

THE TRACTOR ON OHIO FARMS

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BULLETIN

OF THE

Ohio Agricultural Experiment Station

NUMBER 383

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ITS COST OF OPERATION AND ITS EFFECT ON THE ORGANIZATION OF THE FARM

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INTRODUCTION

During July and August, 1919, the Department of Rural Economics at Ohio State University, in cooperation with the Bureau of Agricultural Economics of the U. S. Department of Agriculture—to members of which acknowledgment is due for assistance received in collecting the data in the field—began a 5-year survey study to obtain first-hand information on the costs of tractor operation and the effect of the tractor on the organization of the farm business.

Two areas were selected for this study—one, in northwestern Ohio, a region of level corn-belt farming, embracing roughly the northern half of Allen and the southern half of Putnam County; the other, in northeastern Ohio, a dairy region principally of rolling land, including the southern third of Geauga, the northern tier of townships in Portage, and the northern half of Trumbull County, part of the latter being of level topography.

In 1919, the first year of the survey, 102 farmers who had purchased tractors within the past year were visited. A record of their business for the year 1918, including inventories of livestock, feed, etc., farm receipts and expenses, crop areas and yields, and also a record of what work had been done with the tractors, the fuel and oil used, and the cost of repairs were obtained at that time. Records were kept by these farmers, who were visited in April each year up to April, 1923. In addition to the tractor records, these provided a farm business record of one year without a tractor and

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records for four years following the purchase of a tractor. During this time some of the records were discontinued, but an effort was made to obtain approximately 100 records each year, by including in the survey other farmers who had just purchased tractors.

During the four years from April, 1919 to April, 1923 satisfactory data were obtained on 108 individual tractors, a total of 326 yearly records. Questionnaires and personal letters were sent out in April and May, 1924 in order to keep in touch with the tractors after the survey was discontinued.

USEFUL LIFE OF TRACTORS

Numerous studies relating to the life of the tractor in several other states show that farmers are of the opinion that a tractor will last an average of 5 to 7 years.

In this investigation, out of 62 original tractors which were kept under observation up to May, 1924, or until disposed of, it has been found that only 31, or exactly 50 percent of the original number, are now being used in their fifth year. The age at which the other 31 tractors were sold or traded was as follows:

12 months or less.....	1 tractor
13 to 24 months.....	4 tractors
25 to 36 months.....	7 tractors
37 to 48 months.....	8 tractors
49 to 60 months.....	11 tractors

At the close of the survey those men who had tractors which had been used two years or more were asked to make an estimate of the probable future life of their tractors. Assuming that these machines would continue in use the same number of hours per year as in the past, it was found that their average total life, based on these estimates, would be 1794 working hours.

The selling price or trade-in value of a used tractor represents rather closely the purchaser's estimate of what may be expected from it in the way of further work or its junk or re-sale value. The selling price or trade-in value of the tractors disposed of and the cost price of a new tractor of the same make were obtained. Using these figures and the number of hours of work the old tractor had performed (see Table 1), it is possible to compute the total life of the tractor in working hours or their equivalent, with the equation $D : H :: C : X$, where

- D = difference between cost of a new tractor at time of disposing of old tractor and the amount received or allowed for the old tractor;
H = number of hours the old tractor has been used up to time of sale or trade;
C = cost of new tractor of same make at time of disposal of old tractor;
X = total life of tractor in working hours.

In some instances it is quite doubtful whether the tractor disposed of will give as much future service as the figures in the next to the last column indicate. Tractor No. 17w, which was 55 months old and had been used approximately 3000 hours when traded in, can hardly be expected to last 5 years more, at the rate of work obtained from the average tractor—viz., about 250 hours per

TABLE 1.—Showing an estimate of the working life of individual tractors, based on the amount received for them at time of sale or trade

Tractor number*	Date bought	Disposed of		Received	Value new tractor at time of sale or trade	Hours used	Hours estimated remaining life	Hours total life
		How†	When					
2E	May '18	T	Dec. '22	\$125	\$ 425	1,287	536	1,823
3E	July '19	S	Oct. '22	200	400	364	364	728
10E	June '19	T	Aug. '23	100	425	2,169	667	2,836
11E	Aug. '19	T	Mar. '23	225	450	979	979	1,958
12E	Aug. '18	T	Jan. '22	225	425	641	721	1,362
13E	May '19	T	Sept. '20	540	800	195	405	600
16E	Aug. '18	T	July '21	225	675	358	179	537
20E	April '19	T	June '23	200	750	1,380	501	1,881
24E	April '19	T	Aug. '21	225	675	397	199	596
25E	May '19	T	Nov. '22	187	425	897	708	1,605
31E	June '18	T	June '21	300	650	1,316	1,128	2,444
32E	July '18	S	Mar. '22	227	440	1,103	1,181	2,284
36E	Sept. '18	S	Mar. '22	222	440	1,079	1,104	2,183
41E	July '19	T	May '20	650	870	391	1,155	1,546
41E	June '20	S	Mar. '21	670	800	227	1,170	1,397
43E	April '19	S	May '22	165	460	594	332	926
46E	Sept. '18	T	Mar. '22	150	425	1,460	796	2,256
56E	May '21	T	Aug. '22	200	600	494	247	741
1W	Mar. '19	S	Nov. '20	900	1,225	535	1,481	2,016
2W	Mar. '19	T	April '23	300	885	869	446	1,315
10W	Mar. '19	S	May '22	160	425	926	559	1,485
17W	Nov. '18	T	June '23	135	425	2,997	1,395	4,392
19W	April '19	S	Dec. '20	250	300	142	710	852
20W	Mar. '19	T	July '21	300	725	1,020	720	1,740
23W	Aug. '18	T	Mar. '21	425	650	1,087	2,053	3,140
32W	July '18	T	May '20	700	1,400	562	562	1,124
53W	Feb. '20	S	Mar. '21	780	900	224	1,456	1,680
55W	Feb. '20	S	May '21	900	1,200	204	612	816
57W	Mar. '20	S	Sept. '22	225	425	1,466	1,649	3,115
Average of 18 tractors traded.....						1,028	744	1,772
Average of 11 tractors sold.....						624	965	1,589
Average of 29 tractors disposed of.....						875	828	1,703

*E=eastern Ohio section; W=western Ohio section.
 †T=traded; S=sold.

year, altho the amount allowed for it on a trade would tend to show this. The owner of No. 23w stated that the dealer who took this tractor on a trade did not know how many hours it had been used and lost money on the deal. Certainly, the farmer who bought tractor No. 57w at a public sale did not get a bargain when he paid more than half the purchase price of a new tractor for a machine which had been used nearly 1500 hours.

TRACTOR OPERATING COSTS

Depreciation.—At the end of two years' work the owners were asked their opinion as to how many years of useful life their tractors would give. Of the number, 19 percent stated that their tractors would last a total of 7 years; 28 percent stated 6 years; and 17 percent 5 years, and the others made estimates of 4, 8, and 9 years. Since nearly two-thirds of estimates ranged from 5 to 7 years or an average of 6 years, and since the tractors were being used about 250 hours per year, it was decided to place the life of the tractors at 1500 working hours or an equivalent. In view of the estimates obtained in Table 1, and also those made by the farmers at the close of the survey, this figure seems conservative. In most cases the depreciation charge for each hour of use was calculated by dividing the original cost of the tractor by 1500. For those tractors which were sold or traded, the difference between the original cost and the amount received at time of disposal was counted as depreciation. This difference distributed over the number of hours the tractor had been used gave the depreciation per hour. The estimated life of several tractors was raised to 1750 or 2000 hours when it became evident that they might give that much service.

The average annual depreciation charge for all tractors was \$149.44. This amounted to 16.4 percent of the average original purchase price of \$910.65. The average depreciation per hour of use was 58.4 cents, or 44.1 percent of the total cost of tractor operation. The purchase price of the 29 tractors disposed of was \$874.93, the average amount received for them at time of sale or trade was \$341.80, making the actual depreciation 60.9 cents per hour used.

Depreciation on three-plow tractors in northwestern Ohio in 1921 and 1922 averaged 84 cents per hour of use, or 51.4 percent of the total cost of operation, while for the two-plow tractors in the same section the average depreciation charge was 45.3 cents per hour, or 42.5 percent of the total cost of operation.

Tractors in 1924 cost less than did the machines included in this investigation. If these tractors which were bought in 1921 and 1922 had been purchased at 1924 prices, depreciation of three-plow machines would have amounted to 48.6 percent of the total cost of their operation, and the depreciation of two-plow machines to 40.5 percent of their operating cost.

Interest.—Interest at the rate of 6 percent on the purchase price of the tractor is included in the cost of operation for the first.

year. For each succeeding year 6 percent was charged on the inventory value of the tractor at the beginning of that particular year.

