MAY 1960 ECONOMIC REPORT No. 61

ECONOMIC ASPECTS

of

TRACTOR WORK

1958-59 CROP YEAR

by

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Hill Sheep Farms, Stock Rearing Farms — Reports for the years 1948-49 to 1957-58

Stock Raising and Feeding Farms, Arable Farms, Dairy Farms — Reports for the years 1948-49 to 1957-58

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Piece-Work Potato Gathering
Hill Farming During the Post-War Period
Some Notes on Reseeding Old Grassland on Hill and Upland Farms, 1955-57
Diesel Tractor Costs and Performance in the East of Scotland, 1956-57
Some Notes on Grain Drying - 1957 Harvest
Report on Grain Drying - 1958 Harvest
Organisation of Hill and Upland Farming in Selkirkshire
Economic Aspects of Tractor Work, 1957-58

Copies of these publications may be obtained on request to the Secretary of the College or the Advisory Economist.

FOREWORD

Increased efficiency, a term which is usually taken as synonymous with lower costs per unit, is being brought very much to the forefront following a Price Review which has had the effect generally of reducing the margins between production costs and producers' returns. The farmer, of necessity, must give more thought to all and every means whereby he can achieve a higher level of efficiency and, at a time when the tractor has such an important place in the economy of our farms, the factors which affect the working costs of these power units must be carefully studied.

In this report Mr. Horsburgh has continued the investigation initiated in 1958 but with a different sample of farms. No formula is laid down which will ensure the most efficient use of tractors on any farm but the principal factors which affect the costs per working hour are examined separately and indiciations are given as to how these factors will affect costs. The presentation of the data in this way should be helpful to farmers when considering how to make the most efficient use of their machines.

J. D. NUTT.

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TRACTOR REPORT - 1958-59

I. INTRODUCTION

This survey, the second of an investigation into the economics of farm tractors, was carried out on twenty-five farms in West Lothian. The operating costs were extracted from the farm accounts covering the 1958-59 crop year. Information was also obtained about the work done by the tractors and from this an assessment made of the total hours worked during the year.

The purpose of this study is to compare the utilisation and cost of tractors on farms with different work requirements. The study also throws some light on the problems associated with the use of tractors on the smaller farm.

II. TRACTOR WORK REQUIREMENTS

The total hours worked by the tractors in relation to the extent and type of cropping on each individual farm is shown in Table I.

TABLE I. TRACTOR WORK REQUIREMENTS AND CROPPING

Code No.	Total Cropping Acreage	Total Hours Worked	Total Hours		Distribution of Cropping per 100 Acres				Hours Worked on Cropping per Acre
			On Cropping	On Other Work	Grain	Hay and Silage	Potatoes	Other Roots	
					%	%	%	%	
11	215	3725	2881	844	63	19	10½	7½	13.4
3	200	2489	2435	54	60½	17½	11½	10½	12.2
23	191	3685	2405	1280	59	31	-	10	12.6
22	148	1027	905	122	66	29	-	5	6.1
20	146	2044	1686	358	52	25	11	12	11.5
28	141	2033	1777	256	53	30	4	13	14.4
14	136	1641	1560	81	64	21	7	8	11.5
19	120	2056	1746	310	35	50	9	6	14.6
27	98	1217	1193	24	44	34	3	19	12.4
10	94½	1428	1242	186	51	17	11	20	13.2
7	94	1372	1221	151	46	35	13	6	13.0
6	84	993	859	134	55	29	9	7	10.2
21	77	828	790	38	52	30	9	7	10.3
16	76	993	768	225	50	30	1	19	10.1
9	75¼	1321	1099	222	70	12	13	5	14.6
5	72½	696	637	59	50	41	3	6	8.8
2	69¼	1250	1124	126	48	25	14	13	16.2
13	68	1220	1106	114	51	30	12	7	16.3
8	66	792	708	84	71	9	15	5	10.7
24	65½	774	634	140	54	35	3	8	9.7
1	64½	609	373	236	53	46	1	-	5.8
18	63	597	257	340	44	46	1	9	4.1
17	56½	716	586	130	40½	40½	9	10	10.4
4	20½	281	251	30	49	-	2	49	12.2
25	12½	205	151	54	68	32	-	-	12.1
Average	98	1360	1136	224	54	29	7	10	11.5

As /

As might have been expected, work on the cropping took up the largest share of the tractors' time. With few exceptions general haulage and belt work were of minor importance, accounting on average for only 16.5 per cent of the total hours worked. The actual acreage of cropping will largely determine the total tractor requirements of the farm and this is shown by the total hours worked. There are, however, marked variations in the intensity of use of tractors as measured by the number of hours worked per acre. The reason for this lies in the relative importance of different crops in the total cropping acreages. As shown in Table II root crops call for some 3-4 times as much tractor work as do grain and hay crops. It follows that even small variations in the root acreage can exert a considerable influence on the amount of tractor work on a farm. While the acreage of root crops averaged only 17 per cent of the total cropping, the time spent by the tractors on these crops was relatively high at 35 per cent of the total hours worked.

