if it is worn.
3. Refill radiator with clean, soft water to recommended level.
4. Check for leaks in radiator and radiator hoses.

5. Brush, blow or wash dust, dirt and chaff out of radiator fins.
6. Drain and flush the cooling system once or twice a year.
7. Check to see if thermostat opens correctly; if it doesn't, replace it.
8. Keep radiator overflow pipe open.

#### CHECKING THE CRANKCASE OIL LEVEL

The oil usually found in the crankcase of an engine is of great importance not only for lubrication to reduce friction and prevent wear, but it also helps in keeping working parts cool. It cushions the pounding action on piston pins and bearings and forms a seal between piston rings and cylinder walls. You should never allow the oil to get lower than recommended as the engine will overheat resulting in varnish deposits, stuck rings and stuck valves which will eventually develop corrosive substances that can cause rapid engine wear. After the crankcase temperature reaches 180°F., an additional rise of 17° in temperature doubles the rate of oxidation. Because of the important role of the crankcase oil, it is essential to check the level every day first thing in the morning before starting the tractor. This will give you an accurate reading of the oil level. But only check when your tractor is on a level ground.

Follow these procedures to check the oil level in the crankcase:

1. The crankcase may have either an "oil level gauge" or commonly a "dip stick" for measuring the oil level. Locate it first.
2. Don't check the oil level with your tractor engine running except otherwise as may be suggested by your operator's manual.
3. Remove either the dip stick or oil level gauge and note the marking levels -- "full," "add," "low," or "danger."
4. According to any of the level marks, add very clean oil of the recommended type if needed. Never overfill or underfill.

## DOING THE 10-HOUR GREASE JOBS

There are bearings and wearing surfaces in engines and farm tractors that need greasing. We apply grease in these places because it can stay much longer than oil. On most farm tractors there are places that need grease daily or after each 10 hours of operation. When these points are greased, they are saved from wear and the bearings are protected. It also makes it easier to operate the tractor comfortably. Old farm tractors have more points that need greasing than when new. The 10-hours greasing points are: waterpump, brake pedal assembly, transmission, differential and hydraulic system, lift-leveling box and clutch. Always use the operator's manual because each manufacturer has his own recommendations.

Before applying grease you should wipe off the fittings, and be careful not to get dirt into the bearings. When you grease a dirty fitting you easily get dirt into the bearings. To keep grease fittings free of dirt, always wipe off surplus grease.

Greases are semifluid or semisolid lubricants. They contain mostly oil and some special soap to thicken them. The type of soap used determines the type of grease. Common soaps used for making greases are calcium, sodium, and lithium.

calcium soap - pressure gun or chassis grease

sodium soap - wheel bearing grease

lithium soap - multi-purpose grease

The development of multi-purpose grease has made it possible for tractor operators to use one grease for all grease fittings and hand packed bearings. Multi-purpose grease is water resistant, will withstand high temperature, protects against rust and is long lasting.

Some suggestions:

1. Keep the grease container in a dust free place.
2. Wipe off the grease gun before filling it.
3. Grease the tractor at the end of the day when it is warm.
4. Pump grease slowly.

#### REMOVING WATER AND SEDIMENT FROM DIESEL FUEL

Diesel tractors have an elaborate system for removing water and sediment in the fuel. Removing these is very important because they tend to have bad effects on the fuel injection system: (a) sediment grinds among the finely fitted parts of the injection pump, (b) water causes rusting, (c) water interferes with the proper feeding of fuel and causes rough running of the engine. Always remove trapped water from fuel tank each morning.

Tractor manufacturers take advantage of this situation and have provided for removing the water by such means as putting drain cock on (a) bottom of fuel tank, (b) bottom of first filter, (c) top of sediment bowl.

#### HOW TO REMOVE THE WATER AND SEDIMENT

Procedure:

1. Open drain cock and drain about 1 pint of fuel.
2. Close drain cock.

In sediment bowl and water trap:

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. (Keep gasket in place)
4. Wash glass bowl in kerosene to remove dirt and sediment.
5. Install bowl loosely so that fuel will force air out.



6. Open fuel valve and allow bowl to fill.
7. Tighten thumb nut under bowl when air is completely removed.

#### SAFETY CHECKING OF CLOTHING

If is of greater importance for the tractor and the operator to be well prepared before the day's operation begins. The operator should always be psychologically fit and well dressed.

Procedure for personal safety checking:

1. Check your clothing to make sure they fit fairly well and they should be free of tears, bulging pockets, frayed edges and heavy cuffs.
2. It is good to wear shoes with heel and tight soles to help prevent slippage, tripping and falling.
3. Check the tractor platform steps and pedals for mud, grease, etc.

Checking miscellaneous items:

A good operator is always taking safety precautions and taking care of his tractor very well. It is his duty to continually watch for loose nuts or bolts, bent brackets that need straightening, worn parts that need replacing, cuts or worn tires, tire pressure, loose or worn fan belt, loose wheel lugs, head lights and so on.

Most of these service problems may be done weekly, monthly, semi-annually or yearly, but not all of them can be put off for such a long time. It is good practice to watch for these parts and care for them when they need attention. BE A GOOD OPERATOR.

## CHAPTER III

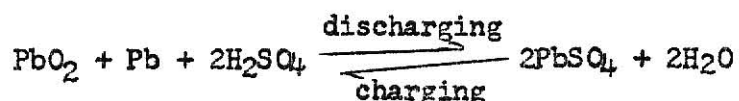
## MAINTENANCE AFTER 50 HOURS OF OPERATION

A week's operating time is often thought of as being 50 hours. Different operator's manuals indicate this service interval as "week" or "60 hours." Some newer model tractors, however, have recommendations for longer intervals for these jobs. The important thing is that you follow a regular service schedule.

## MAINTAINING THE BATTERY

The battery is used to store electrical power for use in starting the engine or operating other accessories, for example, the lighting system. The lead-acid type battery is the most common one used on farm tractors. This type of battery consists of several cells and each cell has a series of positive plates, negative plates, separators, plate straps, and an electrolyte. The positive and negative plates are made of different lead materials. The plates are prevented from touching each other by means of the separators. The electrolyte is a solution of sulfuric acid ( $\text{H}_2\text{SO}_4$ ). To maintain a battery for optimum use you need to understand its working principles.

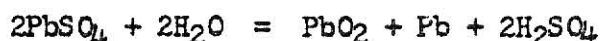
Electrical energy is produced by a chemical action between the sulfuric acid and the types of lead plates. When the battery is being charged, the sulfur is placed in the electrolyte to make the acid stronger. The chemical action takes place as follows:



lead dioxide + lead + sulfuric acid = lead sulfate + water

The lead-acid type cell will develop approximately 2 volts per cell. A 6-volt battery will have 3 cells connected in series. Also a 12-volt battery will have 6 cells. The amount of energy a battery can store depends on the area of the plates. The capacity of a battery is measured by the amount of current it can deliver for a given time.

When a battery is charged, the electrolyte is stronger than when it is discharged. The chemical reaction takes place as follows:



The electrolyte will contain about 36% of sulfuric acid and 64% of water.

Charged batteries give a lot of gas and bubbling. However, do not be frightened when you have an excessive gassing and bubbling in your battery. It is a positive indication that your battery is fully charged.

The available power from a battery is affected by temperature. The chemical action is slower at low temperatures; that is why increased power is needed to crank a cold engine. Your battery when in storage or out of use for a long time will tend to discharge; accumulating sulfur in the plates. This, if it happens, will be a sign for you that the battery is going bad. Therefore, it needs a charge.

When a battery is being charged, an explosive mixture of hydrogen and oxygen is formed from water in the electrolyte by the charging current. It is essentially a good practice to charge batteries in a well ventilated area and to keep away ignitable materials. It is periodically necessary to add water to a battery to replace the water lost during evaporation. Use distilled water, because impure water increases the self-discharging rate of the battery.

STORE BATTERIES IN A COOL PLACE WITH PERIODIC RECHARGING.

When you are trying to maintain the battery liquid level, all you need to do is:

1. Remove caps from battery cells.
2. Fill each cell to proper level with distilled water.
3. Replace caps on battery.

It is important, however, that during the process of adding water in battery cells, you must avoid any little contamination of the water or the electrolyte already in the battery. Therefore, wipe clean battery surface before removing caps. Because of the dryness and hotness of the weather, it is good to check the battery liquid level every 24 hours. NEVER OVERCHARGE THE BATTERY as it will use more water.

#### CHECKING FRAME AND CABLE CONNECTION OF BATTERY

Always check for loose terminal connections or loose hold down clamps on the battery. When terminals are loose, they cause resistance to the flow of current and thus make the battery inefficient in supplying current. Loose clamps cause battery to bounce or shake and this will cause electrolyte to spit off. When caps are loose, plates can damage, thereby causing short circuit. Always clean your battery to avoid corrosion at terminals.

#### TESTING FOR BATTERY CHARGE

There are two common ways to test the efficiency of your battery.

- (1) Use voltameter or (2) hydrometer.

Follow these procedures to test for battery charge with the hydrometer.

1. Remove battery caps. Take note of electrolyte level in each cell. If plates are not covered, add water and delay testing until after operating the tractor for two to four hours. This will enable the water to mix properly with the electrolyte.

2. Insert hydrometer nozzle, compress bulb and then slowly release to draw electrolyte into barrel.
3. Adjust electrolyte level until float rides freely. If the float tends to stick to the side of the hydrometer barrel, shake it sideways gently. If it still sticks, flush the inside of hydrometer with soap and water, then rinse with clean water before further testing.
4. Hold hydrometer vertically while taking reading. Leave hydrometer nozzle in the battery cell to avoid dropping acid on battery or clothing.
5. Return electrolyte to cell from which it was removed.
6. Check remaining cells in the same manner.
7. Replace caps and flush hydrometer with clean water.

Caution! If you accidentally spill some of the electrolyte on your skin or clothing, rinse with water immediately. Apply baking soda or lime to neutralize the effects of the acid.

8. Use table below to interpret results of readings from each of the battery cells.

Specific gravity reading	What it means
1.300	Electrolyte level is low, battery is being overcharged or electrolyte added instead of water.
Between 1.275 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 for use in tropical climates may be fully charged with the specific gravity as low as 1.225.

Less than 1.225	Battery charge is too low. Have it recharged.
If there are more than 50 gravity points difference between the highest and lowest cell readings (e.g. 1.250 high and 1.195 low)	Battery may need to be replaced. Check with a load-capacity tester. The condition may indicate short circuits in the battery, unequal losses of acid from cells, break down of the separators, or accumulation of impurities.

#### HOW TO CLEAN THE BATTERY

The manufacturer's instruction book should be consulted for specific directions for servicing or cleaning the electrical system, particularly for any adjustment since each adjustment is engineered for a particular engine and is very likely to vary from engine to engine. This is especially true of spark-plug and breaker point openings.

##### Procedures for cleaning the battery.

- a. Disconnect cables from battery terminals. This is only done when you have turned off the engine.
- b. Remove battery from carrier.
- c. Clean top of battery, particularly if electrolyte has spilled out, with a saturated solution of baking soda and flush with clean water.
- d. Clean terminals by removing from post and scraping with a knife or a wire brush.
- e. Coat terminals with vasoline or specific rust proofing compound before replacing them.
- f. Flush off and keep clean any electrolyte on carrier.
- g. Wipe carrier and battery to dryness.
- h. Replace battery to carrier and tighten it.

- i. Replace battery terminals in their correct position.
- j. Check battery and other parts for damage which may require repair or replacement.

#### CHECKING AND ADJUSTING V-BELT TENSION

Many of today's farm machines are equipped with either one or two belts which operate the waterpump, fan and generator. Some tractors even use other belts to drive hydraulic pump used for power steering. These belts need occasional checking for tightness and working condition. If regular adjustment and working condition is done, belt replacement will be less frequent.

V-belts are designed to ride on the sides of the pulley grooves, not on the bottom. As long as they ride on the sides, there is ample friction area to deliver power without the belt being particularly tight. If you tighten a V-belt too much bearing wear increases rapidly resulting in a short life for the belt. The extra tightness causes additional wear on the sides of the belt in contact with the pulleys.

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 pulley will provide less engine cooling and there is a good chance the engine may overheat. The generator will operate at reduced speed and this may lower the charge rate of the battery. However, it is important that the V-belt be kept clean. Oil or grease allowed to accumulate on belts will soften the rubber and cause permanent damage.

Procedures for checking condition of V-Belt.

1. Always stop the engine before you check the belt.
2. Check to see how belts seat in grooves of pulley. If it is worn it will ride in the bottom of the pulley groove. Replace it with a

new belt of the type and quantity recommended for your tractor.

How to check for belt tension.

1. Check your operator's manual to determine amount of deflection needed.  
(Deflection is the distance the belt can be pushed or pulled from its normal position)
2. Deflect belt and measure deflection. The amount of deflection recommended in operator's manuals varies from  $1/4$  inch to 1 inch.  
The reason for these variations is the difference in distance between pulleys of various tractors, the varying cross-sectional size of belts, and the different types of belts used.
3. If the deflection increases either more or less than recommended for your tractor, begin by loosening belt tension adjustment. There are two types of adjustment 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 that the groove in the pulley may be widened or narrowed. The adjustment may be on either the fan pulley or the crankshaft pulley.
4. Remove old fan belt and replace with new one if replacing a belt.  
Having done the above, you can slip off the belt from the pulleys.  
When installing a new belt that fits tightly, provide maximum slack, then start one side of the belt over the edge of one of the pulleys and turn the pulley slowly.
5. Adjust to proper tension. You can tighten screws first with hand then with a suitable wrench. A new V-belt will normally stretch during the first few hours of operation and should be adjusted after the first day of operation.



Some means of disconnecting the power unit from the transmission gears and drive wheels of a tractor are necessary because:

1. The engine must be cranked.
2. The engine must attain a certain speed before it will have any power.
3. Shifting of the transmission gears must be permitted for the purpose of securing different traveling speeds.
4. Stopping the belt pulley must be permitted without having to stop the engine and the transmission gears and belt pulley.

#### LUBRICATING THE CLUTCH RELEASE MECHANISM

The clutch is a device used to connect and disconnect the tractor engine from its power train. Fundamentally, the clutch consists of a friction-drive coupling between the engine flywheel or crankshaft and the transmission. A series of springs and plates is used to maintain pressure between the driving plates or flywheel and the driven plate which drives the transmission or pulley, or both, depending on the tractor design. The modern tractor clutch uses a design with either a foot or hand-operated lever to engage and disengage the power.

The clutch's design and its linkages allow the tractor to stand with the engine running; they permit changing gears and a gradual starting of loads at belt, drawbar or power take-off subjecting any part to excessive strains or shocks. The clutch can also prevent power to flow or stop flowing to the hydraulic units. All tractor clutches must fulfill the following requirements:

1. It should not slip
2. It should not grab or drag
3. It should be convenient
4. It should be accessible

5. It should be easy to operate, adjust and repair.

#### TYPES OF CLUTCHES

Modern clutches use either of two types: (a) simple-disk clutch, and (b) multiple disk clutch. These are ordinarily designed to transmit power in either direction of rotation. There are factors which determine the amount of torque (force) a clutch can transmit. These are:

1. Friction area
2. Nature of the friction surface
3. Diameter of friction surface
4. Amount of pressure which holds the surfaces together.