For all tractors included in this survey from April, 1919 to April, 1923 the interest charge averaged \$42.37 per tractor per year, or 4.65 percent of the average original cost. Interest on the investment averaged 16.5 cents per hour of use, or 12.5 percent of the total cost of operation. It should be noted here that this study covered that part of the life of these tractors in which their value was highest. If the study had been continued until the tractors were all worn out or disposed of the average interest charge per year would have been less than the amount given above. Thus if the useful life of a machine is 6 years, the interest charge at 6 percent of the average investment will amount annually to 3.5 percent of its original purchase price. This would reduce the interest charge to \$31.87 per year, or 12.5 cents per hour of use.

Taxes and insurance.—Taxes were estimated at 1 percent of the values used in calculating the interest charge. Thus taxes amounted to one-sixth of the interest charge, averaging \$7.06 per year for all tractors. Insurance amounted to only 51 cents per tractor per year, since practically none of the farmers had taken out any special insurance on their tractors.

Use of buildings.—The cost of tractor shelter was computed at the annual rate of 10 percent of the estimated value of shed or building or part of building in which the tractor was stored. Thus if a tractor occupied one-sixth of a machine shed valued at \$320, the charge for housing that tractor was estimated at \$5.33 per year. Most of the tractors were stored in sheds of low value, and a few of them were allowed to stand out without any shelter. The average cost of shelter amounted to \$4.35 per tractor per year.

Repairs.—The cost of repairs and expert labor was the most variable of all the different items entering into the cost of tractor operation, ranging all the way from nothing to an average of \$214 per year, one tractor owner spending a total of \$643 for repairs in three years. The average amount spent for repairs for all tractors was \$34.87 per year. Repair costs thus constituted 10.3 percent of the total operating cost. Three of the 108 owners had spent nothing for repairs. One had used his tractor one year, one two years and one three years.

The following table shows the average amount spent per year for repairs over the entire period of the survey.

TABLE 2.—Average annual cost of tractor repairs

Average repairs per year	Tractors having specified repairs	
<i>Dollars</i>	<i>Number</i>	<i>Percent</i>
0	3	2.8
0—20	52	48.1
20—40	17	15.7
40—60	16	14.8
60—80	12	11.1
80—100	3	2.8
Over 100	5	4.7
Total	108	100.0

Table 2 shows that more than half of the tractors averaged less than \$20 per year for repairs.

Repairs for tractors purchased in 1918 and 1919 averaged \$42.79 per year, or 4.58 percent of their average original cost, while those bought in 1920 and 1921 had repair bills of only \$11.81 per year, or 1.36 percent of their original purchase price. The newer tractors had not been used quite as many hours per year. Part of the higher repair cost on the older outfits was also due to the fact that repair costs per year increase with the age of the tractor. (See Table 3). The difference in repair costs, however, shows undoubtedly that tractors are now being made of better materials and that farmers are becoming more efficient in using them.

TABLE 3.—Annual repairs on 45 tractors used 4 years

1st year	2d year	3d year	4th year	Average
\$27.04	\$48.05	\$41.48	\$39.23	\$38.95

Repairs are somewhat proportional to the amount of work done. The average cost of repairs for tractors working less than 125 hours per year was \$18.98. The cost increased with the increase in amount of work done, being \$47.11 for machines used more than 375 hours per year. Repair costs per hour of work done, however, decreased from 25 cents per hour for tractors working less than 125 hours to only 9 cents for those working more than 375 hours per year.

Note that in the above chart three tractors, which were used only a total of between 350 and 400 hours, had total repairs costing from nearly \$300 to \$650. It will also be seen that four tractors, each used over 1000 hours, had total repair costs amounting to less than \$50 per year. On one tractor, used 1930 hours, a total of only \$67.25 was spent for repairs.

The question may logically be raised as to whether the average annual repair cost might not have been more than \$34.87 per tractor had the study been continued until all of the tractors were sold or traded in on new ones. The average annual cost of repairs on the 29 tractors disposed of was \$51.15. Their repair cost per hour of use was 16.3 cents. Some of these were sold or traded in on new ones because of the high repair cost and the possibility of more repairs or breakdowns. The 13 which had been used the largest number of hours before being sold or traded had annual repair bills averaging only \$43.08. They had been used an average of 435 hours annually, making the repair cost per hour of use less than 10 cents.

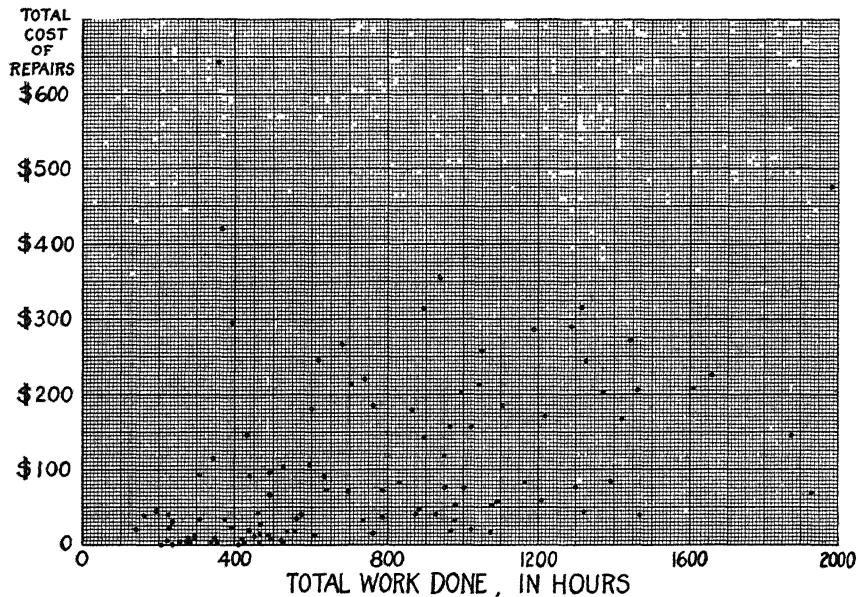


Fig. 1.—Relation of total work done by tractors to their total repair cost. Each dot represents the total amount spent for repairs on a tractor which had been used a total number of hours indicated by its position on the horizontal scale

Of the 108 tractors, designated by the dots in Figure 1, the 19 which had been used over 1200 hours, and hence were probably the most nearly worn out, have had repair bills averaging \$51.87 per year. They had been used an average of 419 hours annually, however, making their repair cost per hour of use 12.4 cents, compared with an average of 13.6 cents per hour for all tractors.

Farm labor.—The time spent by the operator repairing or overhauling averaged only 8 hours per year. This varied from no time spent on 19 of the farms to yearly average of 45 hours repairing by one tractor owner. Chores, or the work which might be compared to daily work of feeding, grooming, and other chores on horses, averaged 16 hours per year, or 37 minutes per 10 hours of tractor work. This item varied from 10 minutes to 2 hours for every day the tractor was used. The value of this labor at an average of 35 cents per hour has been included in the cost of tractor operation.

Fuel and lubricating oil.—The average amounts of fuel and lubricating oil used per 10-hour day by two-plow and three-plow tractors at different kinds of drawbar and belt work are given in Table 4.

TABLE 4.—Fuel and oil requirements for different operations, per 10-hour day, 1921 and 1922

Operation	3-plow tractors, N. W. Ohio			2-plow tractors, N. E. Ohio			2-plow tractors, N. W. Ohio		
	Trac- tors	Fuel	Oil	Trac- tors	Fuel	Oil	Trac- tors	Fuel	Oil
	<i>No.</i>	<i>Gal.</i>	<i>Gal.</i>	<i>No.</i>	<i>Gal.</i>	<i>Gal.</i>	<i>No.</i>	<i>Gal.</i>	<i>Gal.</i>
Plowing	9	18.99	0.96	44	17.40	1.31	26	18.46	1.17
Disking	10	18.00	1.17	38	17.66	1.31	25	18.06	1.22
Disking in combination....	5	18.65	1.23	27	17.73	1.35	15	17.85	1.08
Cutting grain	2	12.25	.66	23	14.71	1.15	10	14.04	.95
Other drawbar work	5	13.95	.95	44	15.49	1.17	15	14.77	1.00
All drawbar work	12	18.23	1.07	46	16.84	1.33	27	17.61	1.16
Filling silo	5	20.18	1.19	29	18.09	1.40	12	17.30	1.11
Threshing	3	19.75	1.48	6	20.32	1.22	6	16.17	1.15
Shredding	9	16.06	1.20	9	14.13	1.08	13	14.94	1.05
Grinding feed	8	11.51	1.10	16	16.32	1.25	14	14.56	.78
Buzzing wood	4	12.33	1.00	33	12.05	1.10	17	12.83	.74
Other belt work	4	11.84	1.30	7	14.92	1.20	4	13.33	.99
All belt work	11	16.48	1.23	38	16.40	1.29	24	14.78	.97
All operations	12	17.23	1.18	47	16.70	1.30	27	16.26	1.10

Average drawbar work required a larger amount of fuel per 10-hour day than average belt work. Some classes of belt work, especially silo filling, required more fuel than was required by average drawbar operations. The three-plow tractors required more fuel for average drawbar and average belt work than did the smaller outfits, but there were some operations at which the two-plow tractors had a higher fuel consumption than the larger machines. The average fuel consumption for all tractors at all kinds of work was 14.8 gallons of kerosene and 1.6 gallons of gasoline for 10 hours of work. The cost of fuel was 20.3 percent of the total operating cost.