TABLE II. NUMBER OF TRACTOR HOURS REQUIRED FOR DIFFERENT CROPS

	Grain	Hay	Potatoes	Turnips and Swedes	Other
Average Tractor Hours per 100 Acres	818	694	2982	2319	1829

It is obvious from the figures in this table that the amount of tractor work to be done on farms of similar size may be very different. For instance, a grain and grassland farm will have a very different work requirement from one which has a high proportion of root crops demanding a relatively high input of tractor hours.

III. TRACTOR COMPLEMENTS AND WORK REQUIREMENTS

Since an important factor affecting the size of the tractor force required on a farm is the amount of work to be done, rather than the acreage to be worked, the farms in this sample have been divided into three different work requirement groups.

1. 'Small' farms - with total work requirement of under 1000 hours
2. 'Medium' farms - " " " " " 1000-2000 "
3. 'Large' farms - " " " " " over 2000 "

The following table shows the number of tractors employed in each of these groups. The average number of hours worked per tractor and the cropping acreage per tractor are also given.

TABLE III. TRACTOR COMPLEMENTS AND WORK REQUIREMENTS

	All Farms	'Small' Farms Under 1000 Hours	'Medium' Farms 1000-2000 Hours	'Large' Farms Over 2000 Hours
Number of Farms	25	11	8	6
Number of Tractors per Farm	2.24	1.7	2.3	3.2
Average Number of Hours Worked per Tractor	585	436	597	844
Average Cropping Acreage per Tractor	45	39	46	54

As /

As the total hours worked per farm increased, the numbers of tractors employed rose from an average of 1.7 to 3.2 per farm. But the figures for the number of hours worked per tractor show that it was not necessary to increase the number of tractors in the same proportion as the total volume of tractor work to be done increased. The average figures for the hours worked increased from 436 per tractor on the 'small' farm to 844 on the 'large' farm; if this increase in the hours worked per tractor had not been possible, the 'large' farms would have required at least 5 tractors per farm instead of an average of 3.2.

All these figures support the general contention that the small scale operator (normally the farmer on a limited cropping acreage) requires a proportionately larger tractor force in relation to the amount of work to be done. This results in a low (and possibly uneconomic) level of tractor usage per annum which may lead to heavier charges for overhead costs such as depreciation.

IV. TRACTOR COMPLEMENTS AND SEASONAL WORK DISTRIBUTION

While the total amount of work to be done on a farm is one important factor affecting the size of tractor force required, the effect of seasonal variations must be taken into account. This is because the farmer does not budget the number of tractors he will require only with regard to the total amount of work to be done, but also with regard to the amount to be done at the busiest season of the year.

The seasonal pattern of work for the 25 farms as represented by the number of hours per tractor per month is shown in Chart I.

This chart shows two marked seasonal peaks - one in the spring and one in the autumn - with slack periods during mid-summer and winter. Where the regular tractor force on a farm is already fully employed, spare tractors may be required to cope with these peak demands. As mentioned in the foregoing section, however, tractors on the 'small' farms were under-employed compared with those on the larger farms. This was not due to seasonal effects but because of the difficulty of obtaining a balance between the number of tractors employed and the total amount of work to be done. Seasonal peak demands are, therefore, less likely to influence the size of tractor force required on 'small' farms. The figures in Table IV show that even at the busiest time of the year the tractors on the 'small' farms were not as fully employed as those on the larger farms.

