Tractor Power for Power Take Off Driven Pumps
Michigan State University Extension Service
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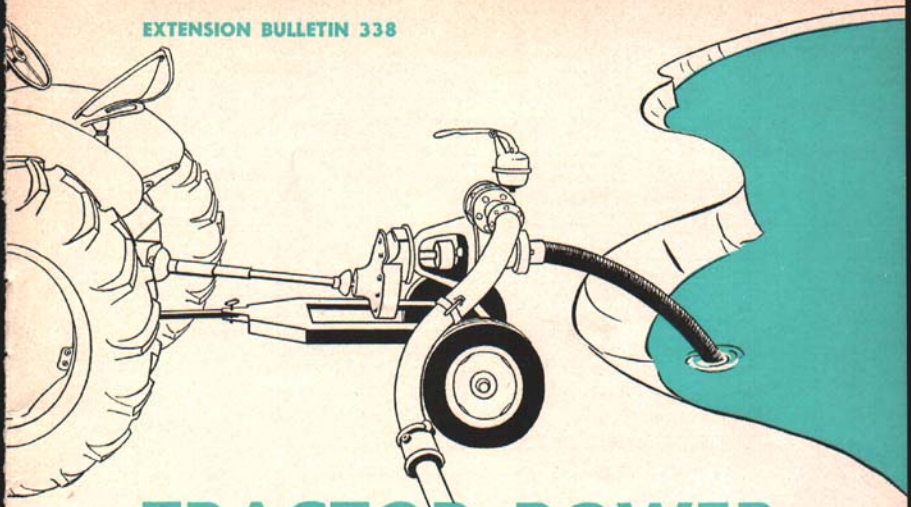

TRACTOR POWER

FOR *POWER-TAKE-OFF* DRIVEN PUMPS

Cooperative Extension Service
MICHIGAN STATE UNIVERSITY
East Lansing

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Tractor Power for Power-Take-Off Driven Pumps

By R. G. WHITE and E. H. KIDDER[1]

The introduction of the power-take-off driven irrigation pump has made it necessary for farm equipment and irrigation equipment dealers to have at their disposal information on the amount of dependable power that can be supplied by the farm tractor. It is generally recognized that 85 percent of the maximum belt horsepower output is a reasonable loading for continuous belt duty.

Irrigation pumping powered through the PTO shaft, however, represents a more constant type of loading. This load requires a continuous, heavy-duty power output from the tractor for a period from several hours to many days. This constant power demand makes it desirable to recommend that the design power requirements of the pump for a particular irrigation system not exceed 75 percent of the available maximum belt horsepower output.

This maximum of 75 percent would apply only where the tractor engine is in good mechanical condition. A lower percentage should be used for older tractors, possibly dropping to 50 percent or lower for tractor motors in only fair mechanical condition.

While the data in Table 1 deal specifically with tractor power available for operation of PTO driven irrigation pumps, it will be reasonably applicable to PTO driven hammer mills and other stationary PTO driven equipment.

SPEED INCREASERS

The American Society of Agricultural Engineers and the Society of Automotive Engineers have standardized specifications for power-take-off shaft revolution per minute (rpm) and location. The standardized power-take-off speed is 540 ± 10 rpm. Irrigation pumps commonly operate at three to four times this speed, making it necessary for the pump manufacturer to supply some type of speed increaser

[1]Assistant professor and associate professor, respectively, department of agricultural engineering. Grateful acknowledgment is made to the Construction Machinery Company for the photograph used in Fig. 1; to the Roper Manufacturing Company for the photograph used in Figs. 2 and 3; and to the tractor manufacturers who assisted in the preparation of Table 1.