Average drawbar work required more lubricating oil than did belt work, except in the case of three-plow outfits in western Ohio which were used largely for belt work. These three-plow tractors required .2 gallon more oil per day for all belt work than for drawbar work. The average oil requirement for all tractors at all operations was 1.25 gallons for 10 hours of work, or an average of 32 gallons per year.

TOTAL COST OF TRACTOR OPERATION

In Tables 5 and 6 are shown the costs per hour of work for each tractor in the northwestern area on which records were obtained. These costs do not include the value of the operator's time. It will be seen that the average cost of operating three-plow tractors in the four years 1919 to 1922 in northwestern Ohio was \$1.73 per hour. The average cost of individual tractors varied from \$1.08 to \$2.27 per hour. For two-plow tractors the average hourly cost was \$1.16 in northwestern Ohio. The average cost of the various two-plow tractors ranged from 74 cents to \$2.21 per hour.

In comparing the hourly cost of three-plow and two-plow outfits, the increased amount of work accomplished with the larger machines should be taken into consideration.

TABLE 5.—3-plow tractors, northwestern Ohio, showing hours used each year and variations in cost per hour of use

Tractor number	1919		1920		1921		1922		Total hours used	Average cost per hour
	Hours used	Cost per hour	Hours used	Cost per hour	Hours used	Cost per hour	Hours used	Cost per hour		
2	No.	DoI.	No.	DoI.	No.	DoI.	No.	DoI.	No.	DoI.
18	148	1.96	91	2.39	345	1.56	175	1.65	759	1.76
20	214	2.39	225	1.81	135	2.10	290	1.57	864	1.92
25	347	1.24	176	1.55	177	1.52	450	1.21	450	1.21
30	592	1.41	192	1.57	.....	.....	180	1.37	880	1.45
32a	478	1.96	84	2.23	.....	.....	.....	.....	784	1.46
32b	.....	.....	295	2.39	410	1.90	260	2.34	562	2.00
39	198	1.63	59	3.35	67	2.56	135	1.84	965	2.17
42	152	2.02	149	2.25	167	2.06	.....	.....	459	2.05
46	194	1.72	48	3.05	52	3.25	80	2.50	468	2.11
47	257	2.12	181	2.29	34	3.75	149	1.68	374	2.27
61	.....	.....	469	1.26	360	1.00	376	.93	621	2.15
66	.....	.....	116	1.68	128	2.05	181	1.67	1205	1.08
71	.....	.....	30	2.81	234	1.68	202	1.51	425	1.79
Ave.	287	1.75	162	1.92	192	1.75	225	1.53	466	1.68

Remarks: Tractor No. 20 had a low cost of operation because its purchase price was lower than the others; No. 32b was a high priced, gasoline-using tractor; No. 46 was used only a few hours per year, resulting in high interest charge per hour of use; No. 61 was used a large number of hours and gave every indication that its life would be 2000 working hours.

TABLE 6.—2-plow tractors, northwestern Ohio, showing hours used each year and variations in cost per hour of use

Tractor number	1919		1920		1921		1922		Total hours used	Average cost per hour
	Hours used	Cost per hour	Hours used	Cost per hour	Hours used	Cost per hour	Hours used	Cost per hour		
	<i>No.</i>	<i>Dol.</i>	<i>No.</i>	<i>Dol.</i>	<i>No.</i>	<i>Dol.</i>	<i>No.</i>	<i>Dol.</i>	<i>No.</i>	<i>Dol.</i>
1	367	1.66	188	1.73	195	1.27	228	1.21	535	1.69
3	181	1.24	225	1.37	250	1.39	144	1.78	829	1.27
6	431	1.44	368	1.35	268	1.16	359	1.08	1,193	1.45
7	311	1.10	225	1.23	.....	.....	.....	.....	1,164	1.13
8	163	1.43	181	1.98	.....	.....	.....	.....	344	1.72
9	353	1.24	385	1.33	249	1.00	382	1.14	1,369	1.19
10	469	1.37	219	1.45	238	1.51	.....	.....	926	1.43
11	309	1.15	184	1.60	.....	.....	.....	.....	493	1.33
15	380	1.34	281	1.87	100	2.13	2	6.12	763	1.65
17	795	.76	580	.84	702	.74	675	.63	2,752	.74
19	100	.82	42	1.48	.....	.....	.....	.....	142	1.01
20	445	1.27	235	1.35	340	1.20	.....	.....	1,020	1.26
21	484	.83	390	1.17	239	1.05	280	1.05	1,393	1.01
22	401	1.20	302	1.92	.....	.....	.....	.....	703	1.51
23a	635	.84	452	.96	.....	.....	.....	.....	1,087	.89
23b	.....	.....	.....	.....	746	.88	553	.78	1,299	.84
31	408	.91	233	1.01	141	1.42	165	1.10	947	1.04
33	247	1.43	276	1.89	.....	.....	.....	.....	523	1.68
34	207	1.09	110	1.45	316	1.20	314	1.10	947	1.18
36	335	1.15	376	1.22	306	1.20	305	1.20	1,322	1.19
37	.....	.....	213	1.39	155	1.13	200	1.04	568	1.20
52	141	1.60	137	1.72	111	1.75	130	1.57	519	1.66
53	.....	.....	224	1.60	.....	.....	.....	.....	224	1.60
54	.....	.....	96	1.53	49	2.66	10	3.66	155	2.03
55	.....	.....	204	2.10	.....	.....	.....	.....	204	2.10
56	.....	.....	157	1.81	57	2.87	72	2.53	286	2.21
57	.....	.....	806	.74	355	.73	305	.81	1,466	.75
60	.....	.....	308	1.10	348	1.02	421	.93	1,077	1.01
62	.....	.....	.....	.....	611	.85	365	.96	976	.89
63	.....	.....	.....	.....	237	.95	112	1.14	340	1.02
64	.....	.....	.....	.....	167	1.06	127	1.25	294	1.14
65	.....	.....	.....	.....	172	1.05	135	1.37	307	1.19
68	.....	.....	32	1.56	241	1.10	253	.98	526	1.07
69	.....	.....	.....	.....	278	1.15	277	.95	555	1.05
70	.....	.....	.....	.....	446	1.07	290	1.13	736	1.10
73	.....	.....	64	1.22	195	1.26	179	1.23	438	1.24
Ave.	358	1.15	258	1.33	277	1.10	251	1.04	.....	1.16

Remarks: Tractor Nos. 7, 9, 21, 23b, and 36 had estimated lives of 2000 working hours; the life of No. 60 was set at 1750 hours; No. 17 was traded in at a good figure in 1923 after a total of 2997 hours use; Nos. 23a and 57 were also disposed of at very satisfactory prices; Nos. 33 and 56 were high priced outfits; No. 54, used a small number of hours per year had high fixed charges per hour of use, while in the case of No. 62 the opposite conditions prevailed; No. 55 was returned to the dealer at a \$300 loss to the farmer.

The cost of operating two-plow tractors in the northeastern area is summarized in Table 7.

The average hourly cost of the two-plow tractors was 15 cents more in the eastern than in the western area. This difference was due largely to higher repair bills in the former area.

TABLE 7.—Showing the highest and lowest cost per hour of operating individual 2-plow tractors and the average hourly cost
Northeastern Ohio

Year	Cost per hour		
	Highest	Lowest	Average
	<i>Dollars</i>	<i>Dollars</i>	<i>Dollars</i>
1919.....	3.73	0.62	1.21
1920.....	4.81	.80	1.55
1921.....	3.93	.83	1.31
1922.....	5.43	.65	1.17
4-year average	4.09	.67	1.31

The wide variation in operating costs per hour of work is due to several factors. In the first place, the purchase price is of importance. The interest charge and taxes are directly proportional to the original cost of the tractor. Depreciation, the largest item in the cost of tractor operation, amounts to twice as much per hour on a \$1200 machine as on a \$600 one, if the cheaper machine lasts as many hours as the higher priced one. A very important factor in determining what it will cost for each hour of tractor use is the mechanical skill and efficiency of the operator. Some of the highest repair bills in this study were due to carelessness and neglect on the part of the man using the tractor. Delay in getting new piston rings often ran the oil consumption to an exorbitant figure, one man using as much as five gallons per day. Failure to take time to grind valves and clean out carbon, a job ordinarily requiring from seven to ten hours, means loss of power and waste of fuel and time.