TABLE IV. /

CHART I. AVERAGE MONTHLY SEASONAL PATTERN OF WORK - HOURS PER TRACTOR

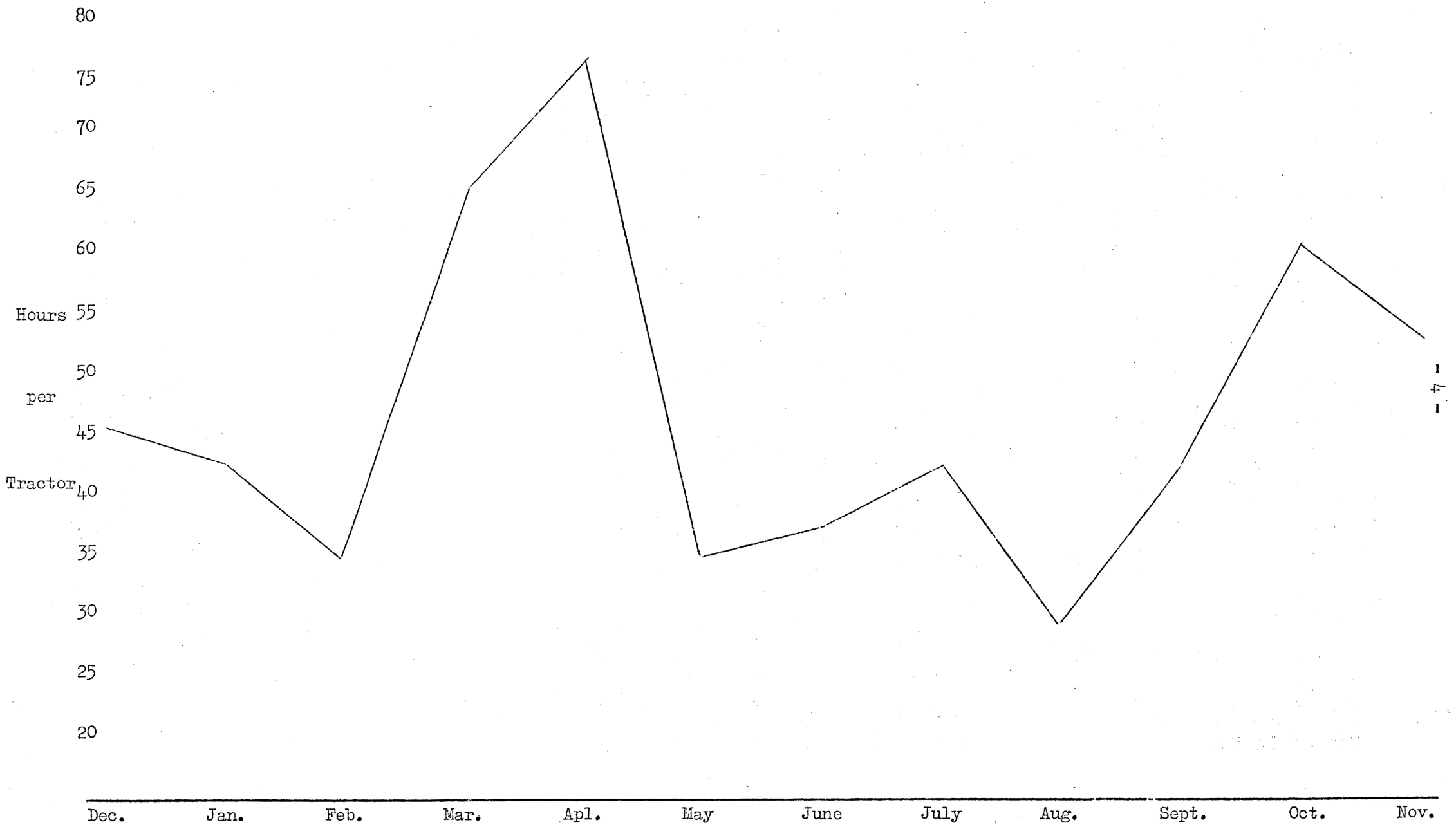

TABLE IV. PEAK NUMBER OF HOURS WORKED PER TRACTOR PER MONTH

Farm Size Group Total Hours Worked	Average Number of Hours Worked per Tractor at Peak Month
	(Hours)
Under 1000 hours ('small' farms)	75
1000-2000 hours ('medium' farms)	101
Over 2000 hours ('large' farms)	145

The fact that there are peaks of tractor work during the year makes it necessary to carry a reserve tractor or tractors on some farms. This is more likely to occur on the 'large' farms than on the 'small' farms where under-employment of tractors is already a major problem. The presence of reserve tractors on any farm will, of course, tend to reduce the average number of hours worked per tractor, but even in this respect the 'large' farms will have an advantage over the 'small' farms. The greater number of tractor hours to be worked on the former calls, indeed, for more tractors per farm but also allows for a higher rate of usage. The same factor will apply to the use of a reserve tractor on a 'large' farm and will result in a lesser reduction in the average hours worked per tractor than would be the case on the 'small' farm where the addition of one reserve tractor to, say, two regular tractors would mean a much greater reduction in the average hours per tractor than would be the case where one reserve is added to five regular tractors. It must, however, be pointed out that the presence of peak requirements for tractor work which necessitate the employment of reserve tractor force does reduce the average hours worked per tractor much below the potential for individual machines*.