"The greater the friction area and diameter of the surfaces, the greater the torque capacity of the clutch." However, you should understand that the clutch force capacity is affected by the type and condition of the friction surfaces.

#### HOW THE CLUTCH WORKS

Clutch 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. And when the clutch pedal is pressed down, the clutch-release assembly is forced against the clutch-release fingers. This then disengages the clutch. That portion of the clutch-release bearing in contact with the fingers rotates at engine speed. However, the rest of the assembly does not rotate.

When your 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 quite similar to the standard dry clutch.

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

Most new tractors come out from the factory prelubricated as such they need no further attention until when the complete clutch assembly is removed for periodic overhaul. But, there are still some models and older ones that require regular lubrication. And the recommended frequency or lubrication varies with different makes and models of tractors. The operator's manual is your best guide. Follow the rules and regulations.

Clutch troubles and adjustment: The modern tractor clutch, if given ordinary care and attention, will seldom fail to perform satisfactorily. Clutch troubles are not unusual and are usually due to misuse or abuse, neglect, or to normal wear without proper adjustment. Some common forms of abuse are:

1. Failure to keep the clutch fully engaged, due to riding the clutch pedal or permitting the lever to remain only partly in the engaged position.
2. Failure to keep the clutch adjusted to compensate for normal wear.
3. Permitting oil and grease to get on friction surfaces.
4. Failure to lubricate the throwout collar and bearings as directed.

Slipping is the most common clutch trouble and can develop from one or more of the causes mentioned above. Excessive slippage causes wear.

A slipping clutch will burn out quickly. The precaution is always keep a clutch either completely disengaged or completely engaged. If you desired to let the engine run with the tractor standing still, the best practice is to put the gears in neutral and engage the clutch. Though there are few moving parts in a clutch, some of these parts require

lubrication. Never overlubricate or grease these parts because when grease gets on the clutch facing it will cause slippage.

Procedure for lubricating clutch-release mechanism:

1. Check your operator's manual to locate if clutch-release mechanism has a lubrication fitting. It always has, sometimes located on flywheel.
2. Clean fitting and then apply lubricant sparingly as recommended by your manual.

DO NOT OVERLUBRICATE!

#### MAINTAINING THE HYDRAULIC SYSTEM AND OIL LEVEL

The hydraulic system consists of the following components.

Pump	Sump (supply tank)
Motor	Accumulator (stored energy)
Valves	Controls (manual or automatic)
Lines	Fluid
Coolers	Actuators
	Filters

The basic principle upon which all hydraulic control mechanisms operate is known as Pascal's Law. "The pressure applied to an enclosed fluid is transmitted equally in all directions."

The hydraulic controls on modern tractors are units designed to utilize engine power for the control of both the implements and tractor without any difficulties. They enable the tractor operator to operate mounted or pull-type implements quickly and easily. Also, the hydraulic system on the tractor provides quick and easy means for attaching, lifting and controlling the adjustment of implements.

With a weight transfer attachment, the hydraulic system aids in

improving traction by transferring weight from trailing implements and the front of the tractor to the drive wheels.

#### TYPES OF TRACTOR HYDRAULIC CONTROLS

##### A. Rear-mounted and trailing machines.

###### 1. Three-point hitch.

- a. Implement raised hydraulically but depth controlled by machine weight, gauge wheels, hitch adjustment, etc.
- b. Implement lifted hydraulically and depth controlled by manual control lever or by load reaction or both.

###### 2. Drawbar or similar special hitch for trailing implements.

- a. Machine setting and adjustment controlled by remote hydraulic cylinders and flexible oil lines.

##### B. Side and front mounted machines.

###### 1. Implement position and depth controlled by linkage connection to hydraulically operated rock shaft.

###### 2. Implement lowered and raised and otherwise controlled by one or more hydraulic cylinders connected to lift pump by flexible oil lines.

###### 3. Combination of rock shaft and independent hydraulic cylinders.

Brown: "On most tractors there is an adjustment for increasing or decreasing the speed of lifting or dropping implements. As a general rule the heavier implements should be lifted more slowly to avoid undue strain on the system."<sup>11</sup>

#### HYDRAULIC OIL

It is very important to use the hydraulic oil recommended by the manufacturer. Most systems are designed to use a highly refined petroleum oil containing specific additives.

The hydraulic oil must transmit power, lubricate all moving parts, protect the metal parts of the system from rust and corrosion, resist oxidation and foaming and separate itself readily from air, water and other contaminants. The oil should be stable over long periods of time and maintain the proper viscosity through a wide range of temperatures. The additives in the hydraulic oil help hold contaminants in suspension and protect the system but will lose their effectiveness with time. Therefore, it's important to follow operator's manual recommendation. A. D. Brown, "The experience of tractor manufacturers indicates that most hydraulic problems come about because of the use of wrong hydraulic oil or the use of one containing dirt and other contaminants."<sup>12</sup>

#### IMPORTANCE OF MAINTAINING PROPER HYDRAULIC OIL LEVEL

Because of the importance of oil in your tractor hydraulic system, it is very essential that you maintain the correct oil level. Thus checking regularly is important.

If you check oil level regularly, you will be able to detect any leak that develops at once. If you allow the oil level to get too low there will be loss of hydraulic power, the oil tends to overheat and the hydraulic pump becomes noisy. If air enters the system, oil tends to oxidize faster which will eventually result in formation of gum and sludge.

#### PROCEDURE FOR MAINTAINING THE HYDRAULIC SYSTEM

The maintenance of the hydraulic system is very similar for older tractors with a separate hydraulic system and late models with a transmission hydraulic system.

1. Change the hydraulic oil filter after the first 10 hours and first 100 hours in a new tractor.
2. Change the hydraulic oil filter at the recommended interval.

3. Check periodically the hydraulic oil level at least every 200 hours, after tractor is broken in.
4. Drain and refill the hydraulic system at the recommended interval by the manufacturer.
5. Make sure to keep dust and dirt out of the system. Dirt is the worst enemy of the hydraulic system because of damage to pump parts and seals.
6. Take care to keep coupling clean when connecting remote cylinders.
7. Keep hydraulic oil containers absolutely clean and use extreme care when adding oil or refilling.
8. Operate the hydraulic units on the tractor correctly and carefully.
9. Always use the hydraulic oil recommended by the manufacturer. The wrong oil in the system will damage seals and lead to premature failure of parts of the hydraulic system.

## CHAPTER IV

## MAINTENANCE AFTER 100 HOURS OF OPERATION

## CHANGING THE CRANKCASE OIL

Troubles caused by faulty lubrication can arise from two general sources: contamination of the lubricant or failure of the lubrication system.

In one of his investigations of tractors in Illinois, J. A. Weber,<sup>13</sup> found that twenty-four of the 60 tractors he inspected needed a crankcase oil change. The test further revealed that there needed to be an oil change because

1. oil was carrying a heavy dirt load
2. oil was inadequately dispersing its load of dirt
3. microscopic examination showed particles of silica
4. oil was acid.

Changing oil regularly: The problem of deterioration and contamination of the lubricant is taken care of by maintaining a regular schedule for draining the crankcase and putting in new oil. However, there are different variations in the recommended periods for changing crankcase oil. With gasoline operated tractors the interval varies from 90 to 300 hours, tractors using distillate from 75 to 150 hours, LP gas tractors from 90 to 300 hours, and with diesel tractors (mostly used in Nigeria) from 60 to 300 hours. Nonetheless, these variations depend on the type of work and operating condition of the tractor in use. It is therefore important that you follow the operator's directives in the manual for best results.

Among the conditions that affect these recommendations are engine



design, the kind of fuel used, oil capacity in relation to size and horsepower of the engine, and the load temperature and dirt condition under which your tractor operates.

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

Today's engines have been better built to operate at higher compression rates, higher speeds, heavier loads and under all types of operating and weather conditions. This has made the job expected of oil to become even greater. The introduction of additive oils has 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 power and the wearing of the engine parts increases rapidly. A point is reached where oil is unable to take up additional contaminants. Then varnish deposits start to form on the pistons, valve lifters and rings as sludge develops. The oil change intervals recommended in your operator's manual are timed so that oil in your tractor should not be contaminated if you maintain your tractor properly.

Procedure for changing crankcase oil:

1. Drain the crankcase oil.

- a. Run the engine hot. This will drain oil and remove contaminants rapidly. Cold engine will not remove contaminants.

- b. Remove drain plug by using the correct wrench and not pliers.
  - c. Let the oil drain long enough to get it all out.
  - d. Flush crankcase. See operator's manual.
  - e. Replace drain plug. If equipped with gasket, put new one on.
2. Change the oil filter. Unlike the air cleaner, the oil filter in your tractor helps keep the tractor live long enough under proper care. The filter removes dirt and all kinds of foreign material that contributes to rapid wear of the tractor engine. There are different types of oil filters now in use. It is good to replace it when changing the crankcase oil.
- a. Locate its attachment to the engine, then wipe dirt off.
  - b. Remove the oil filter bowl or cover.
  - c. Clean inside of filter cover
  - d. Install a new filter (use the type recommended by manual).
  - e. Install new gasket and seal rings.
  - f. Replace the filter cap or cover and tighten firmly with hand, but not too tightly.
3. Fill the crankcase with new oil.
- a. Clean all dust and dirt from around the fill pipe.
  - b. Use clean containers for the oil.
  - c. Add enough oil to fill the filter -- usually one quart.
  - d. Replace the filler cap.
4. Start the engine and run for several minutes.
5. Check for oil leaks.
- a. If there are leaks around the filter, tighten the cap slightly.  
If leak doesn't stop, the gasket may not be in place correctly.
  - b. Stop the engine and check the oil level.

It is a good practice to remove the crankcase pan once a year to clean out accumulated sludge and oil pump inlet screen. If you do, proceed as follows:

1. Remove the oil pan.
  - a. Secure a new pan gasket.
  - b. Remove the cap screws that hold the pan in place.
  - c. Remove the pan and empty oil.
  - d. Scrape the oil gasket from the pan or crankcase.
  - e. Wash the pan inside and out with kerosene or solvent.
2. Remove the oil pump inlet screen and wash thoroughly.
3. If desired, the inside of the engine can now be washed with clean solvent and a clean brush.
4. Examine the bearing for wear.
5. Replace the oil pump screen.
6. Replace the oil pan.
  - a. Install a new gasket.
  - b. Replace pan and tighten cap screws.
7. Put fresh oil in the crankcase.
8. Run the engine and check for oil leaks.

#### SERVICING THE CRANKCASE BREATHER

Care of the crankcase breather is often neglected on most tractors because it is not as visible as other parts. Also, it does not require attention as often as other parts.

The crankcase breather is very important because it helps ventilate the crankcase and prevents dust from being drawn into the engine. Failure to keep the engine and breather clean can result in excessive pressure built up in the crankcase. If this happens, it will force the lubricating

oil past seals and will result in excessive oil consumption. The lack of proper crankcase ventilation will promote formation of acids and sludge in the crankcase. These will be caused by moisture, raw fuel and gases that pass the piston rings from the combustion chamber. However, conditions that may cause sludge formation can be due to operating your tractor in either low or high temperatures.

The crankcase breather can be located in the plate covering the push rod chamber or in the cap on the valve cover and sometimes oil filter tube. Most breathers contain an element of copper which is oil soaked. Dirt in the air passing this element is trapped in the oil and must be removed by washing the element. The element can be cleaned as often as necessary, particularly when you are working in extremely dusty conditions.

When cleaning or servicing the breather, follow these procedures:

1. Locate where the breather is and clean the surrounding areas.
2. Remove the breather carefully not to damage it.
3. Wash the filter element in kerosene or diesel oil.
4. Gently shake element dry or use compressed air at low speed.
5. Re-lubricate the element lightly with crankcase oil -- use clean oil.
6. Replace the element as removed. If a gasket or felt washer is used, make sure you replace it.

#### MAINTAINING TRACTOR TIRES

Tractor tires are made either of metal or rubber. The metal tires can be classified as either the conventional wheel type or the track type, as used on crawler tractors. There are many designs or styles of rubber tires, metal wheels, and tracks. Each design is suited for a specific purpose.

Safety first must be stressed when mounting, removing and servicing

tractor tires. This includes such items as the proper selection and use of tools using safety blocks, and the use of broad base metal horse after the tractor has been jacked up.

For several years, tractors came equipped only with metal tires and were not designed for fast travel, use on highways, or providing comfort for the operator. Such wheels and tracks did not absorb much of the shock resulting from stony fields, frozen grounds, or rough terrain. Instead the lugs increased the shock to the tractor when operated on smooth and firm surfaces and were not suited for transportation purposes.

The size and type of rubber tire used is dependent mainly upon the type, weight, and horse power of the tractor as well as the work to be performed. Where the tractor is carrying mounted equipment that places considerable additional weight upon the wheels, this extra weight on the tractor must be compensated for by using larger tires, sufficient in size to take care of the total weight. This may also necessitate an increase in tire pressure but must not exceed the maximum pressure recommended by the Tire and Rim Association or the tire manufacturers.

Tires have many different types of treads, all of which are designed to give maximum traction under certain conditions of soil, sod and weather, thus affecting the tractive efficiency.

#### INFLATING TIRES

Always maintain the proper tire pressure, because it is the most important factor in satisfactory tire performance and maintenance. The life and service rendered by rubber tires can be shortened materially either by under- or overinflation.

Underinflation can cause the tire to slip on the rim and tear out valve stems or cause buckling of side walls, uneven tire wear, and

excessive flexing that throws undue strain on some parts of the tire; this may injure the side walls or cause breaks in the fabric and cords. In plowing, because of the change in weight distribution, the furrow wheel may require 2 lb. more air pressure than the land wheel. When operating the tractor, always observe the tire from the tractor seat for any tire buckles or wrinkles. Increase tire pressure accordingly.

Overinflation has a tendency to stiffen the tire and prevent the tread from flexing and conforming to ground-surface irregularities, and to reduce traction and increase wheel slippage. It results in excessive tread wear, reduction in ground covered, and increased fuel consumption. Tire manufacturers recommended that tire pressure be checked weekly with an accurate low-pressure gauge. Tubes made of synthetic rubber leak very little air and only need checking every six months. The pressure should not be allowed to drop below the recommendation in the air-pressure chart.

The effects of overinflation on tire life are very evident, because when the tire is operated under an increased air pressure of 100 percent, the normal life is often reduced  $1/4$  to  $1/3$ . Should this pressure be 150 percent above the amount for which the tire is constructed, the tire life is likely to be reduced to  $1/2$  of that tire properly inflated.

Tires can be inflated with a pressure pump, hand pump, or a spark plug pump. Always see that tire-valve caps are securely in place. The caps prevent loss of air through the valve core and also prevent loose soil, sand, gravel, snow, and ice from entering to damage its valve core and air chamber.

After mounting a tire on the rim, inflate to 30 lb. pressure to seat the tire bead on the bead seat and to prevent the tire from creeping and shearing off the valve. Then deflate completely and reinflate the

tire to the correct operating pressure.