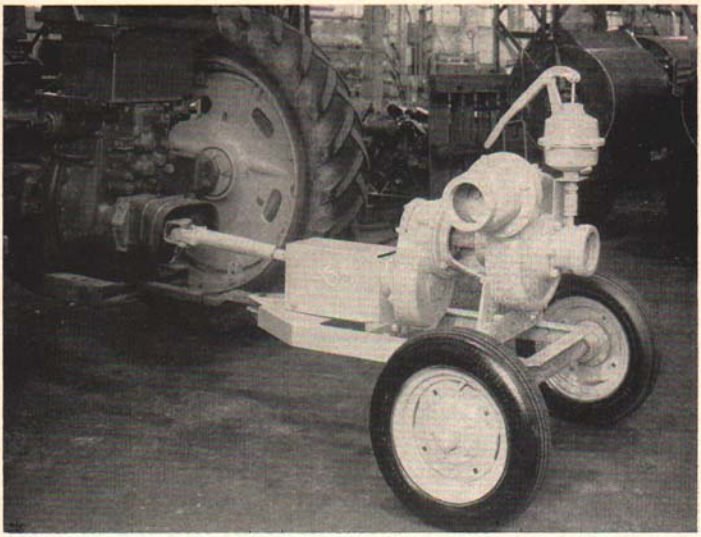

Fig. 1. Trailer mounted PTO driven pump with spur gear type speed increaser.

Fig. 2. Trailer mounted PTO driven pump with bevel gear type speed increaser.

between the tractor PTO shaft and the pump impeller shaft. The pump and speed increaser are commonly mounted either on a two-wheel trailer unit hitched to the tractor drawbar (Fig. 1), or directly on the tractor (Fig. 3). The desired increase in speed is usually obtained through the use of spur gears, bevel gears or V-belts.

The speed increaser in Fig. 1 is the spur gear type. The impeller shaft of the pump should be approximately parallel to the PTO shaft, with spur gears providing the desired increase in rpm.

The unit shown in Fig. 2 is the bevel gear type. The pump impeller shaft is approximately at right angles to the PTO shaft, with bevel gears providing the change of direction and increase in rpm.

The third type employs V-belts and sheaves alone or in combination with gears to obtain the required pump speed.

In some instances, the pump may be attached directly to the tractor, using V-belts or the PTO shaft and gears for the power transfer (Fig. 3).

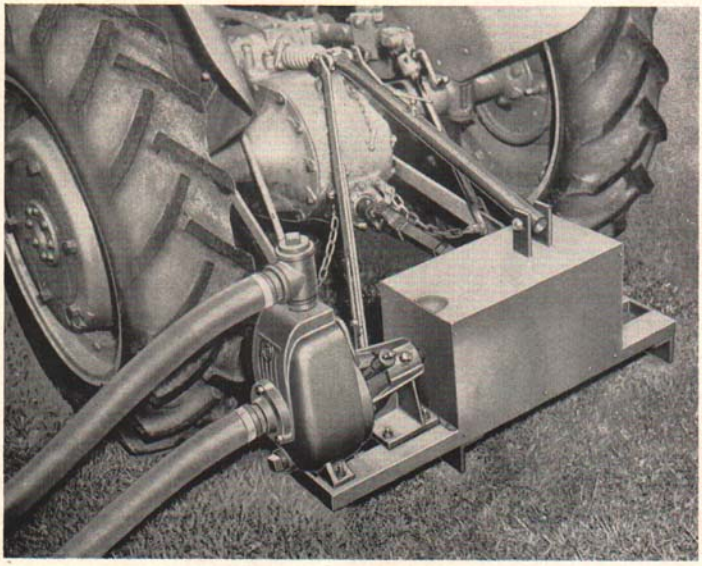

Fig. 3. Drawbar mounted PTO driven pump with bevel gear type speed increaser.

PTO SHAFT ALIGNMENT

Most tractor manufacturers adhere rather closely to ASAE and SAE standards for locating the power-take-off shaft outlet and drawbar on their tractors. It is the responsibility of the pump manufacturer to provide a trailer hitch and power-take-off shaft that will safely and adequately connect the pump to the tractor.

Reasonable care should be exercised to be sure that the power-take-off shaft is properly aligned. To eliminate as nearly as possible the variable speed of rotation and the resulting vibration, shock, and universal joint wear, the universal joint-yokes on the telescoping portion of the PTO shaft should be in the same plane. Correct alignment is shown in Fig. 4a; incorrect alignment in Fig. 4b.