Chart II on the following page shows the average number of hours worked per tractor in relation to the total amount of work available on the 25 farms.

This chart shows a marked increase in the average annual usage of tractors on farms returning total work schedules upwards of 2000 hours per annum. Thereafter there appears to be a falling off in the rate of increase in tractor usage on the larger farms.

The general conclusion would seem to be that while the rates of tractor usage per annum were considerably higher on the 'large' farms, seasonal requirements were of some importance. Such requirements tend to reduce the overall average hours worked per tractor per year due to the necessity to provide additional tractor power at peak periods. In the case of the 'small' farm this additional tractor power may well be provided for by the existing under-employment of the tractor(s). In the case of the 'large' farm the better fit between numbers of regular tractors and the overall annual requirements may mean keeping a reserve or spare tractor. The reduction of peak requirements by the use of larger size implements, by spreading the work load as far as possible or by improvements in the actual organisation of field operations would do much to further enhance the efficiency of tractor work on the 'large' farms in terms of hours of work per tractor per annum.

CHART II. /

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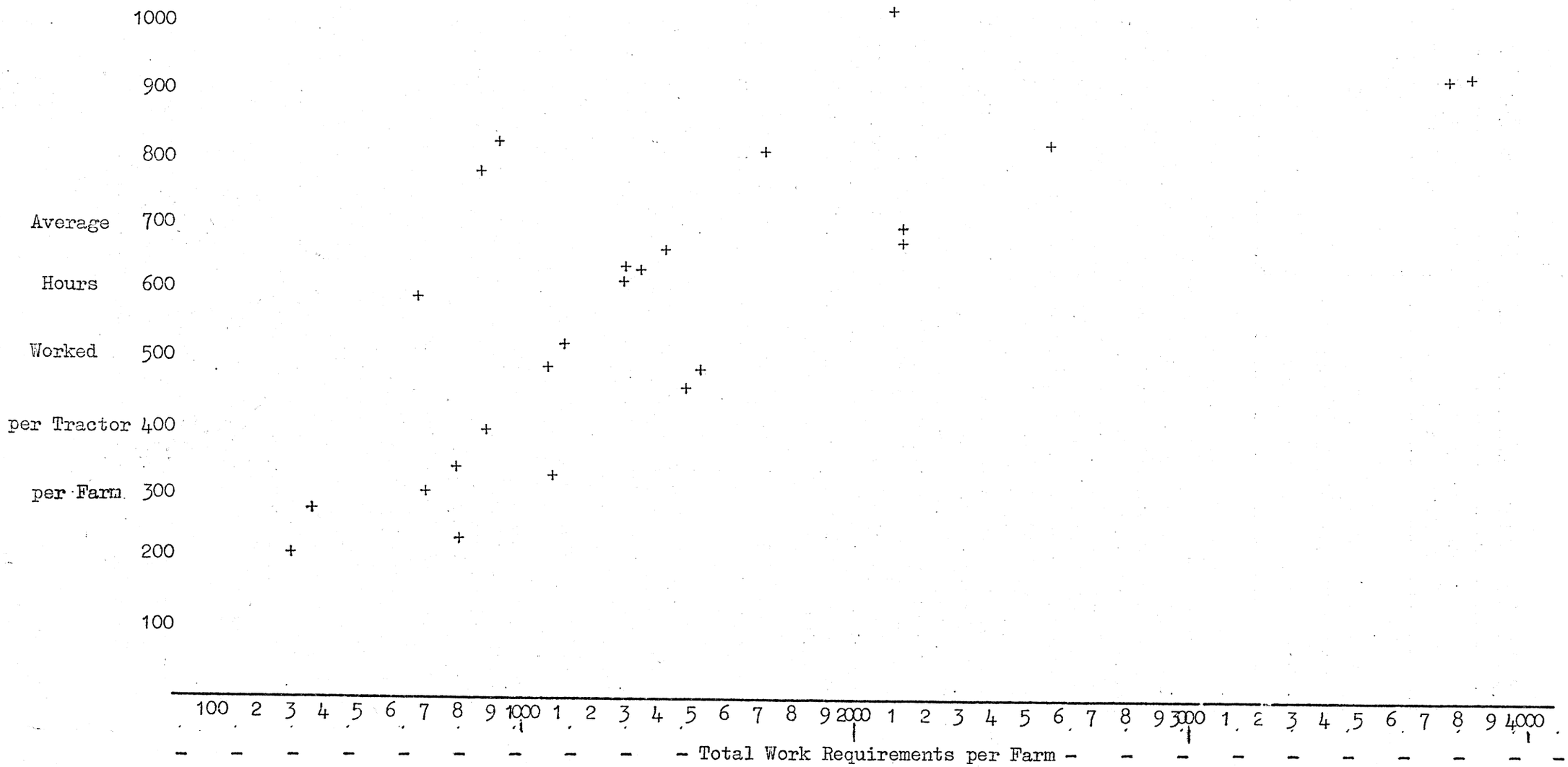
* Report No. 48 - "Diesel Tractor Costs and Performance - 1956-57". Hours worked by individual tractors averaged 1352 hours per year.