Recommended Pressure per Sq. Inch

<u>Tire</u>	<u>Pressure in Pounds</u>
Front	
Two-ply	20
Four-ply	28
Six-ply	36
Eight-ply	44
Rear	
Two-ply	12
Four-ply	12
Six-ply	12
Eight-ply	12

#### MAINTAINING TIRES

Repair cuts in tires immediately, as neglect shortens their life. Tires punctured by nails and similar objects can be repaired by inserting rubber repair plugs from the inside. Keep tires free from oil and grease, as both destroy rubber.

After using the tractor for operating spray outfits or for insect-control works, wash off with water any chemicals that may be on the tires.

Barnyard acids and rust preventatives are harmful to tires; so wash them off before storing.

When working in the field, avoid stumps, stones, deep roots, and other hazards, including the overloading of tires beyond their capacity.

Bright sunlight causes the surfaces of the tires to check and harden. When tractor is not in use, store away from sunlight. When it is to be

stored for any length of time, store in cool, dark place, and relieve the tires of their load by jacking up the tractor.

Steps in removing tractor tires from drop-center rims:

1. With the tire jacked up using a safe power jack, remove the mounting cone.
2. Loosen the beads of the tire from the rim.
3. Turn the wheel so that the valve is at the top, then put the tractor in gear with the wheel in that position to prevent turning.
4. Insert two flat tire tools about 6 inches apart under the outer bead at the top of the tire near the valve stem. Pry the upper section of both beads of the tire into the well of the rim.
5. Pry the outer bead of the lower part of the tire out of the flange. Then, bracing with one tool and prying with the other, work both tools around the tire until the outer bead is over the flange of the rim.
6. Pull the tube out of the casing. If the tube is punctured, it can be removed, repaired, and replaced without removing the tire completely from the rim. Be sure to check the inside of the casing for damage.

Steps in mounting tractor tires on drop-center rims:

1. Place the tube in the tire. Then inflate just enough to round it out and eliminate wrinkles.
2. Turn the wheel so that the valve hole is at the bottom, then engage gear to keep wheel from turning.
3. Lift the tire, placing the inner bead over the outside flange of the rim at the top.
4. With a flat tire tool, pry the rest of the inner bead over the flange of the rim. When this is done, the outer bead will overhang the



flange of the rim so that you can put your hand inside the tire all the way.

5. Put the valve stem through the valve hole, and apply the mounting cone.
6. Insert two flat tire tools about a foot apart under the outer bead.  
Pry the top part of the outer bead into the base of the rim.
7. Holding one tool in place and prying with the other, work the rest of the outer bead over the flange of the rim.
8. Inflate to 20 to 25 lb. until tire seats itself properly on the rim.

Let all air out and reinflate to the correct recommended pressure.

#### USING WHEEL WEIGHTS

Power is lost in the field and tire life cut drastically by wheel slippage. Such slippage also wastes fuel. Therefore extra weight is needed for heavy pulling. It is not required for road operation and light work, such as planting, harrowing, or cultivating, etc.

The drawbar pull on a tractor can be increased and slippage reduced by the addition of weight to the driving wheels. To increase steerability, front-wheel weights are recommended for use as a front-end counterbalance, whenever heavy loads are superimposed on the drawbar or heavy equipment is to be mounted on the tractor.

It is important that during the tire service interval, other parts of the tractor should be inspected in case they may need service or lubrication. Places to be checked are:

1. Generator bearing
2. Distributor shaft
3. Distributor camshaft
4. Power steering oil level.

## MAINTAINING THE OIL FILTER

An oil filter is one of the most important pieces of auxiliary equipment that can be installed on an engine, second only to an air cleaner.

Lubricating oil in an operating engine becomes contaminated with certain materials, which include dirt made up of soil particles common to the region in which the engine operates, core sand that has remained in the casting from the time that it was poured in the foundry, metal particles left from the time the engine was in the machine or repair shop, metal parts due to disintegration of wearing parts such as bearings, carbon resulting from the destruction of oil, water, the heavy ends of fuel and oxidized portions of the lubricating oil must be removed to keep an engine working at peak efficiency. An ideal oil filter would remove all contaminant as rapidly as they occur in the oil and before the contaminated oil reaches any working part. Filters to do these jobs can be classified according to (1) size, (2) installation, (3) filtering principle, (4) direction of flow and (5) material of the element.

### Installation:

Full flow - one receiving all oil from the oil pump.

Bypass - one receiving only a portion of the oil from the pump.

### Filtering principle:

- a. Strainer - one removing the larger particles which occur in crankcase oil by means of closely woven metal or cloth.
- b. Adsorbent - one removing contaminants largely by adhesion.
- c. Absorbent - one removing contaminants not only by adhesion but also by their penetrating the cell structure of the element.
- d. Evaporation - one aiming to remove dilution and water from crankcase

oil by the use of heat.

Direction of flow:

- a. Centrifugal flow - one in which the oil flows through the filtering element radially and outwardly.
- b. Centripetal flow - one in which the oil flows through the filtering element radially and inwardly.
- c. Parallel flow - one in which the oil flows parallel to the axis of the filter.

#### REPLACING AN OIL FILTER

1. Stop the tractor engine and find the location of the oil filter -- usually at the side of the engine.
2. Clean dirt from filter and surrounding areas.
3. Remove plug or screw which holds filter in place.
4. Remove oil filter.
5. Install new oil filter of the recommended type and tighten screw to hold it in place -- usually tighten with hand.
6. Operate engine and check for leakage around filter.
7. Stop engine and recheck oil level.

It is not a recommended practice to re-use the old oil filter element as some mechanics would suggest. This practice is allowable only if you cannot get the correct or recommended oil filter. If you do use the old one, wash thoroughly and carefully with kerosene or diesel fuel. Also wash the bowl that holds the filter element. Then reinstall accordingly.

Oil filter should be changed at the same time you are changing your crankcase oil.

## CHAPTER V

### MAINTENANCE AFTER 250 HOURS OF OPERATION

#### VALVE CLEARANCE ADJUSTMENT

Valves are subject to considerable strain and wear owing to the high temperature to which they are exposed and the speed at which they must operate. Obviously, the exhaust valve becomes much hotter than the intake because it is exposed to an almost continuous flame. In order to resist breakage, corrosion, warping and rapid wear, exhaust valves are made of special alloy steels containing high percentages of chromium, nickel, and silicon and some other metals.

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

Valve-clearance adjustment provides the proper clearances between the ends of the rocker arms and the ends of the valve stems during the time the valves are not being depressed.

A certain amount of clearance between the tappets and the valve stems is usually necessary to make certain that the valves are able to seat properly. If clearance is insufficient, the valves will be held off the seats, the engine will not have proper compression, and the valves and seats will be damaged by burning. Also, the transfer of heat from the valve to the engine block will be interfered with when the valve is in the closed position.

Manufacturers differ in their recommendation -- some say after every 150 hours of operation; others as long as every 600 hours. Proper valve clearance adjustment is important to you because:

1. Valve will give longer service.
2. Engine will start more easily.
3. The engine uses fuel more efficiently.
4. Maximum power will be produced.
5. Engine is less likely to overheat.
6. Smoothest engine operation will be provided.

Valve lash or tappet clearance is the small clearance between the valve stem and the end of the rocker arm. Valve clearance also allows for the heat expansion of parts. In general, the clearance is too small, varying from about 0.006 inch to 0.030 inch. However, the clearance differs depending on the engine make.

Too little valve clearance throws the valves out of time. This causes valves to open earlier and close late. 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 quickly and prevents waste gases from being completely removed. The valves themselves are damaged as a result.

#### PREPARING TRACTOR FOR VALVE ADJUSTMENT (SPARK-IGNITION OR DIESEL TRACTORS)

There are two types of valve arrangements in an engine. One is called an L-head engine; this is when the valves are placed on the side of the engine block. The other is valve-in-head engines; the valve is located in the head of the engine.

1. The operator's manual is your guide to determine whether valve work should proceed cold or hot.
2. Remove parts as necessary to get access to valve unit.
3. Unscrew the nuts which hold valve cover in place.

4. Wipe out dirt and carefully remove valve cover.
5. To prevent accidental starting of engine
  - a. Disconnect center terminal wire to distributor or
  - b. Remove spark plug
  - c. With diesel engine, be sure fuel supply is shut off.

#### HOW TO MAKE VALVE CLEARANCE ADJUSTMENT

Valve tappet clearance on a tractor engine should be checked every 200 to 300 hours of operation. When making valve clearance adjustment proceed as follows:

1. Check the cylinder head for tightness. It is good to tighten it if loose before valve adjustment.
2. Understand the valve arrangement, timing marks and firing order of cylinders.
3. Be sure engine is either cold or warm as suggested by operator's manual.
4. Slowly turn crankshaft until piston in number 1 cylinder is at top dead center (TDC) of compression stroke. The No. 1 cylinder is located next to the radiator on upright engine and on horizontal engines it is next to the flywheel. You can turn the crankshaft with a crank or use the starter key to crank or use screw driver through the timing hole to turn the flywheel. A quicker way to find TDC is to remove the spark plug or injector nozzle and hold thumb, finger over the opening. At compression stroke air will be pushed out against the finger. When a piston is at TDC on the compression stroke, both intake and exhaust valves are closed.
5. With the No. 1 piston at TDC, use the recommended feeler gauge to check for appropriate clearance. Adjust clearance accordingly

(if gap between the rocker arm and valve stem is wider). See operator's manual.

6. If clearance is not correct, loosen adjusting screw lock nut on valve rocker arm.
7. Turn adjusting screw with screwdriver until feeler gauge will slip in and out of gap.
8. Hold adjusting screw with screwdriver and tighten lock nut with wrench. (Recheck gap after you have tightened nut).
9. Determine which cylinder fires next (this can be done by knowing line of firing order).
10. Turn crankshaft until next cylinder in firing order is on compression.
11. Adjust valves following same procedures as on No. 1 cylinder and proceed in same manner with remaining cylinders.

\* Note - With 2- and 4-cylinder engines, turn the crankshaft  $1/2$  turn. With a 6-cylinder engine turn crankshaft  $1/3$  turn. With an 8-cylinder engine, turn crankshaft  $1/4$  turn.

Reassemble parts after valve adjustment.

1. Clean and install spark plugs or injection nozzle.
2. Start engine and check lubrication of rocker arm.
3. Put new gasket on cylinder head.
4. Replace valve cover.
5. Replace other parts of tractor that were removed to gain access to valves.

#### MAINTAINING TRACTOR SPARK PLUGS

The spark plug is the device used in the jump-spark system of ignition that provides the gap for the high voltage current to jump and ignite the charge.

Spark plugs are made in many heat ranges. When replacing the plugs in your tractor, get the plugs recommended for the engine. The heat range of a spark plug is determined by the distance the heat must travel from the lower tip of the center electrode to the spark plug gasket and to the engine. The longer the distance the heat must travel, the hotter the plug will run. A cool plug has a short distance for heat to travel.

Spark plugs are installed in the engine combustion chamber. A spark "jumps" between the two terminals at the base of the plug and ignites the fuel-air mixture which has been compressed to the top of the cylinder. Correct functioning of the spark plug is essential for proper engine operation. The essential of maintaining a good spark plug in proper condition was judged by an investigation on some farm tractors in Kansas.<sup>14</sup>

- - - New spark plugs of the recommended type for each tractor were installed. The effect of horsepower and fuel consumption from changing the spark plug was found. The test showed that there is an increase in horsepower of 5.6 percent and a decrease of 6.1 percent in fuel consumption by the installation of new spark plugs in the tractors. In seven of the tractors that misfired under load, the misfiring was corrected by installing new spark plugs. After the spark plugs were changed, these seven tractors gave an average increase in power of 21.5 percent and a 14.2 percent decrease in fuel consumption.

Used spark plugs will usually give very good service if given occasional or periodic attention and cleaning, thus increasing power and saving fuel. The gap will gradually increase with use, due to the burning up of the points; therefore, plugs should be removed every few weeks and gaps readjusted. Excessive fouling and carbon deposits result in improper functioning because such deposits produce leakage of the electric current



and eventually a short circuit develops.

#### SELECTING THE RIGHT TYPE OF SPARK PLUG

The correct type of spark plug gives the best possible performance and plug life. Use your operator's manual to give you correct size and type of plug that best fits your tractor engine. If for any reason you want to substitute, see your dealer or spark plug chart. For example, a hot-running farm tractor engine or an engine operating on gasoline will require a "cold" plug. By using spark plugs of suggested heat type, you get longer trouble-free service. Engine design affects the length or "reach" of plug recommended. "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 four different types of reach on the 14 mm plugs, ( $3/8"$ ,  $7/16"$ ,  $1/2"$ ,  $3/4"$ ) which is one of the common sizes used on farm tractors.

#### REMOVING PLUGS FROM ENGINE

1. Disconnect spark plug cables from plugs making sure of where the different cables are disconnected.
2. Wipe off dirt on plug and surrounding areas. Then use a special deep-socket wrench to prevent possible damage to insulator.
3. Remove each plug and identify with each cylinder.

#### SERVICING THE PLUGS

Spark plugs can be serviced by first inspecting their condition, cleaning them and making gap adjustment.

- a. Closely inspect the plugs for abnormality such as wear and carbon deposit. And decide whether to recondition or replace the plugs. It is important to replace all old plugs with new ones rather than just one. This gives high efficiency in power, fuel use and engine performance.

- b. Remove oily deposits from plugs by putting them in a pan of solvent.  
Use clean cloth or soft brush to wipe off solvent.
- c. Plug threads should be cleaned with wire brush to facilitate easy reinstallation.
- d. Use a small file or knife to remove hard deposits. Do not tamper with the insulator.
- e. Blow loose materials off plugs with compressed air to get rid of any remaining particles.
- f. Bend the ground electrode (not the center electrode) away to allow room for filing central electrode.
- g. After you have finished filing, bend ground electrode back into its original position.

#### ADJUSTING SPARK PLUG GAP AND REPLACING THEM

The spark plug gap has a very important effect on engine operation, for it is here that actual ignition of the fuel takes place. The gap may vary from .381 mm to 1.016 mm (.015 to .040 inch). Use a feeler gauge of the proper thickness to measure the gap. However, it is very important to recheck gap on new spark plugs before installing.

When replacing plugs in engine proceed as follows:

1. Replace plugs and tighten with fingers. Make sure to replace the copper gasket if it has one. (New gasket is much preferred).
2. Completely tighten plug with a spark plug socket wrench or torque wrench. Complete tightening is necessary to stop heat from building up to cause overheating in plug.
3. Check connection and insulation of spark plug cables. Poor cables may carry the spark when the engine is idling but may fail when a load is applied.

4. Replace poor cables even though they may work fairly well under ideal conditions.
5. Check polarity of spark at spark plug by holding the metal connector of the spark plug wire 1/4 inch from the plug terminal. Then insert the point of an ordinary lead pencil in between. If the spark feathers on the plug side, polarity is correct and vice versa. Correct by interchanging the primary wire connections on the ignition coil.