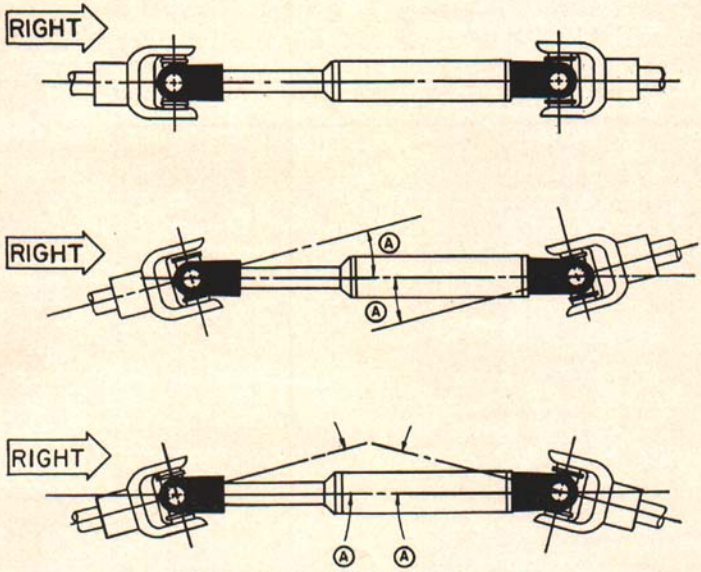

Fig. 4a. Correct PTO shaft alignment.

TRACTOR POWER AVAILABLE THROUGH THE PTO SHAFT

The designer of PTO-operated irrigation systems has the problem of determining the size of pump which will match the power of a

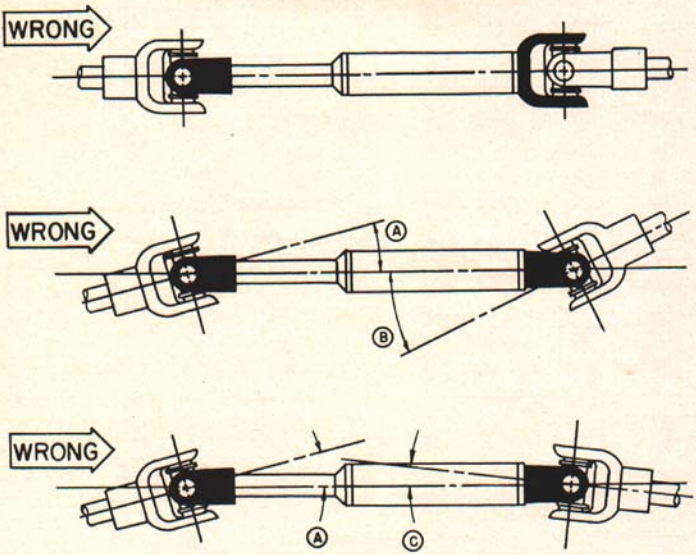

Fig. 46. Incorrect PTO shaft alignment.

particular farm tractor. He must, therefore, know how much horsepower is available through the PTO shaft for the operation of the pump. Tractor manufacturers usually recommend a "rated" loading of 85 percent of maximum belt horsepower and 75 percent of the maximum drawbar horsepower for continuous operation.

The farm tractor's normal day-in and day-out work load is decidedly variable, however, and usually averages far less than the "rated" load. Also, since there is some power loss through the power-take-off shaft and speed increaser, it is desirable to limit the PTO power delivered to irrigation pumps to 75 percent of maximum belt horsepower output. A lower percentage of maximum horsepower should be used with older tractors, depending on their mechanical condition and the date of their last complete overhaul.

A tabulation of most farm tractors on the market since 1940 has been made in Table 1. The maximum recommended horsepower available to the pump has been entered as 75 percent of the maximum sea level calculated belt horsepower, as determined by the Nebraska

Tractor Test unless otherwise indicated. Where the tractor engine must operate at less than rated engine rpm in order to obtain the standard PTO shaft speed, the horsepower available for power-take-off pumping has been adjusted according to engine torque characteristics, as provided by tractor manufacturers.

SAFETY

As a safety precaution, the power-take-off shaft connecting the tractor and pump should be completely shielded. Shielding should be provided by the pump supplier. Non-removable shielding, free to rotate with the PTO shaft but which stops when a slight force is applied, usually provides adequate safety protection. V-belts and sheaves should also be shielded.

Since irrigation pumps are frequently left unattended for long periods of time, it is desirable to install cutout switches to stop the engine in case of low oil pressure or high operating temperature.