RELATION OF HOURS OF ANNUAL USE TO COST OF TRACTOR OPERATION

The number of hours of work done each year by the tractor is also important in determining what its hourly cost will be. This is true because several of the items entering into the cost of tractor operation do not depend on how many hours it is used. Fuel, oil, and chores are the only items which are directly proportional to the amount of work done. Depreciation and repairs depend somewhat

on how much work is done, but these items are not directly proportional to the hours of annual use. All the other items of annual cost—interest, taxes, shelter, and insurance—are the same on any individual tractor, be it used 500 hours or 5 hours a year.

Table 8 shows how the different items of cost vary with the amount of work done each year.

The hourly total of those costs not depending on the amount of work done decreased from 64 cents on tractors used 125 hours or less to 12 cents on those used over 375 hours per year. Depreciation, which depends somewhat on how much a tractor is used, was found to decrease from 77 cents per hour for machines used 125 hours or less, to 50 cents per hour for those working over 375 hours annually. The total repairs per tractor increased with the amount of work done but the hourly cost for repairs was only about one-third as much for tractors doing the larger amount of work.

The figures show that on the large farm, where a large amount of work can be done by the tractor, there is an opportunity of reducing the hourly cost of tractor operation. This will be reflected in the lower cost per acre for plowing or disking and further in the lower cost of producing a bushel of wheat or corn.

It should not be inferred, however, that every farmer should attempt to use his tractor as many hours per year as possible merely for the sake of cutting down the cost per hour. With increased use comes additional outlay for repairs, fuel, and oil. Thus, while it would seldom be sound practice to purchase a tractor on a farm where there is less than 25 days of tractor work to be done annually, the total annual cost of operation increased from \$158.96 for those machines used 125 hours or less to \$541.34 for those doing more than 375 hours annually.

CALCULATING THE PROBABLE COST OF TRACTOR OPERATION

To enable the prospective tractor owner to estimate in advance about what it will cost him to run his tractor, the following form has been constructed. This will give a conservative estimate of what may be expected. How closely this checks with the actual cost will depend largely on how efficient he is in the operation of the tractor, for on his efficiency depend largely the repair and oil cost per hour, and the depreciation, which is the largest item in the cost of tractor operation.

Another factor which will influence the accuracy of his calculation is how closely the total number of days actually worked per year corresponds to his estimate. The average tractor in this

TABLE 8.—Relation of hours of animal use to cost of tractor operation, 1919 to 1922

Items of cost	Hours of annual use														
	(58 records) 1 to 125 hours, average 75			(122 records) 126 to 250 hours, average 182			(82 records) 251 to 375 hours, average 304			(64 records) 376 hours or more, average 501			(326 records) Average hours, 256		
	Per tractor	Per hour	Percent of total cost	Per tractor	Per hour	Percent of total cost	Per tractor	Per hour	Percent of total cost	Per tractor	Per hour	Percent of total cost	Per tractor	Per hour	Percent of total cost
Not depending on amount of work done:															
Interest	\$37.24	\$0.50	23.4	\$45.54	\$0.25	16.0	\$39.05	\$0.13	10.0	\$45.23	\$0.09	8.4	\$42.37	\$0.16	12.5
Taxes	6.18	.08	3.9	7.59	.04	2.7	6.51	.02	1.7	7.56	.02	1.4	7.07	.03	2.1
Use of buildings	3.95	.05	2.5	4.16	.02	1.5	4.62	.02	1.2	4.58	.01	.8	4.35	.02	1.3
Insurance .....	.77	.01	.5	.57	.00	.2	.34	.00	.1	.34	.00	.1	.51	.00	.1
Total..	\$48.14	\$.61	30.3	\$57.86	\$.31	20.4	\$50.52	.17	13.0	\$57.71	\$.12	10.7	\$54.30	\$.21	16.0
Depending on amount of work done, but not proportional to it:															
Depreciation	\$57.30	\$.77	36.0	\$124.40	\$.69	43.8	\$174.30	\$.57	44.7	\$248.82	\$0.50	46.0	\$149.44	\$0.58	44.1
Repairs and expert labor ..	18.98	.25	12.0	29.25	.16	10.3	44.90	.15	11.5	47.11	.09	8.7	34.87	.14	10.3
Farm labor, repairing ..	1.68	.02	1.0	2.34	.01	.8	3.14	.01	.8	4.00	.01	.7	2.75	.01	.8
Total..	\$77.96	\$1.04	49.0	\$155.99	\$.86	54.9	\$222.34	\$.73	57.0	\$299.93	\$.60	55.4	\$187.06	\$.73	55.2
Proportional to amount of work done:															
<i>Kerosene, gallons</i>	<i>108</i>	<i>1.45</i>	.....	<i>262</i>	<i>1.44</i>	.....	<i>446</i>	<i>1.46</i>	.....	<i>705</i>	<i>1.5</i>	.....	<i>380</i>	<i>1.48</i>	.....
Kerosene, cost	\$17.69	\$.24	11.1	\$40.64	\$.23	14.3	\$68.40	\$.23	17.6	\$117.24	\$.23	21.6	\$58.58	\$.21	17.3
<i>Gasoline, gallons</i>	<i>18</i>	<i>.24</i>	.....	<i>32</i>	<i>.17</i>	.....	<i>58</i>	<i>.19</i>	.....	<i>62</i>	<i>.12</i>	.....	<i>42</i>	<i>.10</i>	.....
Gasoline, cost	4.91	.07	3.1	8.37	.05	2.9	13.42	.04	3.5	14.76	.03	2.7	10.28	.01	3.0
<i>Lubricating oil, gallons</i>	<i>11.5</i>	<i>.15</i>	.....	<i>24</i>	<i>.13</i>	.....	<i>37.5</i>	<i>.12</i>	.....	<i>59</i>	<i>.08</i>	.....	<i>32</i>	<i>.12</i>	.....
Lubricating oil, cost	8.08	.10	5.1	17.00	.09	6.0	28.58	.09	7.3	41.02	.08	7.6	23.04	.09	6.8
Farm labor, chores ..	2.18	.03	1.4	4.16	.02	1.5	6.39	.02	1.6	10.68	.02	2.0	5.65	.02	1.7
Total..	\$32.86	\$.44	20.7	\$70.17	\$.39	24.7	\$116.79	\$.38	30.0	\$183.70	\$.35	33.9	\$97.55	\$.38	28.8
Total cost, without driver.	158.96	2.12	100.0	284.02	1.56	100.0	389.65	1.28	100.0	\$541.34	1.08	100.0	338.91	1.32	100.0

investigation was used 256 hours per year. Then too, the newer types of tractors will undoubtedly have an average life far in excess of 150 days of actual use.

COST OF TRACTOR POWER FOR DIFFERENT OPERATIONS

The quantities of fuel and oil used per day at different kinds of drawbar and belt work have been given in Table 4.

The average cost per gallon of kerosene in 1921 and 1922 was 14 cents, of gasoline 22½ cents, and of lubricating oil 66.3 cents for the two-plow tractors in northeastern Ohio, and 82.5 cents for the two-plow and 73 cents for the three-plow machines in the northwestern part of the State.

TABLE 9.—Cost of operating a tractor per 10-hour day

Items of cost	Method of calculation	Cost per day
Depreciation.....	1/150 days × purchase price of tractor.....	\$
Interest.....	6 percent of average investment or 3.5 percent of purchase price ÷ number of days used per year.....	
Taxes.....	1/6 × interest charge.....	.
Building charge.....	\$4.35 ÷ number of days used per year.....	
Man labor, repairing..	.3 hour @ _____ per hour.....	.
Man labor, chores.....	.6 hour @ _____ per hour.....	
Repairs.....	3 to 6 percent of purchase price ÷ number of days used per year.....	.
Fuel.....	Average of 15 gallons kerosene @ _____ and 1.5 gallons gasoline @ _____	
Oil.....	Average of 1.25 gallons @ _____	.
Total cost.....		

In calculating the cost of doing ten hours of different kinds of work it is impossible to distribute to each job its exact share of each of the costs other than fuel and oil. On an operation which requires a large amount of fuel per day the tractor is either running at a high speed or drawing a heavy load, thus developing approximately its maximum horse power. When doing this it is wearing out faster than if it were being used at some operation requiring a small amount of fuel. Certainly an operation like plowing or disking reduces the value of a tractor more than does a light job like drawing a hay loader or grain binder. Similarly running a buzz saw does not cause a tractor to wear out nearly as quickly as does a heavy fuel-requiring job such as silo filling.