CHART II. AVERAGE ANNUAL USAGE OF TRACTORS ON FARMS WITH VARYING WORK REQUIREMENTS



V. TRACTOR COSTS

The first section of this report was mainly concerned with the factors affecting the number and utilisation of tractors on farms with varying total work requirements. The evidence presented showed that the 'smaller' farms employed a much greater tractor force in relation to the amount of work available. This was reflected in the much lower average annual rates of usage per tractor obtained on these farms.

It now remains to see what effect these differences have in terms of cost between the 'large' and 'small' farms in this sample. Table V compares the average costs per tractor and per hour for the three tractor work requirement groups previously described.

The costs of operating a tractor are generally considered to fall into two distinct categories - running costs and fixed charges. The former is directly related to the amount of work done and comprises fuel, minor repairs and servicing. Fixed charges, on the other hand, are incurred irrespective of the work done and comprise depreciation, major overhauls and replacements, as well as the standing charges for road tax and insurance. It follows that a moderate total cost per hour depends essentially on there being a sufficient number of work hours over which to spread these fixed costs. The 'small' farms with low average rates of tractor usage would, therefore, be expected to have high fixed costs per hour, but the figures in Table V show that fixed costs per hour on the 'small' and 'medium' sized farms were, in fact, less than on the 'large' farms. This was mainly due to the lower levels of depreciation cost per tractor on the smaller farms.

The running costs of the tractors on the smaller farms were, however, a rather different story. On these farms average costs per hour for both fuel, and minor repairs and servicing, were much higher. While this resulted in higher total costs per hour for the tractors on the 'small' farms, the 'medium' farms were able to combine low fixed charges with moderate running costs - the net result being a total cost per hour roughly the same as that on the larger farms.

Table V shows that the differences in fuel cost can be attributed to the greater dependence of the smaller farms on vaporising oil type tractors. The quantities of vaporising oil used on these farms averaged two-thirds of the total fuel compared with only one-quarter on the 'large' farms.

A comparison between eight farms using all diesel and seven which used only vaporising oil tractors showed that the fuel cost for the diesel was 1s. per hour for an average consumption of .58 gallons per hour, while for the vaporising oil the comparable figures were 2s.2d. and 1.0 gallons per hour.

TABLE V. /

TABLE V. TRACTOR COSTS AND WORK REQUIREMENTS

	All Farms				'Large' Farms (Over 2000 Hours)				'Medium' Farms (1000–2000 Hours)				'Small' Farms (Under 1000 Hours)			
	Costs per Tractor		Costs per Hour		Costs per Tractor		Costs per Hour		Costs per Tractor		Costs per Hour		Costs per Tractor		Costs per Hour	
	£	£	s.	d.	£	£	s.	d.	£	£	s.	d.	£	£	s.	d.
Fixed Costs :																
Depreciation	29		1:	-	48.5		1:	1¾	28		-:	11¼	16		-:	9
Major Overhauls and Replacements	20.5		-:	8½	25.5		-:	7	10.5		-:	4¼	16		-:	9
TOTAL		49.5	1:	8½		74	1:	8¾		38.5	1:	3½		32	1:	6
Tax and Insurance		4.5	-:	1¾		5	-:	1½		5.5	-:	2¼		3	-:	1¾
TOTAL FIXED COSTS		54	1:	10¼		79	1:	10¼		44	1:	5¾		35	1:	7¾
Running Costs :																
Fuel (Diesel, Vap. Oil, Petrol, Lub. Oil)	42		1:	5	50.5		1:	2½	37		1:	3	37.5		1:	8¾
Minor Repairs and Servicing	10		-:	4	9		-:	2¾	12		-:	4¾	9.5		-:	5¼
TOTAL RUNNING COSTS		52	1:	9		59.5	1:	5¼		49	1:	7¾		47	2:	2
TOTAL TRACTOR COSTS		106	3:	7¼		138.5	3:	3½		93	3:	1½		82	3:	9¾
Percentage Fuel Consumption :		%				%				%				%		
Diesel		56				74				60				34		
Vap. Oil		44				26				40				66		

VI. DEPRECIATION COST

The annual depreciation charge was not calculated at the current inland revenue rate of 28⅛th per cent but on the basis of the actual cost of the tractor, less the estimated resale value, the difference being spread over the life of the tractor on the farm. Other things being equal, it is obvious that the greater the initial cost, the higher the depreciation charge is likely to be. The following table shows the total numbers and the average purchase prices of the different types of tractors employed in each farm size group.