TABLE 1—LIST OF RECENT AND CURRENT FARM TRACTOR MODELS listing available horsepower for operating PTO-Driven Irrigation Pumps

Model	Fuel	Power take-off RPM	Maximum recommended H. P. to pump[1]
ALLIS-CHALMERS			
B	Distillate	560	12.2
B	Gasoline	560	17.2
C	Distillate	560(1400)[2]	15.2
C	Gasoline	560(1400)[2]	17.9
CA	Gasoline	538	20.0
WC, WF	Distillate	534	20.3
WC, WF	Gasoline	534	23.6
WD	Tractor fuel	548	20.7
WD	Gasoline	548	26.9
WD-45	Tractor fuel	548	25.5
WD-45	Gasoline	548	34.0
WD-45	L-P gas	548	33.9
WD-45	Diesel	548	34.1
HD-5	Diesel	539	37.7

[1]Maximum Recommended Horsepower to be used in operating pto-driven irrigation pump is 75 percent of maximum calculated sea level belt horsepower as shown in Nebraska Tractor Tests, unless otherwise indicated.
[2]Motor RPM at which stated pto speed is obtained.
[3]Manufacturer's maximum recommended horsepower to be used in operating pto-driven irrigation pump.
[4]More than one pto speed available. One listed is nearest to ASAE and SAE standards.

TABLE 1—Continued

Model	Fuel	Power take-off RPM	Maximum recommended H. P. to pump[1]
ALLIS-CHALMERS: Cont'd.			
HD-7	Diesel	584	53.3
HD-9	Diesel	430	63.4
HD-10	Diesel	431[4]	76.2
HD-15	Diesel	430	92.9
BROCKWAY			
49G	Gasoline	536(1650)[2]	26.3[3]
49D	Diesel	536(1650)[2]	23.8[3]
J. I. CASE			
VA Series	Tractor fuel	525	14.0
VA Series	Gasoline	525	16.7
VC	Gasoline	556	19.5
S Series (before 53)	Distillate	541	17.8
S Series (after 52)	Tractor fuel	541	19.6
S Series	Gasoline	541	24.8
D Series (before '44)	Distillate	536	28.1
D Series (after '43)	Distillate	540	28.1
D Series (before '44)	Gasoline	536	29.0
D Series ('44-'53 incl.)	Gasoline	540	29.0
D Series (after '53)	Gasoline	540	35.3[3]
L	Distillate	550	37.1
LA	Tractor fuel	550	37.9
LA	Gasoline	550	46.3
LA	L-P gas	550	46.4
400	Gasoline	540	41.1
400	Diesel	540	38.2
500	Diesel	540	48.6
CATERPILLAR			
R-2	Distillate	548	26.3[3]
R-2	Gasoline	548	26.5[3]
D-2 (before '49)	Diesel	548	27.5[3]
D-2 ('49-'54 incl.)	Diesel	548	32.9[3]
D-2 (after '54)	Diesel	545	36.6[3]
R-4	Distillate	545[4]	32.6[3]
R-4	Gasoline	545[4]	34.9[3]
D-4 (before '49)	Diesel	545[4]	35.6[3]
D-4 ('49-'54 incl.)	Diesel	545[4]	46.5[3]
D-4 (after '54)	Diesel	550	45.9[3]
D-6 (before '49)	Diesel	536	68.7[3]
D-6 ('49-'54 incl.)	Diesel	550	68.5[3]
D-6 (after '54)	Diesel	543	72.3[3]
D-7 (before '55)	Diesel	1000	79.0[3]