For this reason depreciation is distributed over the different kinds of work according to the quantity of fuel used. This depreciation in 1921 and 1922 amounted to 32.5 cents for every gallon of fuel used by the two-plow tractors in northeastern Ohio, 27.8 cents on the two-plow, and 48.8 cents on the three-plow machines in northwestern Ohio.

The costs other than fuel, oil, and depreciation were distributed according to the number of hours of each kind of work. This item, composed of interest, repairs, taxes, insurance, shelter, and farm labor repairing and chores, amounted to an average of 35.2 cents per hour for two-plow tractors in northeastern Ohio, 28.1 cents for the same size machines in the northwestern section, and 45.2 cents for the three-plow tractors.

By this method of calculation the average cost of a tractor, without operator, was more for drawbar work than for belt work. For silo filling and threshing, heavy belt work which consumed large amounts of fuel, the cost per day for tractor power was as much or more than for some of the heavier types of drawbar work.

Table 10 gives the cost for tractor power at different operations in 1921 and 1922.

TABLE 10.—Cost of tractor power for different operations, 1921 and 1922

Operation	3-plow tractors, N. W. Ohio			2-plow tractors, N. E. Ohio			2-plow tractors, N. W. Ohio		
	Cost per 10-hour day*	Acres per day	Cost per day	Cost per 10-hour day*	Acres per day	Cost per acre	Cost per 10-hour day	Acres per day	Cost per acre
	<i>Dol.</i>	<i>No.</i>	<i>Dol.</i>	<i>Dol.</i>	<i>No.</i>	<i>Dol.</i>	<i>Dol.</i>	<i>No.</i>	<i>Dol.</i>
Plowing.....	17.55	6.31	2.78	12.75	5.23	2.44	11.68	5.40	2.16
Disking.....	16.81	19.80	.85	12.80	16.52	.77	11.43	16.96	.67
Disking in combination.....	17.57	18.20	.97	12.88	15.56	.83	11.48	15.81	.73
Cutting grain.....	13.63	18.50	.74	11.22	13.36	.84	9.45	15.86	.60
Other drawbar work.....	14.00	.....	.....	11.63	.....	.....	9.83	.....	.....
All drawbar work.....	17.07	.....	.....	12.43	.....	.....	11.26	.....	.....
Filling silo.....	18.59	.....	.....	13.24	.....	.....	11.10	.....	.....
Threshing.....	17.87	.....	.....	14.25	.....	.....	11.02	.....	.....
Shredding.....	15.38	.....	.....	10.82	.....	.....	9.92	.....	.....
Grinding feed.....	12.49	.....	.....	12.06	.....	.....	9.52	.....	.....
Buzzing wood.....	12.93	.....	.....	9.98	.....	.....	8.98	.....	.....
Other belt work.....	12.85	.....	.....	11.83	.....	.....	9.19	.....	.....
All belt work.....	15.81	.....	.....	12.29	.....	.....	9.91	.....	.....
All operations.....	16.35	.....	.....	12.36	.....	.....	10.65	.....	.....

*Excluding value of tractor operator's time.

It should be remembered that the above costs are for tractor power only, and do not include the value of the tractor operator's time nor the depreciation, repairs and other costs on the various implements or machines, other than the tractor, used in the different operations.

No doubt the difference between the cost of drawbar and belt work done by these tractors was even greater than these figures indicate. Many of the working parts of these old models were unprotected against dust and the frame and running gear were not so constructed or designed as to withstand rough treatment.

The reason for the poor showing of the three-plow tractors at plowing and disking is found in the fact that most of these tractors were of a heavy, cumbersome make, no longer manufactured. Three of the three-plow tractors were not used at all for plowing on account of their weight, and with those used five farmers made a practice of removing one of the plows whenever the soil was in such condition that the tractor could not pull a three-bottom gang.

COST OF TRACTOR OPERATION IN 1924

Tractors purchased in 1924 were costing less to operate than those included in this investigation, due to the decline in the selling price of tractors since 1921, with a resulting decrease in the charges for depreciation, interest, and taxes. Improvements have been made in tractor construction and design, which will tend toward lengthening the tractor's life.

Of the twelve three-plow machines in northwestern Ohio on which costs of operation are given (see Table 10), ten, embracing four different makes, are no longer manufactured. One company has gone out of business and the other three are making two-plow outfits of entirely different design. Six of the twenty-seven two-plow tractors in the same area in 1921 and 1922 are no longer on the market. Figures on the operating cost of forty-seven tractors in northeastern Ohio are included in Table 10. Of that number nine are not being manufactured at the present time. One model, of which there were five tractors under observation in that area, is now being replaced by a much more satisfactory 2-bottom tractor.

In general the tractors of today are being made of better materials with a resulting decrease in weight. The new three-plow outfits, especially, are not so cumbersome as their predecessors. Some of the manufacturers are increasing the horse power of their tractors. Other improvements are noted in better lubrication, protection against dust, and better construction in the tractor frame.

It is therefore unwise to base the operating cost of the tractor of today on the performance of the machines of the past. All that can be done is to estimate what these same machines, if purchased today, would cost per hour of use. In order to arrive at a value to be placed on the discontinued models, their last quoted prices before liquidation have been reduced in the same proportion as the prices of the makes still on the market. This reduced theoretical purchase price results in smaller charges for depreciation, interest, and taxes. At the present time kerosene is costing about 14.5 cents a

gallon, gasoline 20 cents, and lubricating oil 60 cents. Assuming no change in the quantities of fuel and oil consumed and no change in repairs, building charges, and farm labor of repairing and chores, the costs of operating tractors bought in 1924 would be approximately 80 percent of the 1921 and 1922 average costs, or \$1.00 per hour for all tractors. The average cost of operating the three-plow tractors according to this calculation would be \$1.41 per hour. The two-plow outfits would average 96 cents an hour in northeastern Ohio and 90 cents in northwestern Ohio or 93 cents per hour for all two-plow outfits.

Table 11 shows how the 1924 daily costs for different operations, computed on the above basis, compare with the costs in 1921 and 1922. Depreciation on the tractors purchased in 1924 has been distributed according to the amount of fuel consumed. The remaining costs other than fuel were prorated over the different jobs according to the number of hours used.

TABLE 11.—Cost of tractor power per 10-hour day for different operations

Operation	1921 and 1922			1924		
	3-pow tractors	2-pow tractor-		3-pow tractors	2-pow tractors	
		N. E. Ohio	N. W. Ohio		N. E. Ohio	N. W. Ohio
Plowing.....	\$17.55	\$12.75	\$11.68	\$15.06	\$ 9.87	\$10.02
Disking.....	16.81	12.80	11.43	14.48	9.92	9.75
Disking in combination...	17.57	12.88	11.48	15.05	9.99	9.79
Cutting grain.....	13.63	11.22	9.46	11.53	8.75	8.04
Other drawbar work.....	14.00	11.63	9.83	12.07	9.05	8.36
All drawbar work.....	17.07	12.43	11.26	14.66	9.67	9.58
Filling silo.....	18.59	13.24	11.10	15.91	10.25	9.44
Threshing.....	17.87	14.25	11.02	15.44	10.97	9.43
Shredding.....	15.38	10.82	9.92	13.29	8.73	8.43
Grinding feed.....	12.49	12.06	9.52	10.78	9.37	8.13
Buzzing wood.....	12.93	9.98	8.98	11.16	7.81	7.59
Other belt work.....	12.85	11.83	9.19	11.08	9.15	7.80
All belt work.....	15.81	12.29	9.91	13.64	9.55	8.41
All operations.....	\$16.35	\$12.36	\$10.65	\$14.08	\$ 9.60	\$ 9.04

It should be borne in mind that in these 1924 estimates depreciation, interest, and taxes are based on the theoretical average present purchase prices of those tractors in use in 1921 and 1922. These average prices are practically the same as for the tractors now on the market, except for the three-plow outfits which are selling at a price about 20 percent higher than the figures used for these machines. However, the increased efficiency of the present day three-plow outfits would more than offset this. When comparing the above costs of operating three-plow and two-plow tractors, the increased amount of work accomplished with the larger outfit should be considered.

EFFECT OF TRACTOR ON FARM ORGANIZATION

There were 26 farms in northeastern Ohio and 19 in northwestern Ohio, or a total of 45, in the study for the full five years. This is a rather small number on which to base any very general conclusions. There were, however, 102 records taken the first year and about the same number each succeeding year until the last, when there was a total of 89 farms in the study. As farms dropped out of the study, for one reason or another, others were added. The trends shown by the summarization of the 45 farms in Tables 12 and 13 are borne out by the entire group of records.