#### CLEANING THE BATTERY

As you use your tractor, dirt, moisture and acid gradually accumulate on top of the battery. Acid and gas that escaped during charging of battery can settle on battery top and can provide damp surface where dust and dirt will cling. It also gets on the battery posts and terminals which can cause corrosion on cable terminals, battery carrier and even tractor frame. If left uncared for, the amount of acid present is enough to provide an electrical path to the metal frame or to the opposite terminal.

A battery when charged but not put into use has the tendency to discharge slowly. 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.

To clean the battery, proceed as follows:

1. Loosen ground strap and disconnect cables first. This prevents short circuits in case you accidentally lay a wrench or screwdriver on the battery in such a way as to contact the opposite battery terminal and some parts of the frame.

2. Use a wire brush to clean outside surface and sandpaper for the inside of clamps.
  3. Remove loose dirt and corrosion particles from top of battery.
  4. Use one or two tablespoons of baking soda in a pint of water. Mix thoroughly and apply on the battery until foaming stops. Then brush dirt off. Be sure to keep water and soda away from entering battery, as this will weaken the acid in the electrolyte.
  5. Wash away residue with clean water.
  6. Dry top of battery with clean cloth.
  7. Reconnect power cable and ground strap.
  8. Apply a coating of grease or vaseline to post and cable clamp connections.
- \* Note - Clean terminals and tight clamps are especially important for diesel engines which require a heavy current flow when starting.

#### MAINTAINING THE SEDIMENT BOWL AND FUEL FILTER

The maintenance of the fuel system is essentially that of inspecting, checking and making repairs or adjustments, as they are needed. If clean fuel is used, only infrequently will any repair jobs need to be done.

Small particles of dirt and water are trapped in the sediment bowl to prevent clogging of the small jets in the carburetor. As often as dirt or water accumulates in the bowl, it will need to be removed and cleaned. Proceed as follows for cleaning.

1. Shut off fuel at the tank.
2. Loosen jam nut holding bowl in place.
3. Twist bowl to loosen it without damaging gasket.
4. Remove bowl, strainer and gasket.
5. Wash strainer in clean solvent and wipe bowl clean.

6. Open fuel valve and observe the flow of fuel. This tends to remove any dirt between the tank and the sediment bowl. It also serves as a check on the condition of the vent hole in the fuel-tank cap.
7. Replace gasket, strainer and bowl. (Always use a new gasket).
8. Tighten bowl against gasket. For diesel engines it may have to be installed loosely until air has been bled from the system; then tighten.
9. Turn the fuel on, as soon as all air is out of the bowl; tighten jam nut enough to stop the fuel from leaking.
10. Start your tractor and check for leaks.

#### SERVICING AND ADJUSTING THE CARBURETOR

Of major importance in connection with any preventive maintenance activity on fuel and air systems is cleanliness. Care must be taken to prevent dirt from entering fuel or air lines of the engine at any time.

Operator's manuals usually do not suggest a regular time for carburetor adjustment. However, it is an important tune-up procedure.

The importance of carburetor adjustment is shown in a Nebraska study of 20 farm tractors. Horsepower and fuel economy of the tractors were checked both before and after adjustment. After the test and various adjustments, the report states that

In general, proper adjustment of the carburetor gave the largest increase in both horsepower and fuel economy. The adjustments made during the test demonstrated the importance of setting the carburetor needle valve accordingly.

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

The study showed that when the carburetors were corrected from too rich a mixture to the proper mixture, horsepower was affected very little but fuel consumption showed an average savings of about 9.5 percent. A rich mixture will also cause carbon deposits to accumulate in the combustion chamber. After adjusting the too lean mixtures, there was an average increase in fuel consumption of 5.3 percent and an average increase in horsepower of 5.3 percent. A lean mixture burns slowly. The slow-burning exhaust gases are extra hot and result in valve burning.

#### THE PRINCIPLES OF CARBURETION

The functions of a carburetor are (1) to assist in properly vaporizing the fuel, (2) to mix the vaporized fuel in the correct proportions with air, and (3) to supply the engine with the proper quantity of this mixture depending upon the load, speed, temperature, and other conditions present. All carburetors, regardless of the type, size, speed, number of cylinders, and other engine characteristics, operate on the same basic principles.

The carburetor is attached to the cylinder block by the intake manifold and is connected to the combustion chamber by the intake valve. On the intake stroke this valve opens and the piston movement creates a low pressure in the cylinder. This results in a suction action at the air entrance to the carburetor and a high-velocity air flow past the fuel-jet nozzle in which a certain fuel level is maintained. Thus a reduced pressure is created at the nozzle and atomized fuel enters the airstream at this point and forms a combustible mixture.

The following conditions are of fundamental consideration in the proper functioning of any carburetor.

1. A constant and specific fuel level must be maintained in the nozzle.
2. There must be at least partial if not complete vaporization of the

liquid fuel, regardless of surrounding temperatures.

3. The correct mixture of vaporized fuel and air must be maintained at all times, regardless of engine load, speed, temperature, atmospheric pressure, and other operating conditions.

The problem of maintaining an optimum fuel mixture and supplying the correct amount of this mixture to each cylinder of an engine regardless of speed and speed range, power output, temperature, atmospheric pressure and other operating conditions is a complex one. Thus, why carburetors are complex. Under normal operating conditions it is to produce a mixture of 13 1/2 lb. air to 1 lb. fuel or an air-to-fuel ratio of 13.5:1. An engine can run on ratios from as rich as 7:1 to as lean as 20:1. Engineers have experimented and found that generally one gallon of fuel required 9000 gallons of air for good combustion of an engine.

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. Because of an additional accelerating well in the carburetor, it provides for the sudden needs of the engine. The well is surrounding the lower part of the nozzle and is always full of fuel while the engine is operating under normal load. With the sudden demand for fuel, the governor opens the throttle valve and air moves past the nozzle much faster, picking up additional fuel which 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. Immediately the demand for power is over and the governor partially closes the throttle valve; the accelerating well refills in preparation for the next heavy demand.

Other tasks of the carburetor is to supply a richer idling mixture which requires an air-fuel ratio of about 12:1. "An engine does not operate well at idling speed unless a richer mixture is supplied." Carburetors are specially built with provisions to supply the proper idling mixture. Two other features on a carburetor need mention for you to take note of. They are the choke valve and the pressure equalizing arrangement to the fuel float chamber.

The choke valve is located at the carburetor air intake. It is used for cold starting by providing extra rich mixture. When you choke your engine you close the choke valve so that most of the air supply is cut off. 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 a passage that connects at the carburetor air inlet and extends around the venturi to the fuel float chamber. This keeps the air pressure in the float chamber the same as that entering the carburetor. This is an important provision because the air cleaner causes a slight drop in air pressure as air passes through it on its way to the carburetor. Without this connection, fuel in the float chamber would have to be exposed to atmospheric pressure and this would be enough more than that of the air entering the carburetor to force extra fuel through the nozzle tip and make the mixture extra rich.

#### PREPARING FOR CARBURETOR ADJUSTMENT

Before making carburetor adjustment, it is important that the carburetor screen be clean and that there are no leaks in the intake manifold or around the carburetor gasket. Any clogging of screen or leaking of air will not give good adjustment. To clean the carburetor,



proceed as follows.

1. Determine if your tractor has a carburetor screen (screen is located at fuel inlet to the carburetor).
2. Shut off valve on fuel line and disconnect line at the carburetor.
3. Remove screen from carburetor.
4. Clean the screen and complete the reassembly.
5. Start engine and check for air leaks at manifold connections and around carburetor gasket.

Generally, the carburetor will do its job without trouble for long periods, provided it has clean fuel of the proper kind and clean air. Except for minor adjustments, the operator should adopt a "hands off" policy for the carburetor.

Occasionally, the carburetor is thrown out of adjustment and this affects the performance of the engine. It may cause overheating, loss of power, poor acceleration, oil dilution, or result in damage to valves, spark plugs, and piston rings. Through careful observation of such symptoms, the need for carburetor adjustment can be detected. However, before any adjustment take note of the following:

1. Unnecessary adjustment of the carburetor can result in loss of power, high fuel consumption and burned valves.
2. Too lean a mixture results in poor economy because of loss of power, poor acceleration, and a tendency to burn valves and spark plugs.
3. Too rich a mixture results in wasteful fuel and in piston and ring wear due to the washing off of lubricating oil, dilution and increased carbon formation.
4. The maintenance of the carburetor should consist mainly of checking nuts and bolts for tightness and making idle speed, idle mixture and

load mixture adjustment.

#### IDLE SPEED ADJUSTMENT

The idle speed adjustment is a stop screw that determines how far the throttle valve will close when the throttle lever is at the full idling position. Always check operator's manual for the particular tractor being adjusted. Start tractor and allow it to warm up, then close the throttle and screw the idle speed adjustment in or out until the desired idle speed is obtained. This will give you a smooth running engine.

#### IDLE MIXTURE ADJUSTMENT

With the engine warmed up and idling at the correct speed, the idle mixture adjustment can be made. To adjust, turn the idle adjusting screw out until the engine runs roughly, then turn the screw in until the engine runs smoothly; this will be the correct idle mixture adjustment. The correct adjustment will usually be found with the adjusting screw turned out one to one and a quarter turns.

\* Note - Screwing the idle mixture screw in usually restricts the air and gives a richer mixture. Screwing it out gives a leaner mixture.

#### LOAD MIXTURE ADJUSTMENT

The procedure is to have the engine warm, open the throttle and screw the load mixture screw in, until engine mis-fires, then turn the screw out until the engine runs smoothly. Now place the tractor under load and observe how it reads. If it back-fires through the carburetor and engine tends to stall or slow down, the mixture is still too lean. Back the adjustment out  $1/8$  of a turn and place the tractor under load again. Repeat this until the tractor takes the load smoothly.

\* Note - Screwing the load mixture screw in usually restricts the

fuel flow and gives a leaner mixture. Screwing it out gives a richer mixture.

#### SERVICING DIESEL-FUEL-INJECTION PUMP

Dust and other foreign material in the diesel fuel will render fuel-injection system inoperative or function unsatisfactorily. To avoid this condition make certain that clean fuel is first put in the fuel tank. Check the fuel filter on the tractor every 30 to 60 hours of operation and allow enough fuel to drain out to remove all sediment. Open the filters every 100 hours or less and wash the filter element in clean fuel oil before reinstalling it. Exchange a worn fuel-injection pump for a new one. Check the oil level in the diesel-fuel-injection pump whenever checking the crankcase oil level. Only a specialist should service an injection pump.

#### ADJUSTING TRACTOR BRAKES

The brakes on a tractor are sometimes called turning-brakes because of their use in assisting to make sharp turns. The maintenance necessary is adjustment and an occasional replacement of the lining.

There are several types of brakes in use. The ones used on tractors are:

1. External band brakes (external contracting)
2. Shoe brakes (internal expanding)
3. Disc brakes (mechanical or hydraulic).

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

The internal expanding brake is similar to those used on automobiles. It uses springs which until when the brake pedal is pressed, the shoe is forced against the drum to cause friction and thus retard the rotation

of the wheels.

The mechanical disc brake is complicated but is more common in use now. The brake has two driven discs, faced on each side, that turn with the axle. These discs rotate whenever the tractor is in motion. Between the two discs are two actuating metal discs held together by springs. These two discs have three steel balls in between them located in caps.

Some tractors are equipped with combination band and mechanical disc brakes to provide more efficient braking capacity.

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

Brake adjustment varies depending on

- a. type of brakes used on the tractor
- b. location of the brakes
- c. kind of linkage between the pedals and the brakes.

#### ADJUSTING THE BRAKES

To adjust the disc-type brake, loosen the brake-adjusting lock bolts. Tighten the three adjusting screws evenly, but do not force them. Back up the adjusting screws  $1/4$  turn to equalize both brakes. Tighten the cap-screws to lock the adjusting screws in place. Be sure the brake pedals are entirely released when making the adjustment. Both pedals should be adjusted to the same position in order that the brakes be equalized. Lubricate brake pedal occasionally.

The external-band type brakes are the simplest of the various types of tractor brakes. Proper brake adjustment is obtained by turning the

setscrews as far in as it will go. Then back it off  $1/4$  to  $1/2$  turn and lock it. Adjust the pedal movement by changing the length of the brake rod. Remove the pin from the end of the clevis and turn it as far as necessary to obtain 1 inch of pedal movement.

To check equalization of brakes on tractor wheels, jack up both wheels free from the ground, then latch the brake pedals together, then start the engine. Operate tractor in either third or fourth gear, then apply brakes. Wheels should stop turning at the same time. If not, loosen the adjustment on the wheel that stops faster. When the correct adjustment has been obtained, tighten the lock nut.

To adjust the internal-expanding type brakes jack up the tractor until both rear wheels are free from the ground. Insert a screwdriver through the slot in the braking plate and turn the adjusting wheel. Be sure the brake pedal is in the release position. Loosen the adjusting nut until the wheel rotates freely but with a slight drag. Repeat procedure on both wheels. Replace the backing plate slot covers. Adjust the brake pedal linkage so that the pedals will be even in the applied position.

Every operator should inspect brakes for excessive wear and worn spots, check the tension of the brake return spring, check the brake drum for scoring, flat spots or roughness, inspect friction plate. Remove any irregularities from splines with sand paper. Clean dirt and grease from all parts and discard all gaskets. Inspect the oil seal, replace brake shoes if worn, inspect bearings and shins.

There are three steps to adjust hydraulic brakes. These are bleeding, push-rod adjustment and brake mechanism adjustment.

#### BLEEDING: TAKING OUT AIR FROM THE SYSTEM

1. Inspect the whole system and clean dirt and grease from cylinder.
2. Check the fluid level in the master cylinder. If low fill it up with recommended oil.
3. Have a helper slowly depress the brake pedal for the right brake while you slowly open the bleed valve. If there is air in the cylinder, bubbles will be seen and will come out with the fluid.
4. Close the bleed valve before releasing brake pedal. The pedal must be released slowly to avoid churning the fluid and creating more air pockets.
5. Repeat this procedure until no bubbles appear at the bleed valve. Bleed the left cylinder too.
6. Bleed the slave cylinder in the same manner.
7. Refill the reservoir to the proper level.

#### ADJUSTING HYDRAULIC BRAKE PUSH-RODS

1. Loosen the lock nut on the push-rods of the master cylinder.
2. Adjust the push-rods until the pedal travels freely.
3. Make use of your tractor operator's manual.

#### ADJUSTING THE TRACTOR CLUTCH

A satisfactory tractor clutch must fulfill the following requirement.

1. It should not slip, grab or drag.
2. It should be convenient, accessible.
3. It should be easy to operate, adjust and repair.

Clutch troubles are not unusual and are usually due to misuse, neglect or to normal wear without proper adjustment. When adjusting the clutch proceed as follows:

1. Check your operator's manual for correct information.

2. Check clutch pedal for free travel. Free travel is the distance the clutch pedal can be depressed before resistance is noticed. Recommendations vary from approximately 1/2 inch to 2 1/2 inches depending on make and model of tractor.
3. If your tractor does not have sufficient pedal free travel, then locate mean provided for clutch adjustment.
4. Adjust linkage by setscrew or lock nut until clutch pedal has sufficient free travel.
5. Tighten lock nut so that it holds adjustment securely.