TABLE VI. TRACTOR TYPES AND INITIAL COST PER TRACTOR

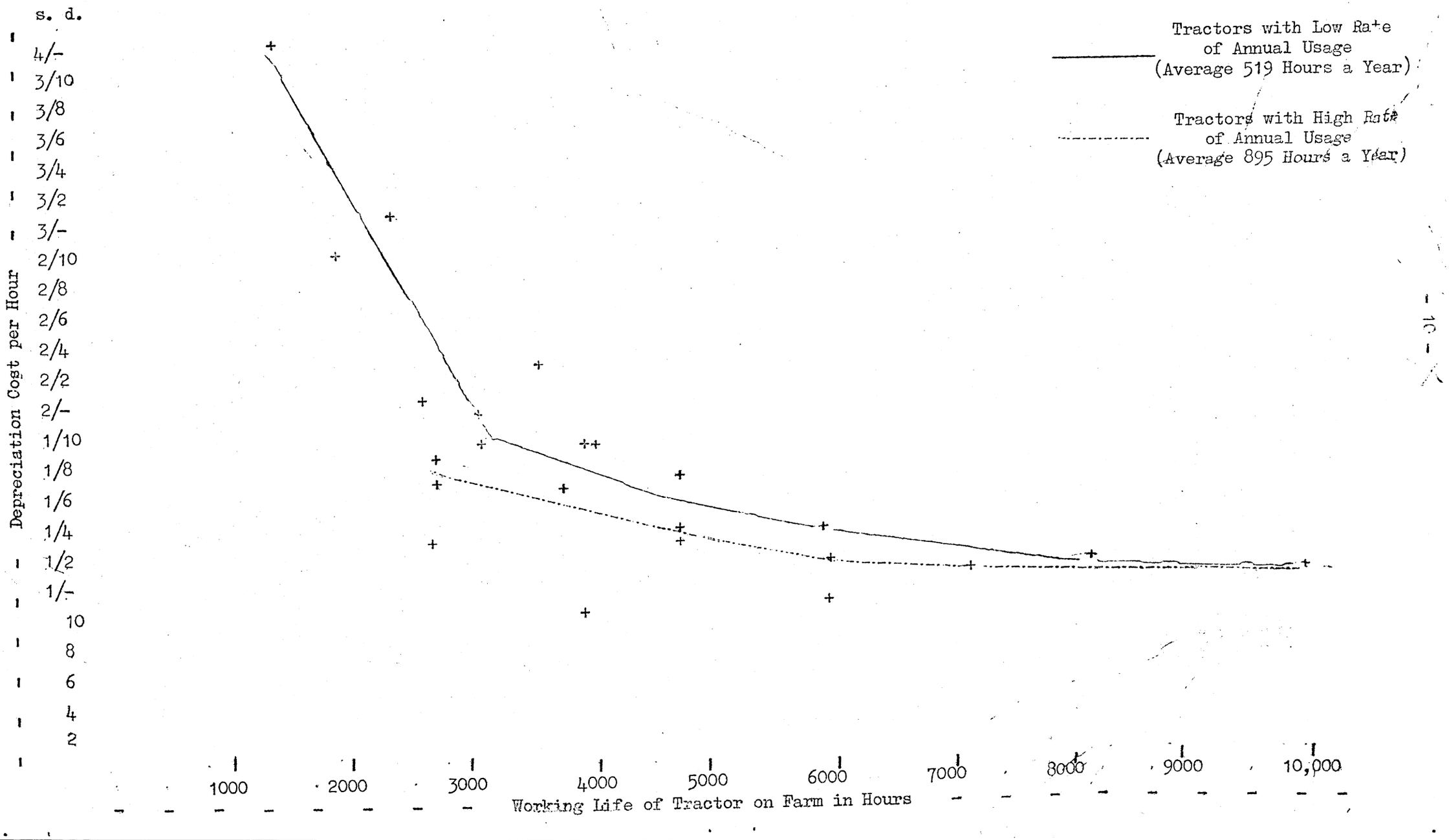
	'Small' Farms (Under 1000 Hours)		'Medium' Farms (1000-2000 Hours)		'Large' Farms (Over 2000 Hours)	
	Total Number	Average Capital Cost	Total Number	Average Capital Cost	Total Number	Average Capital Cost
		£		£		£
New Wheeled Diesel	2	598	6	578	8	568
" " Vap. Oil	1	310	2	485	4	525
Wheeled Diesel (Conversions)	2	205	-	-	1	560
Second Hand Wheeled Diesels	3	388	2	375	4	414
Second Hand Wheeled Vap. Oil	11	155	8	168	2	353
TOTAL TRACTORS	19	252	18	357	19	498