TABLE 12.—Statistics on 26 tractor farms, northeastern Ohio

	1918	1919	1920	1921	1922
Size of Business					
Average farm area.....	209.6	208.5	223.5	213.3	218.7
Average crop area.....	92.0	94.4	105.8	95.9	93.0
Average number men.....	2.25	2.21	2.28	2.20	2.19
Total man-work units.....	549.	554.	649.	662.	657.
Number work horses.....	4.3	4.1	3.8	3.6	3.4
Total horse-work units.....	348.	348.	414.	365.	363.
Productive livestock units.....	23.	25.2	27.5	27.7	26.2
Total animal units.....	27.8	29.5	31.8	31.8	31.1
Labor Efficiency					
Crop acres per man.....	40.9	42.7	46.5	43.6	42.5
Animal units per man.....	12.5	12.8	13.5	14.4	14.2
Man-work units per man.....	241.	251.	285.	302.	300.
Crop acres per work horse.....	21.4	23.0	27.8	26.6	27.4
Horse-work units per horse.....	79	91.	110.0	102.	109.

TABLE 13.—Statistics on 19 tractor farms, northwestern Ohio

	1918	1919	1920	1921	1922
Size of Business					
Average farm area.....	171.4	188.7	188.2	191.6	178.4
Average crop area.....	118.2	128.4	129.2	133.1	120.8
Average number of men.....	2.20	2.12	2.26	2.20	1.98
Total man-work units.....	526.	618.	682.0	638.	586.
Number of work horses.....	4.7	4.4	4.2	4.1	3.8
Total horse-work units.....	468.	548.	532.	512.	471.
Productive livestock units.....	29.3	34.7	34.9	33.3	31.9
Total animal units.....	34.8	39.8	39.6	37.8	36.2
Labor Efficiency					
Crop acres per man.....	53.7	60.5	57.1	60.5	61.
Animal units per man.....	15.8	18.8	17.5	17.2	18.3
Man-work units per man.....	239.	292.	302.	290.	296.
Crop acres per work horse.....	25.1	29.1	30.7	32.4	31.5
Horse-work units per horse.....	100.	120.	126.	126.	121.

Note: During the year 1918, these farms were operated without the use of a tractor; during the other four years a tractor furnished part of the farm power.

SIZE OF BUSINESS

The addition of the tractor to the equipment of these farms resulted in very little increase in their average area during the five years. In western Ohio there was a net increase of 7 acres or 4.1 percent in the average size of farms during the five years; four farms increased their area during the period while three decreased. In eastern Ohio there was a net increase of 9.1 acres or 4.3 percent in size; six farms increased their area while three decreased. The change in crop area was even less. It is interesting to note that the crop area in western Ohio increased an average of 14.9 acres per farm up to 1921, but it fell off 12.3 acres the next year. In eastern Ohio the crop area per farm increased up to 1920 when 15 of the 26 men farmed a larger area; but following that there was a decline, the crop area per farm being only 1 acre more in 1922 than in 1918. The decline in total area and in crop acres per farm since 1920 can probably be assigned to the low prices which have prevailed since that year. Likewise, it is no doubt true, much of the increase during the earlier years was due to high prices rather than to the addition of a tractor to the equipment. Similar to the trend of crop area per farm, the amount of productive livestock increased up to 1920 or 1921 and since that time decreased. But in both sections the amount of livestock on these farms was greater four years following the purchase of the tractor than it was before the tractor was bought. This, however, may be in line with the general increase in livestock in the area rather than due to any effect of the tractor.

TABLE 14.—Change of size of farms

Total area	West Ohio		East Ohio		Both areas	
	1918	1922	1918	1922	1918	1922
99 acres or less.....	2	1	1	0	3	1
100—149 acres.....	8	7	9	6	17	13
150—199 acres.....	3	2	5	10	8	12
200—249 acres.....	3	6	3	3	6	9
250—299 acres.....	2	2	5	5	7	7
300 acres and over.....	1	1	3	2	4	3
Total.....	19	19	26	26	45	45

Another group of non-tractor farmers in Huron County, records of whose business have been kept continuously since 1918, followed about the same trends as these tractor farmers, increasing their crop area in 1920 and 1921 about nine percent or 7 acres over 1918, and then decreasing in 1922 to only 1.3 acres more than in 1918.

While there was little change in the average size of farms there was a decrease in the number of small farms. In western Ohio the farms seemed to be tending towards 200 to 250 acres in size, while in eastern Ohio the tendency was towards 150 to 200 acres.

The most common way of increasing the size of the farm was by renting additional land. It is not possible for all farmers to do this, since there may be no land for rent or even for sale in the neighborhood. Another way of increasing the size of business is to farm the land more thoroly, and a tractor should enable a farmer to do this. Eliminating one year in the rotation, thereby decreasing the acreage in hay, perhaps, and increasing that in corn and wheat, would require more drawbar power.

The ability to get the crop in earlier and thus get the benefits of a longer growing season is frequently given as one of the advantages to be derived from the ownership of a tractor. A study of the corn planting dates on nine tractor farms and seven horse farms in Medina County in 1922, 1923, and 1924 shows that the farmers having tractors had an average planting date four days earlier than those who had only horses. The men with tractors had 25.5 percent of their corn in the ground on May 20, those with horses only 6.4 percent.

In Greene County the tractor does not appear to have the same advantage over horses, as shown by a study of the corn planting dates on six tractor farms and ten horse farms. Those farmers doing all their plowing and fitting with horses had a planting date which averaged three days ahead of those who used tractors. There were these striking differences between the two types of farms:

	Tractor farms	Horse farms
Crop acres per farm	136.2	101.1
Acres of corn per farm	74.1	47.5
Work horses per farm	5.0	5.7
Crop acres per horse	27.2	17.7
Acres of corn per horse	14.8	8.3
Acres planted between May 20 and May 31	30.0	17.1
Acres planted by May 31	66.0	46.8

The season during which spring plowing can be done begins earlier in Greene County than in Medina. The men with tractors have a tendency to delay longer in starting to plow than those who have only horses. These two things, together with the fact the Greene County farmers without tractors had plenty of horses and a much smaller corn acreage than those who owned tractors, explains the difference between the effect of the tractor on planting dates in these two counties.

CHANGE IN HORSES

During the year preceding the purchase of tractors the men in the eastern group were farming 92 crop acres and keeping an average of 4.3 head of work horses, or one for each 21.4 acres; and those in the western area 118.2 acres of crops with an average of 4.7 head of work horses, or 25.1 crop acres per horse.

During the five years from March 1, 1918 to March 1, 1923 there was a reduction of 1.3 work horses per farm in the western area, a decrease of 26 percent. There was a further reduction in the number of colts and other horses not used for field work, equivalent to .7 horse unit. As the colts reached the working age the general practice was to break them and dispose of some of the older horses. About half of the farmers continued to keep a driving horse. The raising of colts was gradually discontinued, there being only 2 colts foaled on the 19 farms in 1922. In eastern Ohio the reduction during the five years was not quite so marked, there being a decrease of 1 work horse and .1 unit of other horses. Table 15 shows the changes in horses on these farms.

TABLE 15.—Horses per farm

Date	Western Ohio		Eastern Ohio	
	Work stock	Other horses	Work stock	Other horses
March 1, 1918	5.0	1.2	4.4	.7
March 1, 1919	4.4	1.2	4.3	.6
March 1, 1920	4.4	.7	3.9	.6
March 1, 1921	4.1	.6	3.7	.6
March 1, 1922	4.0	.6	3.5	.6
March 1, 1923	3.7	.5	3.4	.6

TABLE 16.—Work horses per farm, before and after purchase of tractor

Number of horses	Number of farms having specified numbers of work horses					
	Western Ohio		Eastern Ohio		Both areas	
	1918	1923	1918	1923	1918	1923
2	1	7	3	8	4	15
3	4	1	3	7	7	8
4	3	5	11	7	14	12
5	4	2	3	3	6	5
6	4	4	5	0	9	4
7	1	0	.....	.....	1	0
8	1	0	1	1	2	1
10	1	0	.....	.....	1	0
Total	19	19	26	26	45	45

Table 16 would seem to indicate that some farms did not go as far in reducing the number of horses kept as others. Many of the farmers said that they would have sold more horses had the horse market been better.

A large increase in the number of farms keeping two horses is noticeable. The large crop area per horse on those farms having two horses in 1922 (see Table 17) would indicate the possibility of farming with a small number of horses along with a tractor.

TABLE 17.—Crop acres per horse, 1922, on farms having specified number of work horses

	2 horses	3 horses	4 horses	5 horses	6 horses
Western	46	31	31	22	30
Eastern	43		21		

For any particular farm it may be said that the possible reduction in work horses after the purchase of a tractor depends on the number already on the farm, the work which will still have to be done with horses, and the possibility of hiring extra horses during rush seasons. In most sections of the corn belt the number of horses required for corn cultivation, provided cultivation is being done with horses, will determine the number that can be disposed of.