TABLE 1—Continued

Model	Fuel	Power take-off RPM	Maximum recommended H. P. to pump[1]
CATERPILLAR: Cont'd.			
D-7 (after '54)	Diesel	446	96.3[2]
D-8 (before '49)	Diesel	1000	111.4[2]
D-8 ('49-'53 incl.)	Diesel	1000	125.8[2]
D-8 (after '53)	Diesel	524	149.6[2]
COCKSHUTT			
20	Gasoline	563	22.8
30	Distillate	580	16.9[2]
30	Gasoline	580	24.7
30	L-P gas	580	24.2[2]
30D	Diesel	580	19.2[2]
40	Distillate	530	26.6[2]
40	Gasoline	530	34.2
40	L-P gas	530	34.8[2]
40D	Diesel	530	28.9[2]
50	Gasoline	530	43.4
50D	Diesel	530	39.9
CORBITT			
K-50	Kerosene	640	21.8[2]
G-50	Gasoline	640	27.2
D-50	Diesel	640	26.9[2]
JOHN DEERE			
LA	Gasoline	540	11.4
H	Gasoline	546	11.4
M	Gasoline	550	16.1
MT	Gasoline	550	16.2
MC	Gasoline	550	16.7
B ('41 and '42)	Distillate	554	15.4
B ('43-'45 incl.)	Distillate	528	15.4
B ('46)	Distillate	564	15.4
B ('47)	Tractor fuel	564	18.2
B (after '47)	Tractor fuel	541	18.2
B (before '48)	Gasoline	564	21.5
B (after '47)	Gasoline	541	21.5
A (before '48)	Distillate	546	23.2
A (after '47)	Distillate	542	23.2
A (before '48)	Gasoline	546	29.6
A (after '47)	Gasoline	542	29.6
AR ('42-'46) incl.)	Distillate	546	23.2
AR (after '46)	Distillate	536	23.2
AR	Gasoline	536	29.3
G (before '47)	Distillate	532	27.7
G (after '46)	Tractor fuel	532	29.9

TABLE 1—Continued

Model	Fuel	Power take-off RPM	Maximum recommended H. P. to pump[1]
JOHN DEERE: Cont'd.			
D	Distillate	526	33.6
R	Diesel	536	38.2
40	Gasoline	560	18.9
40-C	Gasoline	560	18.7
40-S	Tractor fuel	560	15.7
40-S	Gasoline	560	18.6
40-U	Gasoline	560	18.6[3]
50	Tractor fuel	541	19.3
50	Gasoline	541	23.2
50	L-P gas	541	24.2
60	Tractor fuel	542	24.9
60	Gasoline	542	31.2
60	L-P gas	542	31.7
70	Tractor fuel	532	33.7
70	Gasoline	532	37.8
70	L-P gas	532	39.0
70	Diesel	532	38.6
80	Diesel	536	50.7
DODGE POWER WAGON			
T-137	Gasoline	563	32.4
FARMERS UNION CENTRAL EXCHANGE			
Co-Op No. 3S	Gasoline	548	35.7[3]
Co-Op No. 3LF	L-P gas	548	36.2[3]
FERGUSON			
Pony	Gasoline	540	9.1
TE-20	Gasoline	545(1500)[2]	17.4[3]
TO-20	Gasoline	545(1500)[2]	17.4[3]
TO-30	Gasoline	545(1500)[2]	19.9[3]
TO-35	Gasoline	536(1493)[2]	21.0[3]
FORD			
9N	Gasoline	545(1500)[2]	14.4[3]
2N	Gasoline	545(1500)[2]	14.4[3]
8N (before '48)	Gasoline	545(1500)[2]	13.0[3]
8N ('48 and '49)	Gasoline	545(1500)[2]	16.0[3]
8N (after '49)	Gasoline	545(1500)[2]	16.5[3]
8NAN	Tractor fuel	545(1500)[2]	13.9[3]
NAA	Gasoline	545(1500)[2]	19.6[3]
640,740	Gasoline	536(1500)[2]	19.6[3]
650,660	Gasoline	545(1750)[2]	22.0[3]

TABLE 1—Continued

Model	Fuel	Power take-off RPM	Maximum recommended H. P. to pump[1]
FORD: Cont'd.			
800, 900 series	Gasoline	545(1750)[2]	31.0[3]
Major	Diesel	542(1200)[2]	24.0[3]
FRIDAY			
048	Gasoline	540(1200)[2]	25.0[3]
GIBSON			
EF	Gasoline	603	9.5[3]
H	Gasoline	741	19.5
I	Gasoline	741	32.3
HARRIS FOUR WHEEL DRIVE			
PH40 (F6W-C)	Gasoline	545(1800)[2]	34.0[3]
PH53 (F8W-C)	Gasoline	642	39.0
FDW-C (G.M.)	Diesel	642(2000)[2]	34.3
FDW-C (Continental)	Diesel	642(2000)[2]	33.5
INTERCONTINENTAL			
C-26	Gasoline	550	23.4
D-26, DE	Diesel	550	23.1
DF	Diesel	550	26.9
INTERNATIONAL HARVESTER			
Cub	Gasoline	1600	7.3
A, Super A	Distillate	541	12.8
A, Super A	Gasoline	541	14.3
Super A-1	Gasoline	541	16.5[3]
B, BN	Distillate	541	12.5
B, BN	Gasoline	541	14.4
C	Gasoline	539	16.6
Super C	Gasoline	539	18.3
H	Distillate	540	18.3
H	Gasoline	540	20.9
Super H	Gasoline	540	26.0
M	Distillate	537	27.5
M	Gasoline	537	29.4
MD (before '51)	Diesel	537	27.4
MD (after '50)	Diesel	537	30.0
Super M	Gasoline	537	36.4
Super M	L-P gas	537	36.6
Super MD	Diesel	537	36.2
W-4	Distillate	540	18.7
W-4	Gasoline	540	20.9