While most of the expensive tractors - e.g. new diesels - were to be found on the 'large' farms, the 'small' ones relied mainly on cheap second hand machines. An examination of the resale values of new tractors suggests that the drop in market value is particularly high in the first few years, thereafter the drop in value is not so great. Second hand tractors are therefore not only cheaper in first cost, but are also less subject to the heavy initial drop in market value. There were, in fact, several instances where second hand tractors have been used for a number of years and sustained little or even no loss in value. Thus, while the average initial cost of the tractors on the 'large' farms was almost twice as great as that on the 'small' farms, the average annual depreciation charge per tractor was fully three times as great. If, therefore, the 'small' farms in this sample had used new tractors, total costs per hour would probably have been much higher. This would seem to confirm the opinion that the best way to minimise the disadvantages of operating tractors on a small scale is to buy second hand.

An alternative method is that where tractors have a limited annual use, their life on the farm should be extended until their total hours worked are the same as those for tractors with a high rate of annual usage. In this case, it could be argued, depreciation costs should be charged at the same rate per hour regardless of the number of hours worked each year.

In Chart III the relationship between the depreciation cost per hour and estimated length of life (in hours) for each new diesel tractor in /

CHART III. DEPRECIATION COST PER HOUR - NEW WHEELED DIESEL TRACTORS



in the sample is examined. The graphs roughly indicate the average decline in depreciation cost per hour for two levels of annual tractor usage - the higher level averaged 895 hours per annum and the lower 519 hours per annum. It is assumed that these average rates of annual usage do not vary throughout the life of the tractors.

The chart shows how the cost of depreciation is affected by the two factors - the heavy drop in market value which has to be faced in the initial years of a tractor's life and the annual output of hours of work. In the case of tractors with a low rate of annual usage the heavy write-off in the first years means a very heavy cost of depreciation per hour if the working life on the farm (the period between purchase and replacement) is only short. As the length of life on the farm is extended the incidence of depreciation per working hour falls to a much lower level even though the annual usage is only small. For tractors with a high rate of annual usage the incidence of depreciation is much less heavy even if the tractor is kept for only a limited period. The depreciation cost per working hour certainly becomes lighter the longer the tractor is kept on the farm and would normally be less than for tractors with a lower level of annual usage, though these costs tend to get closer together under both sets of conditions. This sort of comparison suggests that on the 'small' farm where the annual requirements are low, the best means of reducing depreciation costs per hour is to retain a new tractor over a long period of years or, as is most commonly done, buy second hand tractors and thus avoid the initial heavy write-off.

VII. MAJOR OVERHAUL AND REPLACEMENT COSTS

The costs of replacing parts such as engines, tyres and batteries, as well as the costs of major overhauls are also considered under the general heading of fixed charges. In the long run, major repair costs per hour should be similar regardless of differences in annual usage so long as low annual usage is compensated for by extended life on the farm. The fact that these costs occur in relatively large amounts at infrequent intervals means that up to the time when the repairs are incurred the cost per hour may be subject to wide fluctuations if these costs are included from time to time as part of the fixed charges.

The following table shows the cost of major overhauls and replacement parts for the new wheeled diesel tractors according to their age in terms of hours worked.

TABLE VII. COST OF MAJOR OVERHAULS AND REPLACEMENT PARTS FOR NEW WHEELED DIESEL TRACTORS ACCORDING TO THEIR AGE (IN HOURS)

Age of Tractors in Hours Worked	Up to 1000 Hours	-2000 Hours	-3000 Hours	-4000 Hours	-5000 Hours
Number of Tractors	6	6	4	4	3
Total Outlay per Tractor :	£	£	£	£	£
Overhauls - Engine	-	-	-	20.5	-
Transmission etc.	-	-	9.3	-	8.0
Replacements - Engine	-	-	-	-	-
Tyres	-	7.83	65.3	28.0	81.7
Other	-	7.33	8.7	34.75	24.7
TOTAL OUTLAY PER TRACTOR	-	15.16	83.3	83.25	114.4
Average Cost per Hour (Pence)	-	2½d.	8½d.	6d.	6d.