CHANGES IN HORSE FEED

In two similar sections in Ohio in which farm cost accounts have been kept since 1920 it has been found that the purchase of a tractor has resulted in the feeding of less hay and grain per remaining horse. The horses, doing less work, are on pasture a larger proportion of the time. Thus the reduction in corn fed per horse after the purchase of a tractor averaged 18 percent, oats 25 percent, and hay 10 percent. The increase in pasture was 18 percent. With corn at 80 cents per bushel, oats 50 cents, hay \$12 per ton, and pasture \$1.50 to \$2.50 per month, the net decrease in feed cost would be \$5 per horse per year in western Ohio, and \$7 per horse per year in the eastern area.

SAVING IN MAN LABOR

On these farms there was a slight reduction in the amount of man labor employed after the purchase of a tractor. There was also an increase in the crop area and amount of livestock, so that each man did more work after a tractor was introduced. Since

there were changes in size of farm business as well as changes in amount of labor, the saving in man labor can best be seen by referring to Table 18.

TABLE 18.—Crop acres and livestock per man

	Before purchase of tractor	After purchase of tractor					Percent increase
	1918	1919	1920	1921	1922	Average	
Crop acres per man . . West	53.7	60.5	57.1	60.5	61.0	59.8	11.4
Animal units per man . West	15.8	18.8	17.5	17.2	18.3	17.9	13.6
Crop acres per man . East	40.9	42.7	46.5	43.6	42.5	43.8	7.1
Animal units per man..East.	12.5	12.8	13.5	14.4	14.2	13.7	9.6

All of this saving of man labor cannot be credited to the tractor.* Part of the increase in work done per man may have been due to the increased use of other labor saving machines, such as the automobile and farm truck, milking machine, two-row cultivator, etc. It should be noted here, however, that the tractor farmer did have more time to spend on outside labor, that is, custom work away from the farm, either with horses or with the tractor. Total man work units per man increased from 241 to an average of 290 per year, or almost exactly 20 percent. (See Tables 12 and 13).

CHANGES IN COST OF POWER AND LABOR

In addition to the decrease in the cost of keeping horses, the reduction in the amount of man labor employed, and the additional outlay necessary for operating the tractor, there are several other factors which must be considered in computing what effect the introduction of a tractor has on the annual power and labor bill. Among these may be mentioned the changes (1) in the items of interest, depreciation, and repair costs on the machinery other than the tractor; (2) in the cost of hired belt work; and (3) in the receipts from work done with horses and tractors away from the farm.

In Tables 19 and 20 are summarized the changes in the combined net cost of power and labor due to the introduction of the tractor. In working out these tables the same prices per unit of horse feed were used for all five years. Likewise the fuel used by the tractor was valued at the average price paid during the four

*In the group of Huron County farms without tractors it was found that the amount of work done per man from 1919 to 1922 was more than that accomplished in 1918, there being an increase of 3.7 percent in crop acres and 11.4 percent in animal units per man, or about the same increase in livestock and only about two-fifths as much increase in crop acres per man as occurred on these two groups of tractor farms.

years, 16.3 cents a gallon, and the lubricating oil at 72 cents a gallon. The rates for labor were also kept constant, at \$45 per month for hired labor, \$35 per month for unpaid family labor, and \$50 per month for the farm operator's labor. These constant values thus eliminate any differences in power or labor cost which may have been due to changes in industrial and agricultural conditions. The costs of keeping only the work horses are included in these tables, no consideration being given to the feed, labor, etc., on colts and driving horses.

In 1918, before the purchase of a tractor, the net cost of power and labor on the farms in the western area was \$2050 (this includes a value of \$600 on the farm operator's labor), or \$17.34 per crop acre. Following the purchase of a tractor the total net cost rose the first year to \$2337, an increase of \$287 over the previous year. The combined effect of the reduction in cost of keeping the work horses, the reduction in cost of hired belt work, the slight decrease in labor cost, and the increased returns from outside work were not sufficient to overcome the combined cost of operating the tractor and the additional upkeep and interest charges on equipment purchased for use with the tractor, such as plows, disks, and other tillage tools, feed grinders, silage cutters, corn huskers, and other machines used for belt work. There had been an increase of 10.2 crop acres per farm, so the cost of power and labor was \$18.20 per crop acre, compared with \$17.34 when horses alone were used. After the first year following the addition of a tractor, the total net cost of power and labor as well as the cost per crop acre showed a decrease from year to year. This was due to the fact that the number of work horses was still being reduced, the cost of hired belt work was becoming less, and the receipts from custom work done with the tractor were increasing. The per-acre cost of power and labor showed an average of \$17.01 for the years when tractors were used, as compared with \$17.34 for the year when tractors were not used.

In the eastern area the introduction of the tractor has not brought about any saving in power and labor cost. Only during 1920, when the crop area per farm was at its height, was the cost of power and labor per crop acre less than it was when horses furnished the power. During the other years the total as well as the per-acre costs were higher than before the purchase of the tractor, the cost of power and labor per crop acre being \$22.24 as an average for the four years with tractors as compared with \$21.89 per crop

acre when horses furnished the power. The reasons for the difference between the effect of the tractor on power and labor cost in the two sections are that a bigger saving in man labor together with a larger increase in size of farm was effected by the introduction of the tractor in the western area, and here too there was a greater decrease in the cost of hired belt power.

In these two tables the cost of tractor operation includes depreciation and interest charges based on the original purchase prices, which were much higher than in 1924. It was shown in the section entitled "Cost of Tractor Operation in 1924" that the present estimated cost of operation of the average tractor would be \$1 per hour, of the two-plow outfit 93 cents per hour. This reduction of \$50 to \$100 in the annual cost of operating a tractor would be just about enough to bring the annual power and labor bill in the eastern area down to where it was before tractors were purchased. Then there is a possibility of further reduction in the number of work horses, with a corresponding decrease in the cost of keeping them.

It has sometimes been stated that a tractor will be unprofitable unless enough horses can be disposed of to bring about a reduction in the cost of their keep sufficient to cover the annual cost of operating the tractor. This is sound if the tractor has no effect on the amount of man labor employed, does not enable the farmer to increase the size of his business, and if the tractor is used only for drawbar work on the home farm.

Home belt work constituted 19 percent of the total work done by the tractors in western Ohio, or an average of 52 hours annually per farm for the four years. Of course a few of the belt operations, such as sawing wood, did not contribute much toward making the tractor pay for itself; but the fact remains that the average cash outlay for belt work was reduced from \$175 to an average of \$120 annually for the four years following the purchase of a tractor, and to an average of \$95 in 1921 and 1922.

In eastern Ohio the tractors were not used to as large an extent for belt work as in the western area. In the farmer 21 of the 26 men used their tractors for some form of home belt work, but averaged only 24 hours annually per farm for the four years. The cost of hired belt work was reduced from \$120 to an average of \$83 annually following the introduction of the tractor.

That these decreases in the cost of hired belt work were not due to a decline in the rates charged for threshing or other belt work is shown in Table 21.

TABLE 19.—Cost of power and labor per farm
19 farms, western Ohio

	Before purchase of tractor	After purchase of tractor			
	1918	1919	1920	1921	1922
Work Horses, average for year Number..	4.7	4.4	4.2	4.1	3.8
Other horse units. Number..	1.2	.9	.6	.6	.5
Total horse units. Number..	5.9	5.3	4.8	4.7	4.3
Cost of Keeping Work Horses					
Feed. Dollars..	287	242	231	226	209
Man labor Dollars..	94	70	67	66	61
Depreciation. Dollars..	56	53	50	49	46
Interest. Dollars..	28	26	25	25	23
Shoeing Dollars..	22	21	21	20	17
Other costs Dollars..	61	57	55	53	49
Total work horse costs Dollars..	548	469	449	439	405
Cost per work horse. Dollars..	117	107	107	107	107
Tractors					
Drawbar work Hours..		230	153	157	140
Home belt work. Hours..		56	56	54	44
Custom work. Hours..		40	41	54	83
Total work. Hours..		326	250	265	267
Fuel cost Dollars..		85	72	75	78
Oil cost Dollars..		30	124	22	26
Depreciation. Dollars..		184	39	152	144
Repairs. Dollars..		39	16	28	33
Interest. Dollars..		54	45	36	31
Other costs Dollars..		20	18	17	18
Total tractor costs Dollars..		413	314	330	330
Cost per hour horse. Dollars..		1.27	1.26	1.25	1.24
Other Machinery Costs					
Depreciation Dollars..	141	189	185	174	162
Interest at 6 percent. Dollars..	69	89	88	87	80
Repairs Dollars..	34	36	40	33	25
Total other machinery costs. Dollars..	244	314	313	294	267
Cost of belt work hired. Dollars..	175	149	143	106	83
Field machine work hired. Dollars..	8	7	2		
Labor					
Hired labor, months. Number..	8.0	7.1	8.8	8.6	4.2
Family labor, months Number..	6.4	6.3	6.3	5.8	7.6
Total labor, months. Number..	26.4	25.4	27.1	26.4	23.8
Total cost labor* Dollars..	1,090	1,064	1,143	1,117	986
Gross cost, power and labor. Dollars..	2,065	2,416	2,364	2,286	2,071
Receipts, horse and tractor work. Dollars..	15	79	78	121	158
Net cost, power and labor Dollars..	2,050	2,337	2,286	2,165	1,913
Crop acres Number..	118.2	128.4	129.2	133.1	120.8
Net cost per crop acre Dollars..	17.34	18.20	17.69	16.27	15.84

*Other than labor on work horses and tractor.