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

1. Inspect starter motor for lubrication.
2. Check the transmission and differential oil level.
3. Service the distributor.

## CHAPTER VI

## MAINTENANCE AFTER 500 HOURS OF OPERATION

## SERVICING THE DISTRIBUTOR

The purpose of this mechanism is to distribute the high-voltage circuit from the coil to the various cylinders of the engine in the proper order. Electrically the distributor is composed of a rotor, breaker points, and condenser and a cap in which is mounted a group of metal terminals, sometimes called "lugs." Each cylinder of the engine has one terminal. The high-voltage current jumps from the rotor to the terminal without contact and travels through the spark-plug cable to the spark plug.

Some distributors are equipped with ball bearings for which the manufacturer recommends a special type of cam and ball-bearing lubricant. Parts of the distributor, such as the shaft advance mechanism, breaker cam, breaker-plate assembly of the rotating type, and breaker-lever pivot, are to be lubricated according to operator's manual.

The breaker points interrupt the current in the primary winding of the coil, which induces a high voltage in the secondary winding of the coil. These points are timed with the engine so that the high-voltage current is developed and delivered to the spark plugs at the proper time. Weber found that 27 of the 55 farm tractors he studied had breaker points problems. And the reason is because the operators have not been checking the breaker points accordingly.

It is important that the breaker point opening be adjusted according to the specifications of the engine, since an improper opening will affect the timing of the ignition and engine performance.



The condenser is connected across the breaker points and serves the purpose of absorbing the induced energy in the primary circuit at the time the points break, thus preventing arcing at the points and helping to build up a higher voltage in the secondary circuit. Other parts to take note of when servicing distributor are the centrifugal advance mechanism and the vacuum advance mechanism.

Basically, an advance mechanism is a device which times the spark to occur at a certain time as determined by the engine speed. The centrifugal advance mechanism is the most popular advance. It has 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. An extra advance mechanism is used on some distributors for greater fuel economy; this is called vacuum advance.

#### CHECKING THE CONDITION OF THE DISTRIBUTOR

1. Remove dirt from outside surface of distributor and cap. Use a dry cloth or remove grease with small amount of diesel fuel or kerosene.
2. Remove cap and clean inner surface. Leave wires connected.
3. Check distributor cap for chips or cracks. If cap is cracked, replace it with a new one. If distributor needs changing, get a new one.
4. Pull the distributor arm or rotor straight up or out from end of shaft, wipe clean and inspect for cracks or excessive burning of metal strip. Replace defective parts.
5. Check the centrifugal advance mechanism. It is located in the lower part of the distributor body. It is usually a set of weighted levers which revolve with the distributor shaft. As engine speed increases, the weights move out automatically advancing the timing of the spark.

As engine speed decreases, the levers are pulled back by springs and spark timing is retarded.

6. Check breaker points. If points are rough but show only slight pitting and metal deposit, smooth up with an ignition fill. Never use sand paper or emery cloth as particles may cause points to burn. If points are badly pitted and worn, replace them with a new set.
7. Check tightness of screw holding the condenser. It must be well tightened.

To replace breaker points, proceed as follows:

1. Remove breaker arm and spring.
2. Remove stationary breaker point and bracket.
3. Clean, then lubricate cam with a special high temperature grease prepared for this purpose.
4. Install new points in reverse order. Apply a drop of SAE-10 crankcase oil around the contact point pivot post before installing new points. Be sure electrical connections are tight.

#### ADJUSTING BREAKER POINTS

1. Turn engine until cam opens breaker points to widest position.
2. Check points for proper spacing using a feeler gauge of recommended thickness. The gap should be .010 to .028 inches. The proper width gap is provided when there is a slight drag on the feeler gauge as you pull between contact points.
3. If adjustment is needed, loosen lock screw on bracket that provides adjustment. Then adjust points for proper spacing and alignment.
4. Lock breaker point in position with lock screw.
5. Recheck gap between points and wipe points clean. Rechecking assures you that gap setting has not been changed while tightening with

lock screw.

- \* Follow the operator's manual for your tractor to check and adjust the cam angle.

#### REASSEMBLING THE DISTRIBUTOR

1. Use at least two drops of SAE-10 crankcase oil to lubricate wick in center of camshaft.
2. Reassemble distributor in reverse order from that outlined in checking the condition of the distributor.
3. Inspect condition of wires leading to spark plugs and to ignition coil. Correct any defect immediately.

#### TIMING THE IGNITION

One of the very important factors in the correct operation of any internal combustion engine is the time of occurrence of the ignition. That is, the combustion mixture of fuel and air must be ignited so that the piston will receive the force of the explosion just as it reaches head dead center at the end of the compression stroke and is ready to start on the power. If the spark comes too early, the explosion will take place before the piston reaches the end of the compression stroke and the result will be a knocking effect and great loss of power. If the spark occurs too late the explosion will be delayed resulting in even more power loss and overheating.

A study of 50 farm tractors in Kansas<sup>15</sup> showed that retiming caused increased horsepower and decreased fuel consumption in 26 cases. After proper timing, the average horsepower increased 5.3% and fuel consumption decreased 5.3%.

The time that the spark occurs varies tremendously in different engines and models. Therefore always follow factory specifications for

timing procedures. For simplification, timing marks are placed on flywheel, vibration damper at the end of the engine or on fan pulley.

There are two methods of timing an engine:

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

#### TIMING BY BREAKER POINT

1. Locate timing marks on flywheel or fan pulley.
2. Loosen or remove spark plug from No. 1 cylinder. If you are working alone, loosen plug No. 1 2-3 turns so you can hear air escape past it on the compression stroke. This will enable you to tell when No. 1 cylinder is on the compression stroke.
3. Remove distributor cap.
4. Crank the engine until No. 1 cylinder starts compression stroke.  
Watch which way the distributor rotor is turning.
5. Continue to rotate 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 they are just starting to open, timing is satisfactory and vice versa. If not, loosen clamps that hold distributor to engine block.
8. Turn the distributor body slowly in the direction the rotor normally turns.
9. Turn distributor body slowly in opposite direction until points start to open.
10. Tighten clamps that hold distributor body and reassemble distributor.
11. Tighten No. 1 spark plug and attach sparkplug wire.
12. Start the engine to see that it operates satisfactory. If your

engine is not firing on all cylinders or is backfiring, make sure firing order is correct. Firing order for four cylinders is 1-3-4-2 or 1-2-4-3. Firing order for six cylinders is 1-5-3-6-2-4.

#### TIMING BY THE USE OF A TIMING LIGHT

1. Locate timing marks on flywheel or fan pulley.
2. Connect timing light as recommended by manufacturer.
3. Determine from the operator's manual what timing mark to use with light, e.g. at idling speed it is the TDC marking.
4. Chalk the timing mark so it is easy to see.
5. Start engine and run at recommended speed.
6. Direct timing light at markings on the flywheel or fan pulley.  
Watch for fan blades.
7. Loosen clamps that hold distributor.
8. Turn distributor body slightly until timing mark is opposite pointer.
9. Tighten distributor and remove timing light.
10. Replace cover over timing hole if one was removed.

#### MAINTAINING THE STARTER AND GENERATOR

The purpose of the generator is to supply current for the tractor's needs and to keep the battery charged. The generator driven by the tractor engine changes mechanical energy into electrical energy. This energy is used to charge the storage battery and operate the lights and sometimes the ignition. The battery supplies cranking current and ignition current until the generator starts.

The generator is belt driven and is located at the front of the tractor. When the engine is not running, the battery supplies electrical energy. The job of the generator is not as heavy as that of the starter but operates continuously while the engine is running. An alternative

for the generator on modern tractors is the alternator. A generator develops direct current which is suitable for direct use by the battery and electrical equipment of the tractor, while the alternator develops alternating current, current which flows back and forth. This cannot be directly used by the battery, but must be made to change in one direction by means of electronic "check valves" called diodes. The advantages of the alternator over the generator are:

1. Its ability to produce a higher output than the comparable rated generator at lower and idle engine speeds.
2. Simple construction which requires less maintenance.

#### THE STARTER MOTOR

A starting motor consists of a dc motor that is engaged to a gear on the engine by means of a sliding pinion gear. The pinion gear is meshed with a ring gear on the flywheel of the engine by a solenoid. When electrical power is switched on the dc motor, the solenoid is simultaneously activated, which in turn engages the pinion. The spring on the pinion disengages the pinion when power to the solenoid is shut off.

#### SERVICING THE STARTER AND GENERATOR

Most tractor manufacturers recommend that the only service required on the alternator by the operator is to periodically inspect the wiring connections and keep them clean and tight. Follow these steps to service your starter and generator.

1. Wipe dirt from starter or generator housing.
2. Remove cover band.
3. Inspect for thrown solder.
4. Check brushes for wear and binding action.
5. Replace any worn or damaged brushes.

6. Check brushes for binding action in holder. If there is binding action, remove and wipe brush holder with a clean cloth.
  7. Check electrical connections for tightness.
  8. Inspect commutator for wear and roughness.
  9. Remove dirt or glaze from commutator surface with no. 00 sandpaper.
  10. Clean the commutator on a generator while the engine is running slowly.
  11. Clean the commutator on your starter while the starter is turning the engine.
  12. Seat new brushes on commutator. If not seated properly use the brush-seating stone on the commutator until the brushes are seated.
  13. Blow out dust from commutator, brush holders and casing.
  14. Replace band and polarize the generator before starting the engine.
- \* Do not attempt to polarize alternator systems.

#### SERVICING DIESEL ENGINE FUEL FILTER(S)

An important part of any diesel fuel system is the fuel filter. Because the high-pressure pump, the metering system and the nozzle are manufactured with extreme precision, the fuel must be very clean before it reaches these parts. A two-stage filtering system is usually employed and it needs only infrequent attention. A pressure gauge is often placed in the line between the low-pressure fuel filters. When the pressure gauge reaches a certain level it indicates that the fuel filters need to be replaced.

The service interval for fuel filters on diesel tractors varies from 250 hours to as long as 2000 hours depending on the model and make of the tractor, also the number of filters used and their sizes.

Servicing the fuel system of a diesel tractor is of greater importance than a gasoline engine tractor. Because any damage done to a diesel

tractor is of greater cost to correct. The service life of the injection pump and injector nozzles may be a matter of few hours if water and dirt particles are allowed to reach them. This is because the injection pump and nozzle have very finely machined parts with clearance sometimes as small as 0.001 to 0.0003 inch. These precision machined parts are necessary to develop and use the high pressure required on the nozzle tips so the engine will operate properly and efficiently. Because of the delicateness of these parts, manufacturers often recommend that these parts be sent to factory or factory-approved service centers where they can be serviced.

Much of the moisture and dirt particles get into the fuel during handling and storing, and by condensation, especially when fuel tanks are not filled prior to shut-down at night. Proper handling and proper care in changing filters, however, can reduce dirt and moisture to such a point that your tractor will give thousands of hours of service without repair to the injection pump or the injector bodies.

#### THE WORKING SYSTEM OF THE DIESEL FUEL SYSTEM

The diesel fuel system has five working parts with some tractors having a sixth. Those 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 that the low-pressure line can be fed by gravity. Most tractors, however,



are equipped with a transfer pump.

The low-pressure line is of particular interest since this is where the fuel filters are located. It and the fuel tank require regular servicing which can be done by the operator.

Either the injector-pump or injector-nozzle combinations can be connected to any of the low-pressure line combinations. The job of the injection pump is to apply high pressure to the fuel. This high pressure is used by the injector nozzles to make a fine mist of the fuel as it is sprayed into the cylinders. This is to provide an immediate and 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 a spark-ignition engine.

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

\* Follow the directions in the operator's manual very carefully in maintaining and servicing the diesel engine fuel system.

#### CHANGING FUEL FILTERS

1. Turn off fuel supply at tank.
2. Clean outside of filter body and engine area around filter.
3. Drain fuel from filter.
4. Remove old filter.
5. Clean inside of filter bowl (unless self-contained).
6. Install new filter with new gaskets.
7. Complete the filter assembly and tighten it.
8. Replace drain plug or tighten the drain valve.

### BLEEDING FUEL LINES ON DIESEL ENGINES

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

Proceed as follows when bleeding:

1. Open bleed valve on top of filter.
2. Open fuel tank valve. This will force air through the bleed valve and replace the air space with fuel. If a transfer pump is located between the fuel tank and the filter you are bleeding, you will find a bypass line and valve. By opening the valve, fuel bypasses the pump so air can be bled out of the filter.
3. Close bleed valve.

### SERVICING FRONT WHEEL BEARINGS

The service intervals for front-wheel bearings as indicated in most tractor operator's manuals vary from 500 to 1200 hours of operation or yearly. With many farm tractors, the front wheel bearings should be cleaned and repacked twice a year.

To disassemble and clean the front-wheel bearing, proceed as follows:

1. Raise front wheels off the ground by a jack.
2. Clean dirt from wheel and hub cap and remove hub cap.
3. Remove cotter pin and adjusting nut.
4. Remove thrust washer and outer bearing.
5. Pull wheel off the spindle.
6. If the inner bearing remained in the hub, remove it.

7. Wash bearing and hub in a safe solvent. Shake the bearings dry or use compressed air, but do not allow bearings to spin, as there will be damage.
8. Examine bearings for wear. If there is evidence of much wear or corrosion, replace both parts of bearing.
9. Examine grease-retainer ring and seal. Replace if damaged.
10. Clean hub, hub cap and spindle with solvent.

#### PACKING AND ASSEMBLING THE FRONT-WHEEL BEARING

1. Pack each bearing with recommended grease.
  - a. Use wheel bearing grease or all-purpose grease.
  - b. Place grease in the palm of the hand and work the grease into the bearing until all spaces between the rollers are filled.
  - c. Wrap the bearing in clean paper until ready to install.
2. Replace inner bearing and grease-retainer seal if removed originally.
3. Position wheel on spindle and install outer bearing.
4. Install thrust washer and slotted adjusting nut.
5. Turn wheel and tighten slotted adjusting nut until wheel "drags," then loosen.
6. Lock nut with cotter pin (use new cotter pin).
7. Replace hub cap.

#### MAINTAINING THE COOLING SYSTEM

The condition of the cooling system of the engine has a remarkable bearing on the performance that is expected from the tractor. Running at too low or too high a temperature will affect the operation as well as cause need for repairs. Therefore, in order to service and maintain the tractor properly, manufacturers have determined the temperature at which engines operate most efficiently. The recommended maintenance intervals

of a tractor vary from 400 hours of operation to once a year. However, if water is used in warm weather and antifreeze in cold weather, it is desirable to flush the radiator twice yearly -- once in the spring when antifreeze is removed and again in the fall before antifreeze is added.

#### LIQUID COOLING

The principles of liquid cooling are primarily the same in all farm tractors. The coolant travels from the radiator into the engine block, through the head, and back into the radiator. In the engine, the unused heat from the combustion and friction is absorbed by the coolant from the cylinders, the combustion chambers, and the valve parts. The water or antifreeze solution is cooled as the air is drawn through the radiator core by the fan. Air from the fan which is blown over the engine, as well as the air circulating in the engine, also aid in cooling.