TABLE 1—Continued

Model	Fuel	Power take-off RPM	Maximum recommended H. P. to pump[1]
INTERNATIONAL: Cont'd.			
Super W-4	Gasoline	540	26.0
W-6	Distillate	537	27.5
W-6	Gasoline	537	29.1
WD-6 (before '51)	Diesel	537	27.3
WD-6 (after '50)	Diesel	537	29.5
Super W-6	Gasoline	537	36.6
Super W-6	L-P gas	537	36.8
Super WD-6	Diesel	537	36.4
W-9	Distillate	538	36.8
W-9	Gasoline	538	39.3
WD-9 (before '50)	Diesel	538	36.9
WD-9 (after '49)	Diesel	538	39.9
Super WD-9	Diesel	538	50.4
100	Gasoline	541	15.8
200	Gasoline	539	19.0
300	Gasoline	541	29.9
300-U	Gasoline	541	32.1
400	Gasoline	534	39.5
400	Diesel	534	36.3
W-400	Gasoline	534	40.2
W-400	Diesel	534	36.4
T-6	Distillate	540[4]	27.5
T-6	Gasoline	540[4]	29.2
TD-6 (before '51)	Diesel	540[4]	27.2
TD-6 (after '50)	Diesel	540[4]	30.2
T-9	Gasoline	535[4]	36.5
TD-9 (before '51)	Diesel	535[4]	34.4
TD-9 (after '50)	Diesel	535[4]	36.7
TD-14	Diesel	691	48.0
TD-14A	Diesel	716[4]	56.5
TD-18	Diesel	614	63.5
TD-18A	Diesel	691[4]	76.5
LOVE			
C-51	Gasoline	550[4]	37.1[3]
CF-51	Gasoline	550[4]	38.5[3]
MASSEY-HARRIS			
Pony 11	Gasoline	540	9.1
Pacer 16	Gasoline	540	14.4
20K, 82	Distillate	551	17.3[3]
20, 81	Gasoline	551	21.3

TABLE 1—Continued

Model	Fuel	Power take-off RPM	Maximum recommended H. P. to pump[1]
MASSEY-HARRIS: Cont'd.			
Colt 21 (before '55)	Gasoline	551	20.3[3]
Colt 21 (after '54)	Gasoline	661	20.3[3]
22K	Distillate	551	17.3[3]
22	Gasoline	551	23.7
102 Jr.	Distillate	551	20.6[3]
101 Jr.	Gasoline	551	24.2
Mustang 23K (before '55)	Tractor fuel	551	17.3[3]
Mustang 23K (after '54)	Tractor fuel	661	17.3[3]
Mustang 23 (before '55)	Gasoline	551	23.3[3]
Mustang 23 (after '54)	Gasoline	661	23.3[3]
30K	Distillate	534	19.5[3]
30	Gasoline	551	26.5
33K	Tractor fuel	551	22.5[3]
33	Gasoline	551	30.3
33D	Diesel	551	25.5[3]
102 Sr.	Distillate	587(1600)[2]	28.1[3]
101 Sr.	Gasoline	551	35.9
44K	Tractor fuel	534	29.6
44	Gasoline	534	35.3
44 L-P	L-P gas	534	33.8[3]
44D	Diesel	534	32.3
44-6	Gasoline	551	30.8[3]
44K Special	Tractor fuel	534	28.5[3]
44 Special	Gasoline	534	37.7
44 L-P Special	L-P gas	534	33.8[3]
44D Special (APE pump)	Diesel	534	31.4[3]
44D Special (PSB pump)	Diesel	534	32.6[3]
203	Distillate	543	39.0[3]
203G	Gasoline	543	46.5[3]
55K	Tractor fuel	521	40.9[3]
55 (before '51)	Gasoline	521	46.0
55 (after '50)	Gasoline	521	51.2
55 L-P	L-P gas	521	47.3[3]
55D	Diesel	521	45.2
MERCER (FARMASTER)			
30-CK	Gasoline	580	22.4
30-BD	Diesel	580	18.9