TABLE 20.—Cost of power and labor per farm
26 farms, eastern Ohio

	Before purchase of tractor	After purchase of tractor			
	1918	1919	1920	1921	1922
Work horses Number..	4.3	4.1	3.8	3.6	3.4
Other horse units..... Number..	.7	.6	.6	.6	.6
Total horse units..... Number..	5.0	4.7	4.4	4.2	4.0
Cost of Keeping Work Horses					
Feed Dollars..	327	283	262	248	235
Man labor Dollars..	86	66	61	58	54
Depreciation Dollars..	52	49	46	43	41
Interest Dollars..	26	25	23	22	20
Shoeing Dollars..	26	24	21	19	17
Other costs Dollars..	52	49	46	43	41
Total work horse costs..... Dollars..	569	496	459	433	408
Cost per work horse..... Dollars..	132	121	121	120	120
Tractors					
Drawbar work Hours.....		234	213	199	208
Home belt work Hours.....		16	26	27	28
Custom work..... Hours.....		62	43	55	40
Total work..... Hours.....		312	282	281	266
Fuel cost..... Dollars.....		84	78	78	73
Oil cost..... Dollars.....		29	27	27	25
Depreciation..... Dollars.....		168	160	154	134
Repairs..... Dollars.....		24	74	49	38
Interest..... Dollars.....		47	38	31	25
Other costs..... Dollars.....		20	18	18	18
Total tractor costs..... Dollars..		372	395	357	313
Cost per hour..... Dollars.....		1.19	1.40	1.27	1.18
Other Machinery Costs					
Depreciation..... Dollars..	117	154	152	142	138
Interest at 6 percent..... Dollars..	59	74	77	71	70
Repairs..... Dollars.....	34	40	44	37	34
Total other machinery costs..... Dollars..	210	268	273	250	242
Cost of belt work hired..... Dollars..	120	81	86	80	85
Field machine work hired..... Dollars..	5	3	1		
Labor					
Hired labor, months..... Number..	8.2	8.3	8.8	9.0	9.0
Family labor, months..... Number..	6.8	6.2	6.6	5.4	5.3
Total labor, months..... Number..	27.0	26.5	27.4	26.4	26.3
Total cost labor*..... Dollars..	1,121	1,127	1,159	1,128	1,127
Gross cost power, and labor..... Dollars..	2,025	2,347	2,373	2,248	2,175
Receipts, horse and tractor work..... Dollars..	11	160	110	119	99
Net cost, power and labor..... Dollars..	2,014	2,187	2,263	2,129	2,076
Crop acres..... Number.....	92.0	94.4	105.8	95.9	93.0
Net cost per crop acre..... Dollars..	21.89	23.17	21.39	22.22	22.32

*Other than labor on work horses and tractor.

Altho it would not be sound practice for a farmer to purchase a tractor with the expectation of paying for it, and all the additional costs resulting therefrom, out of the savings made in doing his own belt work or from receipts for custom work, yet the doing of custom work should be regarded as a possible means of reducing the total power and labor costs. It would be unwise for a farmer to do custom work of any sort unless he receive enough to pay wages for his own time, the oil and fuel for the tractor, and something to cover depreciation and repair charges due to this extra work.

TABLE 21.—Average rates charged for threshing, in cents per bushel

Area	Grain	1918	1919	1920	1921	1922
Western { ...	Wheat	6½	7	8	7	6½
	Oats	4	4½	5½	4	4
Eastern { .	Wheat	6	7½	8	8	6½
	Oats	4	4½	5	4½	4

The rates received for custom work varied from \$1 to \$3 or more per hour depending on the nature of the work and the other tools furnished. In the eastern area silo filling constituted 32.9 percent of the custom work done, plowing and disking 31 percent, road scraping 16.3 percent, threshing 10.8 percent. In the western area belt work was the major kind of custom work done, corn husking constituting 37.3, threshing 31.3, silo filling 17.8, and plowing and other field work 10.5 percent.

SHALL I BUY A TRACTOR?

Assuming that the farmer or some member of his family has sufficient mechanical ability to operate a tractor efficiently, thereby keeping down repair, fuel, and depreciation charges, the first question that ought to be decided is whether or not the tractor will prove to be a profitable investment. From what has been presented it is evident that a tractor will not be profitable unless it enables the farmer to do one or more of the following: (1) Reduce the number of work stock on the farm; (2) reduce the amount of hired or unpaid family labor required; (3) farm an increased acreage or the same acreage more thoroly or care for more livestock; (4) reduce the cost of hired belt work; or (5) do some custom work in the neighborhood at a profit.

As an example, let us suppose that a farm previously operated with six horses is able to dispose of one horse. The farmer estimates that he will use the tractor 300 hours annually. Supple-

mentary equipment valued at \$300 is purchased. The total annual charge for depreciation, repairs, and interest on this equipment will be about 20 percent. One month of hired labor is eliminated. The farmer does his own silo filling, thereby saving a cash expense of \$35. Forty hours of custom work can be done for neighbors at \$2 an hour. This information could be worked out in the form given in Table 22.

TABLE 22.—Method of calculating the differences in power and labor costs

	Before purchasing a tractor	After purchasing a tractor
Cost of keeping (6) horses @ (\$110) per year.	\$660	
Cost of keeping (5) horses @ (\$100) per year.		\$500
Cost of operating tractor (300) hours @ (\$1)		300
Additional equipment costs.		60
(\$300) Investment @ (20%) per year.		
Totals.	\$660	\$860
Increase in power cost.		\$200
Reduction in labor (1) month @ (\$45)		45
Reduction in cost of hired belt work		35
Returns from custom work		80
Total.		\$160
Increase in power and labor cost.		\$ 40

In this particular case the farmer would gain nothing in dollars and cents thru the purchase of a tractor, unless he increased his crop area or crop yields. In order to break even he would have to raise a crop having a net value of only \$40 more. However, had he reduced the number of work horses to four, the cost of power and labor would have been decreased \$60 due to the purchase of a tractor.

Generally there are other factors that enter into the farmer's decision. Many farmers in this survey expressed the opinion that it was costing more to farm with a tractor than if they were doing the work with horses; but, since the tractor enabled them to be relieved of considerable worry and to get their work done in a shorter time, they were satisfied, in the large majority of cases, even tho it were costing more. Being able to do the field work more quickly and to start the milking and other chores without having to tend a team of horses, thereby putting in shorter hours, was a big factor in the eastern area, a dairy region.

SUMMARY

The tractors in this survey were being used an average of 256 hours per year.

On the basis of statements made by farmers at the close of the survey the tractors were estimated to have a total life of 1794 working hours. On the basis of the amount received for tractors disposed of, the working life of these tractors would be 1703 hours.

Depreciation is the largest item in the cost of tractor operation, being 44.1 percent of the total cost.

Repairs averaged \$34.87 per year, or 10.3 percent of the operating cost.

Two-plow tractors required an average of 16.5 gallons of fuel and 1.2 gallons of lubricating oil per 10-hour day. Three-plow outfits required 17.2 gallons of fuel and 1.2 gallons of oil per 10 hours.

There was a wide variation in the cost of operating individual tractors. The cost of two-plow tractors, for instance, varied from 67 cents to \$4.09 per hour. Chief among the factors causing these wide variations are the efficiency of the operator and the number of hours of annual tractor use.

In 1924 the average hourly cost of operating two-plow tractors was estimated at 93 cents, three-plow tractors \$1.41.

Following the introduction of tractors there has been an increase of approximately 20 percent in the amount of work done per man. Not all of this saving of man-labor can be credited to the tractor, however.

There was a reduction of 1.3 work horses per farm in western Ohio and 1 work horse per farm in eastern Ohio, an average reduction of 24.5 percent.

The tractor made possible a reduction in the amount of feed fed to each remaining work horse.

In western Ohio, but not in eastern Ohio, there was an actual reduction in the combined cost of power and labor per crop-acre following the purchase of tractors.

Before a tractor can be considered a profitable investment it should enable the farmer to do one or more of the following: (1) reduce the number of work horses; (2) reduce the amount of hired labor; (3) farm an increased acreage or the same acreage more thoroughly; (4) reduce the cost of hired belt work; or (5) do some custom work at a profit.