All water-cooled tractor engines have a radiator and fan. Circulation of the coolant is accomplished either by means of a pump or thermosiphon action. Pumps of the centrifugal type are in common use and operate in conjunction with a thermostat. The thermostat, a temperature controlled valve between the cylinder head and the radiator, controls the flow of the coolant and thus aids in maintaining the desired engine temperature. The thermosiphon uses neither pump or thermostat. Circulation is accomplished by heat from the engine. The coolant expands as it warms; thus it becomes lighter and travels upward and out of the engine into the radiator. It is replaced in the engine by the heavier cooled water or antifreeze solution from the bottom of the radiator. In order to maintain the desired engine operating temperature a curtain or shutter is used.

Some systems also use a close cooling system and operate under pressure. Other systems operate at atmospheric pressure. The principal

advantage of the pressure system is that it aids in preventing the loss of the coolant, either through evaporation or slopping. It permits engine operation at a slightly higher temperature. It also reduces danger of loss of antifreeze when of the alcohol type.

#### SELECTING AND USING COOLANTS

The common coolant for the liquid cooled engine is water. Clean, soft water is preferred. Hard water containing minerals such as lime soon deposits a layer of rocklike insulating material in the engine water jacket and radiator. This retards the transfer of heat; and may even partially clog the radiator core. Thus the engine will run hot.

\* Never put hot water in a cold engine or cold water in a hot engine. Never run your tractor without a coolant.

Allow a hot engine to idle and cool off somewhat before stopping. Never remove a radiator cap from an overheated engine. Give the liquid time to cool before removing the cap from a pressure type system.

#### FILLING THE RADIATOR WITH ANTIFREEZE SOLUTION

Fill the cooling system in accordance with the instructions in the operator's manual. The recommended permanent type of antifreeze agents in common use are those having an ethylene glycol base. Do not use an alcohol type antifreeze because it has low evaporation point. Never add antifreeze to the coolant without warming up the engine.

When filling the system with an antifreeze solution, proceed as follows:

1. Drain and flush the system with clean water.
2. Close all drain openings.
3. Mix the correct amounts of antifreeze and water in the desired proportion, and fill the cooling system; or pour the correct amount

of antifreeze into the radiator and then fill with water.

4. Warm up the engine to the operating temperature to allow for thorough mixing of antifreeze and water.
5. Stop the engine and, with the use of the hydrometer, determine the freezing point of the coolant.
6. Throughout the cold-weather season, periodic tests of the coolant are necessary to protect against freezing.
7. Flush off the system and clean with washing soda if necessary by the end of freezing weather. Then fill the cooling system with clean water and a fresh supply of rust inhibitor.
8. See operator's manual for correct use of rust inhibitor.

#### KEEPING THE RADIATOR IN GOOD OPERATING CONDITION

The radiator itself consists of two tanks between which is a core (the cooling element). In addition, the grill, screen, and shutter or curtain are considered a part of the radiator assembly. The most common type of core is the "fin and tube" type.

Several conditions can occur that will cause the radiator to function improperly and result in heating. Many of these difficulties are as a result of clogging of the screen with insects, chaff, dirt, or straw between the grill and screen or screen and core, foreign material collected on core, bent core plates, lime or sludge on the interior surfaces of the radiator, or leaks. Follow these procedures:

1. Remove the radiator cap and inspect the gasket.
2. Replace the gasket if necessary.
3. Remove the radiator grill and screen; clean out the dirt, chaff, and straw.

4. Blow out the exterior surface of the radiator core with compressed air, or wash with water. Straighten all bent fin plates. Be careful for any additional damage.
5. Inspect the curtain or shutter for an operable condition and proper adjustment. If damaged, replace with a new one.
6. Inspect radiator for leaks. If there are leaks take radiator to a well equipped repair shop.
7. Reinstall the screen and radiator grill.
8. With the radiator cap removed, drain the cooling system. Collect a little to inspect for dirt and sludge.
9. Clean the cooling system with a solution of washing soda and water.
10. Close all drains, and in accordance with the instructions in operator's manual, fill the cooling system with the cleaning solution.
11. Operate the engine until the water is hot, drain the cleaning solution from the system, and flush with clean water.
12. Refill the system with a coolant to the recommended radiator level.

#### CLEANING COOLING SYSTEM OF DEPOSITS

In most cases cooling system deposits can be removed by using a solution of washing soda or lye. About 3 lb. of ordinary washing soda to 7 gal. of clean, soft water is recommended. Place this solution in the radiator, and operate the engine with the filler cap off until the water becomes hot. Then drain and flush with clean water. It is necessary to use a stronger solution or special solutions that can dissolve heavier lime deposits.

What causes corrosion and deposits:

1. Mineral deposits - caused from using hard water.

2. Rust - which may be loose or in deposit form. This is the result of minerals in the water and rusting of iron parts caused by the presence of water and air.
3. Galvanic corrosion - where different metals in the cooling system react with each other through the coolant.



## CHAPTER VII

### MAINTENANCE AFTER A YEAR OF OPERATION

The yearly maintenance jobs are probably the most neglected of all. Some tractor owners never get around to doing them. Some do part or all of the jobs every few years.

#### CLEANING THE TRACTOR

From an owner's standpoint, the following are reasons that help justify regular cleaning of the tractor:

1. It reflects good management, adequate servicing and pride.
2. Helps protect paint and parts that are affected by tractor dirt.
3. Minimizes the chances for dirt to enter the air cleaner, oil cup, fuel filters, cylinder etc. during servicing.
4. Cleaning helps reveal leaks in the cooling system, cracks and loose parts in the tractor.
5. Safety is improved.

There are two ways of cleaning the tractor on the farm. You can use (1) a commercial solvent called a "de-greaser" or (2) kerosene or diesel fuel. If you are using a degreaser, check the instructions on the can. Some are flammable and are dangerous if used in a closed building or near a flame.

The procedure for using de-greasers, 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 accumulation of grease and grime.

4. Apply solvent on areas that need cleaning. Use spray gun for de-greaser and paint brush for kerosene or diesel fuel.
5. Let solvent set approximately 15 minutes.
6. Remove solvent from engine surfaces with strong stream of water for de-greaser and strong soap solution. Apply with paint brush and flush with water for kerosene or diesel fuel.
7. Check for areas that have been missed.
8. Replace hood and panels that were removed originally.
9. Idle engine for 10 or 15 minutes for quick drying.

#### SERVICING THE OIL BATH AIR CLEANER

Most tractor companies recommend that you clean the entire air-filter assembly once every 1000 hours or yearly. An Illinois study of 60 farm tractors, found that the air cleaner assembly on 35 of them had never been completely cleaned. Another study in Kansas of 50 tractors<sup>2</sup> showed that after servicing fuel consumption decreased from 4.6% to 22.5%. At the same time horsepower was increased from 1% to 27% of all 5 tractors that needed air-cleaning services.

The cleaning of the air-cleaner assembly should proceed as follows:

1. Remove oil cup and screen tray.
2. Inspect center tube and lower filter element.
3. Remove dirt from center tube. Use a lintless cloth soaked with diesel fuel or kerosene and push it through the center tube with a stick.
4. Clean dirt from lower filter. Wash the mesh in kerosene or diesel fuel.
5. Clean shell and upper metal-wool filter. Soak the entire assembly in kerosene or fuel oil, then flush with clean solvent to remove the loosened oil and dust.

6. Drain filter body and screen for few minutes.
7. Clean the screened air intake cap or pre-cleaner.
8. Check hose connections.
9. Reassemble filter parts.

#### SERVICING THE HYDRAULIC SYSTEM

Hydraulic controls are units designed to utilize engine power for the control of both the implements and tractor. Oil is the most common liquid used in hydraulic systems because it is a lubricant and therefore will lubricate the precision working parts and also protect them from rust.

In tractor hydraulic systems, hydraulic pumps are used to develop the required pressure. One pump is frequently used to supply the high pressure oil for a number of different controls. Pistons and cylinders are used to convert the hydraulic power into mechanical power. The many valves used are to control the oil flow.

With any hydraulic system the problem of contamination is the same as for the gear-drive mechanism -- that of field dust, rust particles, moisture from condensation and metal particles. Contaminants of this type will 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 may be any one of the following:

1. Hydraulic implement control only.
2. Hydraulic steering only.
3. The two above as two independent units.
4. Hydraulic implement and steering combined as one system; also hydraulic brakes.

## SERVICING THE HYDRAULIC IMPLEMENT-CONTROL SYSTEM

- \* Be sure to check your operator's manual for specific directions.
- 1. Position lower links to lower position.
- 2. Remove drain plug and drain oil.
- 3. Run engine briefly to remove oil from pump.
- 4. Remove filter cover and filter element or screen.
- 5. Clean filter housing and screen.
- 6. Install filter housing and screen.
- 7. Reinstall drain plug.
- 8. Flush the hydraulic system with hydraulic oil (see operator's manual).
- 9. Thoroughly clean area around filter plug or plate.
- 10. Remove filter plug or plate and add the proper type of hydraulic oil.
- 11. Start engine and operate lift through several cycles.
- 12. Recheck oil level and add oil as necessary.
- 13. Replace filter plug or plate.
- 14. Clean hydraulic breather.

## SERVICING THE HYDRAULIC STEERING SYSTEM

If your steering system is supplied with oil from the same pump that supplies the implement control, then you have serviced it. But if it is independent of implement control, proceed as follows:

- 1. Remove drain plug and drain system.
- 2. Start engine and turn steering 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 with new.
- 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 refill if necessary.

#### ADJUSTING THE ENGINE GOVERNOR

A governor is a device that automatically regulates the speed of an engine. In general, governors for internal-combustion engines are of the centrifugal spring-loaded type, some having horizontal and some vertical axes of rotation.

As the governor rotates, centrifugal force tends to move the weight outward; an increase in speed results in an increase in centrifugal force. The thrust-bearing fork, governor shaft, and operating lever restrain the weights from moving outward.

Governor linkages provide a means of changing the tension on a governor spring when the hand throttle is moved. When the throttle is moved to increase speed, the governor control rod and lever move to increase the governor spring tension. The increased tension on the governor spring moves the throttle rod to "open" the throttle. The open throttle causes the engine speed to increase until the centrifugal force can balance the governor spring tension. If the operator moves the hand throttle to reduce speed, the governor spring tension is reduced. The governor weights then force the throttle closed. Engine speed will be reduced until the force on the weights again equals the spring tension.

When the governor cannot maintain the speed, the engine speeds up

and then slows down, a condition known as hunting. When this happens, have the governor repaired by the dealer serviceman.

#### PREPARING THE TRACTOR FOR STORAGE

Studies have indicated that proper housing frequently doubles the life of farm equipment and thus materially reduces the annual cost of depreciation. Since the tractor is the power center on farms, it is good farm management to provide weather-proof storage during both the idle and work seasons.

If your tractor will not be used for as long as three or four months or longer, it pays to prepare it for storage. When storing follow these procedures:

1. Check your operator's manual for instructions on your particular tractor after which you should --
2. Clean exterior of tractor.
3. Clean air cleaner and refill oil cup.
4. Operate tractor until the engine is thoroughly heated.
5. Service oil filter.
6. Drain crankcase and refill.
7. Start engine and run for several minutes to lubricate engine parts.
8. Drain and refill transmission.
9. Clean and repack front-wheel bearings.
10. Service the hydraulic systems.
11. Drive tractor to storage location.
12. Drain and flush the cooling system. If you are storing your tractor without coolant, be sure to drain the radiator and engine block completely, leave drain valves open and replace radiator cap loosely. Tag a Warning label against operating tractor.

13. Drain fuel tank, fuel line and carburetor.
14. Remove, clean and replace sediment bowl.
15. Clean and regap spark plugs.
16. Pour about two tablespoons of rust-preventive oil into each cylinder.  
Turn engine several times to distribute oil on the cylinder surfaces.
17. Plug ends of exhaust pipe and breather pipe.
18. Remove and store battery in cool place.
19. Jack up tractor and place wood blocks under the axles to remove weight from tires.
20. Position clutch in disengaged position.
21. Cover tractor with tarpaulin if it is not being stored in a building.
22. Order any parts that may need to be installed when the tractor is taken from storage.

#### REMOVING TRACTOR FROM STORAGE

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

## CHAPTER VIII

### MAKING ADJUSTMENTS TO MEET OPERATING NEEDS AND OPERATING THE TRACTOR

#### CHECKING AND ADJUSTING SEAT POSITION

Seat adjustment which provides for the most comfort and relaxation can also provide freedom from weariness. Seat position should be checked, and adjusted if necessary. It should be adjusted to the position that permits you to reach all of the controls from a comfortable sitting position.

Most tractors have seats that can be raised or lowered, as well as adjusted to the weight of the operator. If, after the seat is adjusted, and you can't reach the controls easily from a comfortable sitting position, leave the tractor alone and do not attempt to drive it.

#### CHANGING WHEEL SPACING

On most farms it is necessary to change the rear wheel spacing to meet the various farming operations. For plowing, the wheels should be spaced so that the right rear wheel runs in the furrow and not on the plowed ground. The other wheel must be spaced the same distance from the center of the tractor for evenness. For cultivation, the wheels will need re-spacing to keep them in center of the rows. For mounted equipment, change space to allow flexibility of moving equipment. On hills, wide wheel spacing helps avoid overturning.

Whatever method of spacing wheels used, both front and rear varies with the different makes and models of tractors. Front-wheel spacing adjustment is possible on some makes of tractors. If the tractor is equipped with an adjustable front axle or other methods, it is possible



to set the wheels treads to track with respective rear-wheel tread positions.

For front wheels proceed as follows:

1. Raise the front end of the tractor.
2. Loosen the bolts holding the axle-extension clamps.
3. Pull out the cotter pins, and remove the axle-extension clamp pins.
4. Remove the bolts from the tie-rod clamps.
5. Pull the axle extensions out an equal distance on both sides to the desired tread position, and move the tie rods to correspond.
6. Replace axle-extension clamp pins in the holes selected, and tighten the clamps. Also, replace and tighten bolts in tie-rod clamps.

Front wheels should have  $1/8$  to  $1/4$  inch toe-in ( $1/8$  inch closer in front than rear), measurement being taken from the inside of the front wheels at axle height.

To adjust the toe-in, disconnect the steering-knuckle arms, loosen the lock nuts, and turn the tie-rod ends in or out as required. Be sure to make each arm adjustment equal.

The spacing of the rear-wheel treads on one make of tractor can be accomplished by reversing the rear wheel discs and by attaching the rims to the discs in different positions. Other tractors permit adjustment of wheel-tread width by moving the wheels on a splined axle to the width desired. Consult the operator's manual for more information.

#### ADDING WEIGHT FOR TRACTION AND BALANCE

Power can be lost in the field and tire life cut drastically by wheel slippage. Such slippage wastes fuel.