TABLE 1—Continued

Model	Fuel	Power take-off RPM	Maximum recommended H. P. to pump[1]
MINNEAPOLIS-MOLINE			
V	Gasoline	540	9.0[3]
RT Series (before '51)	Gasoline	560	18.0
RT Series (after '50)	Gasoline	600	20.9
BF Series	Gasoline	562	20.7
BG Series	Gasoline	559	20.7[3]
ZT Series	Gasoline	615	24.7
ZA Series	Gasoline	615	28.1
ZB Series	Gasoline	615	28.5[3]
ZB Series	L-P Gas	615	28.5[3]
UT Series	Distillate	575	27.8
UT Series	Gasoline	575	34.0
UT Series	L-P Gas	575	36.6
UT Series	Diesel	585	34.5[3]
UB Series	Tractor fuel	585	29.6
UB Series	Gasoline	585	37.8
UB Series	L-P gas	585	39.9
UB Series	Diesel	585	34.5[3]
GT Series (before '50)	Gasoline	526	43.2
GT Series (after '49)	Gasoline	585	44.6
GT Series	L-P gas	585	43.2[3]
GT Series	Diesel	585	48.0[3]
GB Series	Tractor fuel	585	42.0[3]
GB Series	Gasoline	585	51.4
GB Series	L-P gas	585	56.2
GB Series	Diesel	585	48.9
OLIVER			
60-HC	Gasoline	533	14.6
66-HC	Gasoline	533	19.5
66-D	Diesel	533	19.8
70-KD	Distillate	538	21.6
70-HC	Gasoline	538	25.0
77-HC	Gasoline	533	29.1
77-LP	L-P Gas	533	28.6
77-D	Diesel	533	27.9
80-KD	Distillate	577	31.0
80-HC	Gasoline	577	31.8
88-HC	Gasoline	533	33.5
88-D	Diesel	533	33.9
90-KD	Distillate	530	37.5[3]
99-HC	Gasoline	530	47.9
Super 55-HC	Gasoline	545	26.9

TABLE 1—Concluded

Model	Fuel	Power take-off RPM	Maximum recommended H. P. to pump[1]
OLIVER: Cont'd.			
Super 55-D	Diesel	545	25.6
Super 66-HC	Gasoline	533	26.7
Super 66-D	Diesel	533	26.6
Super 77-HC	Gasoline	533	34.6
Super 77-D	Diesel	533	34.5
Super 88-HC	Gasoline	533	43.6
Super 88-D	Diesel	533	41.7
Super 99-HC	Gasoline	532	48.8[3]
Super 99-D	Diesel	532	48.8
Super 99-GMD	Diesel	532	62.6
HG (before '49)	Gasoline	551	15.4
HG, OC-3 (after '48)	Gasoline	551	19.8
OC-6	Gasoline	533	23.9[3]
OC-6	Diesel	533	23.7[3]
AG-6	Gasoline	603	30.1[3]
AD	Diesel	603	32.0[3]
BD	Diesel	608	36.1
OC-12	Gasoline	590[4]	45.2
OC-12	Diesel	590[4]	44.2
DG	Gasoline	550	53.6
DD	Diesel	512	55.8
OC-18	Diesel	1500	111.8[3]
SHEPPARD			
SD-2	Diesel	550	20.0[3]
SD-3	Diesel	550	30.0[3]
SD-4	Diesel	532	50.0[3]
SILVER KING			
370, 371, 450, 470, 471	Gasoline	545(1330)[2]	25.9
TERRATRAC (American Tractor)			
GT-25	Gasoline	616	19.4[3]
GT-30	Gasoline	616	23.6
GT-34	Gasoline	616	25.5[3]
DT-34	Diesel	616	23.3[3]
WILLYS FARM JEEP			
Jeep (before '53)	Gasoline	2000	22.3
Jeep (after '52)	Gasoline	2400	27.9