The /

The figures in this table show the general tendency for these repair costs to increase with age - replacement parts, particularly tyres, being the most important items of cost. Overhauls, by comparison, were of lesser importance and no replacement engines were required for the tractors with a working life of up to 5000 hours.

There were considerable variations in the incidence of major repairs for tractors at different ages. For this small sample of tractors the greatest increase in repairs came at a comparatively early stage - somewhere about 3000 hours. As a result these costs per hour were increased to a maximum of 8½d. an hour, but decline thereafter to 6d. an hour. This emphasises the fixed cost element in major repair costs, which means that immediately following a large increase in repairs, average costs per hour tend to be lower until such time as further major repairs are called for.

Since the first big increase in repairs came at 3000 hours it might be reasonable to suppose that the next would be due somewhere about 6000 hours. Furthermore, it might be suggested that after a working life of 5000 hours a tractor will require in the near future such expensive items as replacement engines and major overhauls. If that is the case, it seems likely that repair costs per hour will rise sharply again at the latter end of a tractor's life.

VIII. REPLACEMENT POLICY

Referring back to Chart III, it is seen that while the majority of the tractors were sold between 3000 and 5000 hours there were considerable variations in individual cases. While some farmers preferred to keep their tractors as long as possible, others sold them earlier before major repair costs increased to any great extent.

Where the replacement policy is based on the purchase of new tractors, the stage at which it would be worthwhile replacing a tractor depends essentially on two factors. The first is the normal reduction in the average cost of depreciation per hour as the life of the tractor on the farm is extended (assuming there is a steady rate of annual usage) as shown in Chart III. The second is the extent to which the costs of major repairs per hour of working life are likely to be increased or decreased as time goes by and the critical periods for heavy expenditure of this nature come round. It has been shown in Table VII that the costs of major repair items became progessively heavier until about the 3000-hour stage. Subsequently there was a reduction in the average cost per hour worked until, it is suggested, another heavy outlay on repairs becomes due at about 6000 hours, when the average cost would be increased sharply. This would suggest that after the 3000 hours stage, it would pay to keep a tractor until such time as the next heavy expenditure on repairs was imminent and then sell. In this way an increase in the average cost per hour would be avoided.

For tractors with a low rate of annual usage there is no getting away from the fact that to sell at the lower critical "age" of 3000 hours means a very heavy average depreciation cost per hour and the best policy would seem to be one of keeping the tractor on the farm so as to bring this element of cost down to a much lower level. Where it is possible to reach a high rate of annual usage the position is not quite so clear as the incidence of depreciation in the average cost per hour will be relatively low. The available data suggest costs of 2½d. and 1s.7d. per hour for major repairs and depreciation - a total of 1s.9½d. per hour up to 3000 hours. The onset of heavier repair costs about that stage would, of course, bring about an immediate increase in the total charge per hour over the 3000 hours but the effect of keeping such a tractor on until the next critical period is likely to bring the average costs per hour of major repairs and depreciation down to 6d. and 11d. respectively. This gives /

gives a total of 1s.7d. per hour or 2½d. per hour less than the cost if sold before incurring repair costs at the 3000-hour stage. This constitutes an advantage of some £60 over a working life of 6000 hours.

The replacement problem is not present to the same degree where the policy is based on the purchase of second-hand tractors. It has already been shown in Table V that the fixed costs are relatively low on 'small' farms which rely to a greater extent on second-hand machines.

IX. SUMMARY AND CONCLUSION

The results of this survey show that small scale farms generally use a greater tractor force in relation to the amount of work to be done than do the larger farms. This results in a lower level of running hours per annum for each tractor. Seasonal variations in the amount of work to be done have a similar effect in reducing the overall rate of tractor utilisation especially on the larger farms. The effect is less acute, however, since only a small proportion of the tractor force is under-employed.

By relying mainly on second-hand vaporising oil type tractors, the 'small' farms kept depreciation costs to a minimum but, in so doing, incurred somewhat heavier fuel and repair costs. While the economy of using second-hand tractors as compared with new ones on the 'small' farms is undisputed, there may be a good case for changing over to diesel. For an annual usage of 500 hours, the average saving in fuel cost at 1s.2d. an hour would be almost £30 a year. Since the difference in purchase price between roughly equivalent diesel and vaporising oil tractors might be anything up to - but almost certainly not exceeding - £100, this would be recovered within a reasonable number of years. Nevertheless, for the very light users in this sample, where the possible savings in fuel cost per annum would be much less, the second-hand vaporising oil tractor should prove the better proposition. Furthermore, where capital is lacking, it is likely that the relatively low price range within which the small farmer must choose, restricts him to the vaporising oil machine.

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