For heavy pulling, extra weight is needed. It is not required for road operation and light work, such as planting, harrowing or cultivating

or when heavy equipment is mounted on the tractor. The drawbar pull on a tractor can be increased and slippage reduced by the addition of weight to the driving wheels, by attaching cast-iron or other kinds of solid weights to the wheels. The use of liquid in the tires is the most common practice and may be the most economical if the added weight is always needed for all the work performed. The amount of increase in drawbar pull and of reduction in slippage by the addition of certain weights varies with the type of soil. See operator's manual of your tractor for weight recommendation.

To increase steerability, front-wheel weights are recommended for use as a front-end counterbalance whenever heavy loads are superimposed on the drawbar or heavy equipment is to be mounted on the rear end of the tractor.

\* Caution: Water will freeze. To avoid this danger use a calcium chloride solution.

#### STARTING THE TRACTOR

Learning the proper way to start and stop a tractor is an important first step toward becoming a safe, skilled tractor operator. The best place to start is by reading your operator's manual.

#### STARTING PROCEDURE

Not all tractors use the same starting procedure. Here are some rules that should be included in the procedure for starting any tractor safely:

1. Make a daily maintenance and safety check.
2. Take your position in the operator's seat. Adjust the seat so you can reach and operate all the controls.
3. Place the gearshift in neutral or park.

4. Make sure the power-take-off and hydraulic lift levers are in the neutral position.
5. Look out for the safety of others by checking to see that all persons are out of the way.
6. Put your foot on the clutch. This reduces the load on the starter and is good precaution in case tractor is in gear.
7. Turn on the switch and start the tractor.
8. After the engine starts, let it run at half throttle for a few seconds to let the oil pressure stabilize. Avoid pulling heavy loads for the first few minutes of operation.

#### IF THE ENGINE DOESN'T START

If the engine, whatever its type, fails to start on the first try, wait until the engine stops rotating before trying again. If the starter is engaged while the engine is turning, there is a chance of causing damage to the starter or to the ring gear on the engine. In trying to start any tractor, don't engage the starter for periods longer than 15 seconds, to prevent the battery from overheating and running down. Don't keep grinding on the starter because failure to start may be due to something seriously wrong with the tractor.

When the engine fails to start, you have to become a "trouble shooter." Perhaps you forgot to turn on the fuel. Or there might be a loose or broken ignition wire. Then too, the engine may be flooded by excessive choking. If you cannot find the fault right away, have a qualified mechanic check for you.

#### CONTROLLING TRACTOR MOVEMENT

"More than 85 percent of all tractor accidents involve members of the farm family. Of course, in many situations members of the family do

most of the tractor work. However, few tractor operators, family or otherwise, have had training for the job of tractor operation."

One of the most important factors in tractor safety is to be very sure that each person who operates a tractor or any vehicle is trained, physically fit, and qualified to do the job.

The new tractor operator should first practice, without equipment attached, in a level field. A skilled operator should be the trainer. The trainer is supposed to start and demonstrate the operation to the student and show him how each element operates. Then the new operator can take the seat, while the trainer stands on the drawbar to give assistance if needed. After the new operator has learned to operate the tractor alone in a level area, his next step is to attach and operate the equipment, then, gradually work into the more difficult jobs of tractor operation.

The tractor is normally divided into three working parts which are very much interrelated: viz, engine, transmission and the final drive.

Engine: crankshaft and flywheel

Transmission: drive shaft, clutch and gear shafts

Final Drive: differential ring gears and bull gears.

The low speed transmission unit on a farm tractor must transmit full engine power continuously, as the tractor moves itself across soft fields or in a cloud of dust, pulling a plow, a disc, a lister or other piece of farm equipment. With the tremendous loads the tractor transmission and final drive units carry and the types of service imposed upon them gives the reason why they are made so sturdy (built with heavy-duty steel with gears rigidly assembled on steel shafts that turn in large ball, or roller, bearings). The final drive assembly is the final unit

in the driving mechanism. It is an arrangement of gears which permits the final-drive-shaft axle to each wheel to revolve simultaneously and at different rates of speed when necessary, as in making turns.

There are two types of transmission -- manual or hand shift and power transmission. With the hand shift, gears are disengaged or engaged manually to get the desired speed either forward or reverse movement. It has selected gears of 1, 2, 3, R-reverse. Depressing the clutch and with the help of the gear lever shifting to 1st gear then to 3rd gear will give speed from high to smooth running.

The power-assists transmission is a newer type of transmission consisting of an assembly of planetary gear units. These gears move automatically giving forward speeds and when a reverse movement is needed, the lever is shifted from drive position to reverse position.

\* Always engage gears smoothly to stop any damage on the gear teeth.

#### OPERATING A MOVING TRACTOR

Many tractors are manually steered, but on some models power steering is equipped. Tractors with hydraulic mechanisms lessen the amount of pull needed on the steering wheel to turn the wheels.

Applying individual wheel brakes will also help tractor steering, especially when making short turns. By pressing on the brake, the wheel movement is reduced and turning the steering wheel either side, will turn the tractor. However, it is necessary when slowing the movement of the tractor to depress the clutch pedal, then shift the gears from three to one.

\* Never match your clutch pedals, it causes the plates to wear.

#### OPERATING THE TRACTOR ON SLOPES AND HILLSIDES

Keep wheels spread as wide as possible for the job -- even when on

level ground. A tractor will overturn sideways much more easily if the wheels are close together. Watch for rocks, humps, or holes which may cause the tractor to tip. Make uphill turns with caution. Turn downhill if stability becomes uncertain. Backward upsets are apt to happen when climbing hills, going forward out of a ditch, or overloading the drawbar. If you have to go up a steep slope, back the tractor up the slope. Use lower gears when going downhill.

#### STOPPING A TRACTOR

Just as it is important to know how to start an engine and operate a tractor, there are some rules that must be followed when stopping a tractor. The following procedures are suggested:

1. Reduce engine speed with the throttle and let the engine idle for a few minutes. This cools the engine down and helps prevent warped valves and damaged turbochargers. It also helps keep the engine from backfiring.
2. Shut off the engine by turning the key to the off position. On diesel tractors pull the shut-off valve.
3. When the engine is completely stopped, put the gearshift lever in park or low gear. This can prevent rolling if tractor is parked on a slope.
4. Set the brakes. This will help to make sure the tractor will not accidentally roll downhill.

## CHAPTER IX

## HITCHING TO TRACTOR-OPERATED EQUIPMENT

Have you ever thought about the many different ways in which a tractor can be used? Some tools, such as a drag harrow, are merely hitched to the drawbar and other implements, such as a forage chopper may be driven by the PTO (power-take-off) shaft from the tractor. Since there are various designs and sizes of tractors which makes the job of hitching confusing, it is important to know how to connect implements correctly, and how to operate the equipment safely.

## ATTACHING EQUIPMENT TO THE DRAWBAR

When you hitch your tractor to an implement, it is important always to use the drawbar. Never try to pull a load from the axle or seat, or from one of the links of a three-point hitch. When you do, there is danger of upsetting your tractor or damaging it mechanically. There are two types of tractor drawbars in use:

1. Regular drawbar
2. Supplemental drawbar fitted to a three-point hitch.

Check the height of the hitch on your tractor. The distance should be from 13 to 17 inches as measured between ground level and the hitch point on the drawbar. Adjusting your drawbar to this height not only provides safe hitching but is also standard height for use of the PTO shaft. Changing height is usually accomplished by: (a) turning the drawbar over, (b) adjusting the drawbar bracket or (c) adjusting the drawbar frame assembly where it bolts to the tractor frame. See your operator's manual for more information.

Check drawbar length setting. Most tractors provide for a close hitch for all jobs except those requiring connection to a PTO shaft.

Check lateral or sideways position of drawbar for disking, harrowing, and pulling most heavy loads; let the drawbar swing freely.

Back your tractor into position so that hole in drawbar is in line with hole in hitch of implement.

Set and lock tractor brakes if on sloping ground.

Attach implement to drawbar.

#### HITCHING REAR-MOUNTED EQUIPMENT

Most modern tractors are equipped with hydraulic controls for raising, lowering, and adjusting rear-mounted equipment.

Three-point hitches are standardized so that implements and tractors of different makes and models can be used interchangeably. There are three categories of implements designed for the standard three-point hitch. These are:

Category	Maximum Drawbar Horsepower
I	up to 45
II	40 to 100
III	80 and over

The hitching procedures that follow are basic for all tractors:

1. Check drawbar position to make certain it will not interfere with movement of the hitch.
2. Back tractor so lower links are in position for connecting to implement hitch pins.
3. Raise or lower hitch with hydraulic control to height needed to connect to implement hitch pins.



4. Attach left lower link to left hitch pin of implement and insert linch pin.
5. Attach right lower links to implement hitch pin and insert linch pin.
6. Attach upper link to implement mast.

#### CONNECTING THE POWER TAKE-OFF (PTO)

When hitching to the PTO shaft use the extended hitch. There are two standard speeds for the PTO shaft on newer tractors. One is 540 rpm, the other is 1,000 rpm. If you use a PTO speed of 540 rpm the hitch point must be 14 inches from the end of the PTO shaft. If you use a PTO speed of 1,000 rpm, the distance from the hitch point to the end of the PTO shaft must be 16 inches. However, when hitching to the PTO shaft follow these procedures:

1. Set wheel brakes.
2. Disengage power to PTO shaft.
3. Shut off engine.
4. Remove safety cap or tube from end of PTO shaft.
5. Check PTO shaft to determine shaft speed. If there are six splines, it is for 540 rpm, but if 21 splines, it is for 1,000 rpm implements.
6. Check splined coupling on machine to be connected to PTO. If coupling has the same number of splines as on PTO shaft proceed with step 7. If they are different proceed as follows:
  - a. Determine if your tractor has one or two PTO speeds.
  - b. If two speeds available, exchange stub shafts, or expose 540 rpm shaft, if permanently installed.
7. Check inside spline of universal joint for dirt.
8. Clean and oil outside spline of tractor power shaft.
9. Check telescoping shaft.

10. Slide U-joint into position on PTO shaft and fasten securely. If U-joint is too large use an adapter.
11. Check connection by pulling firmly on power shaft assembly.
12. Check alignment of PTO shaft assembly and make sure hitch point is centered between two universal joints.
13. Attach safety shield over PTO shaft.
14. Engage power take-off (PTO).
15. Operate PTO shaft at slow speed to check shaft connection.
16. Check telescoping shaft(s) with tractor and implement in normal angle for turning corners.

#### CONNECTING TO REMOTE HYDRAULIC CYLINDER

The remote cylinder is one that can normally be removed from one implement and mounted on another. It is controlled separately by a second lever on the regular hydraulic control quadrant on the tractor. It is especially well fitted for controlling trailing implements but can be used on tractor-mounted equipment in addition to the regular hydraulic hitch control.

There are two types of remote cylinders -- the single-acting type and the double-acting type. Single-acting cylinders are connected to the hydraulic system by only one hose and can exert force in only one direction. They are usually used on equipment where a simple raising and lowering action is needed. Double-acting cylinders have two hoses and can exert force on an implement in both directions. This is commonly used on equipment where position adjustment is needed on a machine. These cylinders are standardized so that they can be used on various combinations of tractors and equipment.

For connecting a remote cylinder, the following procedures are used:

1. Mount remote cylinder on implement if not already mounted permanently on implement.
2. Examine cylinder to determine if it is single-acting or double-acting type.
3. Determine if the tractor hydraulic system supplies one-way or two-way pressure or both.
4. Remove dust plugs from couplings.
5. Relieve pressure in tractor hose lines.
6. Clean hydraulic connections and attach couplings.
7. Adjust hydraulic-hose support so coupling ends will not touch ground when disconnected.
8. Operate hydraulic cylinder and check for proper operation. If implement moves in wrong direction, exchange hose connections on a two-way hydraulic system. If the cylinder doesn't move smoothly, you may have air trapped in the oil line. If so, remove cylinder and hose connections. Move the control lever back and forth several times until all air is removed.
9. Check hydraulic-system oil level.

## CHAPTER X

## OPERATING A TRACTOR UNDER FIELD CONDITIONS

Farming is classified as a dangerous occupation. In fact, it is estimated that farming has a higher accident rate per man hour than any occupation in industry. This may seem strange when, by comparison, some machines used in the factories are more dangerous than farm machines. It is the conditions under which they are used that makes the difference. However, most farm machinery accidents are as a result of carelessness, which includes all human factors. It is therefore, very important, that the operator of farm machines develop good judgement on both safe and efficient tractor operation.

## MAKING ADJUSTMENTS BEFORE STARTING FIELD WORK

## CHECKING THE POWER TAKE-OFF

When the power take-off is not to be used:

1. Disconnect power to power take-off shaft.
2. Be sure the guard is in place over end of power take-off shaft.
3. If PTO will be used, determine if the PTO is set for the speed you wish (see operator's manual).
4. Recheck to make sure shields are in place over power take-off shafting.
5. Engage power-shaft shifter lever.
6. Check operation of power shaft and equipment at approximately half speed.

## CHECKING THE HYDRAULIC SYSTEM

Most modern tractors do not have provision for disconnecting the pump. Hydraulic power is needed continuously for implement control and to supply power brakes, steering, hydraulic motors, etc. In fact,

hydraulic horsepower, available on present tractors, ranges from 2-6 to as high as 28!

There is provision in most hydraulic systems to automatically relieve the pumps when hydraulic demands are low. This helps provide efficient operation for the system.

If you have an old tractor and will not be using the hydraulic system, disengage the pump, but if you will be using it, proceed as follows:

1. Move hydraulic control lever through "raise" and "lower" positions to make certain system is operating satisfactorily. There are limit control and proportioning control actions on most hydraulic controls.
  - a. With the limit control, movement of the lever in either direction from neutral, will cause the implement to continue raising or lowering until the lever is returned to neutral. The implement remains fixed in that position until the control lever is moved again.
  - b. With the proportioning control, movement of the control lever in either direction will cause the implement to be raised or lowered in proportion to the distance you move the lever on the quadrant.
2. Set supplemental hydraulic controls as necessary. If your tractor is connected to a trailing implement equipped with a remote cylinder, set stop on piston for the 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.

If your tractor is connected to mounted equipment, it may have a similar cylinder and adjustable-stop arrangement as used on the remote cylinder. However, for direct manual control of the hydraulic unit

there may be a stop located on the quadrant.

Some tractors are equipped with automatic draft control. 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 plows and disc harrows. The draft control lever may be mounted on the gear case or on the quadrant assembly along with the hydraulic control lever (see operator's manual).

3. Check rate of lowering and raising of implement or hitch. A flow control valve, called "response control" governs the speed with which an implement is lowered for ground engagement. For plowing or cultivating a fast drop is desirable, while a slow gentle drop is best for a planter.
4. Check implement hitch (whether for transporting or for field work).

#### MATCHING GEAR SELECTION AND ENGINE SPEED WITH LOAD

Most tractor manufacturers give suggested speeds for various farm jobs in the operator's manual.

If there are four speeds forward on your tractor your selection can be 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.

These are good and general recommendations, but the conditions under which you operate a tractor vary widely, so select gears to give speed that will give you satisfactory engine efficiency.

You can get greatest efficiency from a carburetor engine on a heavy load when the speed control lever is completely open. On a diesel engine,

it too, operates with the most efficiency when fully loaded with the speed-control lever completely open. For light load operation, both carburetor and diesel engines will give the greatest efficiency by using the highest gear at which the tractor will still have the necessary pull.

#### CHECKING AND CORRECTING TIRE SLIPPAGE

Some tire slippage is to be expected with rubber tires, but, generally the slippage should not exceed 15 percent during normal field operations. You should either add weight to the rear wheels to provide more traction or reduce the tractor load.

Avoiding slippage is important because it (1) causes rapid tire wear, (2) wastes fuel, and (3) wastes valuable time.

When checking for tire slippage, follow these procedures:

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 (be sure chalk mark is directly under axle when you stop).
5. Measure distance to point of stop at chalk mark "A".
6. Hitch tractor to load and repeat steps 1 through 3.
7. Measure distance to point "B".

Figure percent of slip as follows:

$$\frac{(\text{Distance A}) - (\text{Distance B})}{\text{Distance H}} \times 100 = \% \text{ slip}$$

You can reduce slippage by any one of the following three methods:

1. If plowing, add more weight to the land wheel.
2. Engage the differential lock.
3. Apply braking action on the spinning wheel to slow it down.

## PULLING OUT OF MUD, HOLE OR DITCH

Only few tractor operators realize the possibilities of a tractor turning over backwards when the rear wheels become completely mired in a mud hole or lodged in a ditch. When mired down in mud, disconnect the drawn equipment and try to get something under the front of the rear wheels -- something to provide enough traction so the tractor will pull ahead with its own power.

To avoid accidents under this condition proceed as follows:

1. Try backing out.
2. If step 1 doesn't work, try digging out in front of the rear wheels, shift into first gear, use moderate engine speed, and let the clutch engage slowly.
3. If the second step doesn't work, get another tractor to pull yours out.



## CHAPTER XI

## TRACTOR SAFETY ON THE HIGHWAY AND REFUELING

About one-half of all fatal tractor accidents occur on highways, county(village) road and other roadways. Collisions with other motor vehicles are an important cause of death. Inexperienced operators, unsafe operation, not watching the road, and excessive speed are common causes of tractor accidents on roadways.

A two-year study of 708 highway accidents involving slow-moving vehicles<sup>14</sup> was conducted in Ohio State University. The result was frightening:

- 96 percent were collisions involving a motor vehicle and a slow-moving vehicle.
- 90 percent occurred during daylight hours on dry highways.
- 50 percent happened on open level highways, nearly 40 percent at intersections, the rest on hills, grades and curves.
- 75 percent of the accidents involved farm tractors.

## TRACTORS ARE NOT BUILT FOR HIGHWAYS

Tractors are not designed for use on highways and public roads. The road speed of a tractor is much slower than that of an automobile or truck. It will take an automobile 7 seconds to travel 410 feet to overtake a tractor travelling at 15 mph.

Tractors also have a high center of gravity which makes them easier to overturn, if turned sharply while travelling at excessive speeds.

The quick acting power steering on tractors requires the full attention of the driver while he is travelling at higher speed. The tractor is designed for rapid maneuverability at low speed, not high speed.

Tractors are not made to carry passengers. For this reason, carrying passengers on the tractor is a dangerous practice.

Tractors are being used to pull larger and larger loads on highways. Heavy loads hitched to a tractor travelling at road gear speeds easily creates steering and braking problems. Especially when the tractor is travelling downhill with the load. Remember, a tractor has only two brakes; one for each rear wheel.

#### STATE LAWS RELATING TO FARM EQUIPMENT

There are certain laws in your state that apply to the operation of farm equipment on public roads. These laws cover the operation, lighting, and identification of farm equipment on public roads.

#### SAFE DAYTIME DRIVING ON HIGHWAYS

It is important that you avoid the use of busy highways. If you have to use a two-lane highway, drive on the shoulder if possible and go slowly enough to see obstructions or holes that could cause an upset. When it is necessary to use the highway surface, avoid the dangerous practice of driving with one wheel on the pavement and the other on the shoulder. This practice encourages faster moving vehicles to try to pass when there isn't enough room. Therefore, it is better to occupy one full lane of the road.

Hilly, winding roads are hazardous because the driver of an oncoming vehicle cannot see you and you cannot see him. As a result there may be a collision or someone might have to take to the ditch. The best way to avoid highway accidents is to stay off the road as much as possible. If you must use the highway, use it when traffic is the lightest and make your equipment as easy to identify as possible.

The slow-moving vehicle identification emblem is most recognized. It should be placed on the rear of any tractor, or tractor with towed equipment. The SMV emblem consists of a fluorescent yellow-orange triangle with a dark, red reflective border. The yellow-orange triangle is for daylight and the red border is for night identification.

#### SAFE DRIVING AT NIGHT

For night use or for limited vision conditions, if it becomes very necessary that you travel, there are safety light suggestions as follows:

1. Two head lamps.
2. At least one tail lamp (red).
3. At least one flashing warning lamp mounted high and to the left of your tractor.
4. A second flashing lamp on a towed or mounted implement.

"Tractors should have one or two white lights visible 500 feet forward, and a red light visible 500 feet to the rear" --

Uniform Vehicle Code.<sup>16</sup>

#### PRACTICE COURTESY

Safety on the highway begins with courtesy. When traffic piles up behind you, pull off the road at the first opportunity and let it pass. Remember, it is a privilege for you to operate your tractor and equipment on a highway. Don't abuse this privilege. Practice courtesy. Know and obey the rules of the road as they apply to tractors and other slow-moving vehicles.

#### REFUELING A FARM TRACTOR

Safety needs to be practiced at all times and not just in connection with certain jobs and tasks to be performed. Many accidents are the result of momentary lack of attention, which emphasizes the need for

always being alert in both operating the machine and performing the work. Haste and lack of skill frequently produce accidents; therefore, take the time necessary to do each job safely.

Proper refueling of your tractor is more than just filling the tank with fuel. The time and method of refueling are important because of their influence on:

1. Keeping out moisture.
2. Keeping out dirt.
3. Avoiding fire hazards.

Most operator's manuals suggest that you fill the fuel tank at the end of the day or whenever you finish using the tractor. The reason is to keep out moisture from accumulating in the tank.

Diesel fuel and water mix rather readily and the water is slow to settle out. If water gets to the injector pump, it causes galling and sticking of the finely-machined pump parts which is expensive to repair.

Dirt is an equally bad actor in a carburetor. It often closes or partly closes the small openings that provide for proportional air-fuel mixture.

Fire hazards exist when handling any kind of fuel. But with gasoline and LP gas it is greater. So, allow engine to cool before refueling.

#### REFUELING WITH LIQUID FUELS (gasoline, kerosene, or fuel oil)

1. Check against fire hazards by shutting off engine and turn off all electrical switches.
2. Check mouth of container or hose nozzle for dirt. Remove any dirt with 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 for fuel to expand if heated.
5. Replace fuel tank cap tightly.

## SUMMARY OF THESIS

The modern farm tractor is the result of many years of development. Its present efficiency is possible because of engineering progress in design, metallurgy, fuels, lubricants, and manufacturing methods.

The engine may be two, four or six stroke cycle; single or multiple cylinders; manifold or solid fuel injection and a gasoline or diesel burner. All the internal combustion engines have many things in common. But, distinctively, they all require constant, systematic<sup>and</sup> intelligent care and maintenance to insure their highest efficiency, freedom from trouble and long life. Maintaining peak efficiency is a matter of following well-defined maintenance practices. The operator's manual is the guiding light for care of the tractor.

The farm tractor is a hard-working piece of precision machinery. It is capable of working long hours at capacity loads in the heat and dust of tropical climates or in the cold and snow of temperate climates. Finest and most appropriate materials have gone into its construction as a result of research work. To insure satisfactory operation over long periods of time, fine adjustments are made by the manufacturers, and are required of by the owners or operators.

As mechanized agriculture is increasing in Nigeria because of the Government's effort and farmers' interest and need for quick tillage and other farming activities; to bring more land under cultivation for the success of the "Green Revolution," it is very necessary that the farmers know the proper care, maintenance and operation of the machine they use on their farms.

As in any developing country, the cost of a farm tractor is very

high and the repair cost is also high. To avoid breakdowns and to save time and money, it is necessary that farmers know how to do all maintenance jobs properly when it is required.

Servicing the tractor on a regular basis is a matter of:

1. Keeping an accurate record of the tractor's operating time and,
2. Seeing that the service jobs are done on schedule.

All the instructions about care and maintenance of tractors are given in the operator's manual of each make, but information has been summarized in this study to help any farmer understand the effective use of his manual.

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## APPENDIX

Please indicate in the right column the importance of each maintenance operation for the maintenance of a farm tractor.

	Ess.	Very Imp.	Imp.	Not Imp.
1. Servicing the air cleaner assembly				
2. Checking the crankcase oil level				
3. Checking the cooling system				
4. Doing the 10-hour grease job				
5. Removing water and sediments from diesel fuel				
6. Safety checking of clothing				
7. Maintaining the battery				
8. Checking and adjusting V-belt tension				
9. Lubricating the clutch release mechanism				
10. Maintaining the hydraulic system oil level				
11. Changing crankcase oil				
12. Replacing the oil filter				
13. Servicing the crankcase breather				
14. Maintaining tractor tires				
15. Making valve clearance adjustment				
16. Maintaining spark plugs				
17. Cleaning the battery				
18. Cleaning the sediment bowl and fuel filter				
19. Adjusting the carburetor				
20. Adjusting the tractor brakes				
21. Adjusting the engine clutch				
22. Servicing the distributor				

Please indicate in the right column the importance of each maintenance operation for the maintenance of a farm tractor.

	Ess.	Very Imp.	Imp.	Not Imp.
23. Timing the ignition				
24. Adjusting breaker points				
25. Maintaining the starter and generator				
26. Servicing diesel engine fuel filters				
27. Servicing the front wheel bearings				
28. Cleaning the tractor				
29. Servicing the drive mechanism				
30. Servicing the cooling system				
31. Servicing the hydraulic system				
32. Adjusting the engine governor				
33. Preparing the tractor for storage				
34. Checking and adjusting seat position				
35. Changing rear-wheel spacing				
36. Adjusting front-wheel spacing				
37. Adding weight for traction and balance				
38. Starting the tractor engine				
39. Starting tractor movement				
40. Operating a moving tractor				
41. Stopping tractor movement				
42. Making adjustment before starting field work				
43. Matching gear selection and engine speed				
44. Checking and correcting tire slippage				

Please indicate in the right column the importance of each maintenance operation for the maintenance of a farm tractor.

	Ess.	Very Imp.	Imp.	Not Imp.
45. Pulling out of mud or ditch				
46. Changing fuel filters				
47. Operating on slopes and hills				
48. Hitching to tractor-operated equipment				
49. Providing safety warning devices				
50. Using right-of-way				
51. Refueling the tractor				

Importance scale:

Essential, six points  
 Very important, four points  
 Important, two points  
 Not important, no points

Please circle only one letter from (a) to (e) in answering the following questions.

1. How would you characterize the effort of the government in making tractors available to the farmers?
  - (a) Superior
  - (b) Excellent
  - (c) Very good
  - (d) Good
  - (e) Average
2. How efficient is the Tractor Hiring Unit System?
  - (a) Superior
  - (b) Excellent
  - (c) Very good
  - (d) Good
  - (e) Average
3. What level of interest have the farmers in using tractors to mechanize their farms?
  - (a) Superior
  - (b) Excellent
  - (c) Very good
  - (d) Good
  - (e) Average
4. How would you rate the present qualification of the farm tractor mechanics?
  - (a) Superior
  - (b) Excellent
  - (c) Very good
  - (d) Good
  - (e) Average
5. How would you characterize the maintenance and operation of farm tractors in Nigeria?
  - (a) Superior
  - (b) Excellent
  - (c) Very good
  - (d) Good
  - (e) Average

Please circle only one letter from (a) to (e) in answering the following questions.

6. How would you rate the Mechanical Section in the Ministry of Agriculture administratively?
  - (a) Superior
  - (b) Excellent
  - (c) Very good
  - (d) Good
  - (e) Average
7. How would you characterize the technical background of the extension worker in Nigeria?
  - (a) Superior
  - (b) Excellent
  - (c) Very good
  - (d) Good
  - (e) Average
8. How would you rate the publicity given to new agricultural technology in Nigeria?
  - (a) Superior
  - (b) Excellent
  - (c) Very good
  - (d) Good
  - (e) Average



A TRACTOR MAINTENANCE AND OPERATION PROGRAM  
FOR SCHOOLS OF AGRICULTURE IN NIGERIA

by

ANDREW D. KESWET

B. S., Kansas State University, 1979

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AN ABSTRACT OF A MASTER'S THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Agricultural Education

KANSAS STATE UNIVERSITY  
Manhattan, Kansas

1982

Innovations in agriculture require borrowing technology from industrialized nations with careful selection of technology which will be most appropriate to local conditions, including the adaptation of mechanical equipment for farming. To make adequate use of technology, for the farm tractor, farmers must be trained to use that machinery. Good maintenance and operation of the farm tractor has a direct effect upon its power output, fuel efficiency, and long service life.

The objectives of this study were:

1. To determine the importance of competency areas of tractor maintenance and operation which could be included in a farm mechanics curriculum course for the schools of agriculture.
2. To assess the government's encouragement to use tractors for mechanization.
3. To serve as a guide for the development of a curriculum in preparing farm mechanics courses which should include competencies essential for all areas of activities in tractor maintenance and operation.

To this effect, the author developed a questionnaire on the competency areas for the farm tractor. The questionnaires were sent to Nigerian students studying agriculture at Fort Hays State University and Kansas State University. These students have worked with the Ministry of Agriculture and Natural Resources in their various states for ten or more years. A total of thirty questionnaires were sent and twenty-five were returned, for an 83% return. Each of the respondents indicated the importance of fifty-one competency areas for Tractor Maintenance and Operation.

The results were computed and then an average importance for each competency area was determined as follows:

Essential -----	6 points
Very important -----	4 points
Important -----	2 points
Not important -----	0 points

Eight questions were included to assess government encouragement to use tractors for mechanization. The results of the second part of the questionnaire determined the average performance for each question as follows:

Superior -----	5 points
Excellent -----	4 points
Very good -----	3 points
Good -----	2 points
Average -----	1 point

The results for the importance of each competency area served as the basis for the material developed in this study. Each of the fifty-one competency items received an average importance rating of two or more points and was included in the Tractor Maintenance and Operation curriculum.

The Farm Tractor Maintenance and Operation curriculum in this study has been categorized according to the service and maintenance jobs recommended by most tractor manufacturers as follows:

- Maintenance after 10 hours or daily service jobs
- Maintenance after 50 hours of operation
- Maintenance after 100 hours of operation
- Maintenance after 250 hours of operation

Maintenance after 500 hours of operation

Maintenance after a year of operation

Making adjustments to meet operating needs

Operating farm tractor under field conditions

Hitching to tractor operated equipment

Refueling and safe tractor operation.

The author concluded that the curriculum should be used in the schools of agriculture in Nigeria. Recommendations also called for setting up courses and schools in Tractor Maintenance and Operation for farmers in Nigeria.