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MAINTENANCE IN PERSPECTIVE

by

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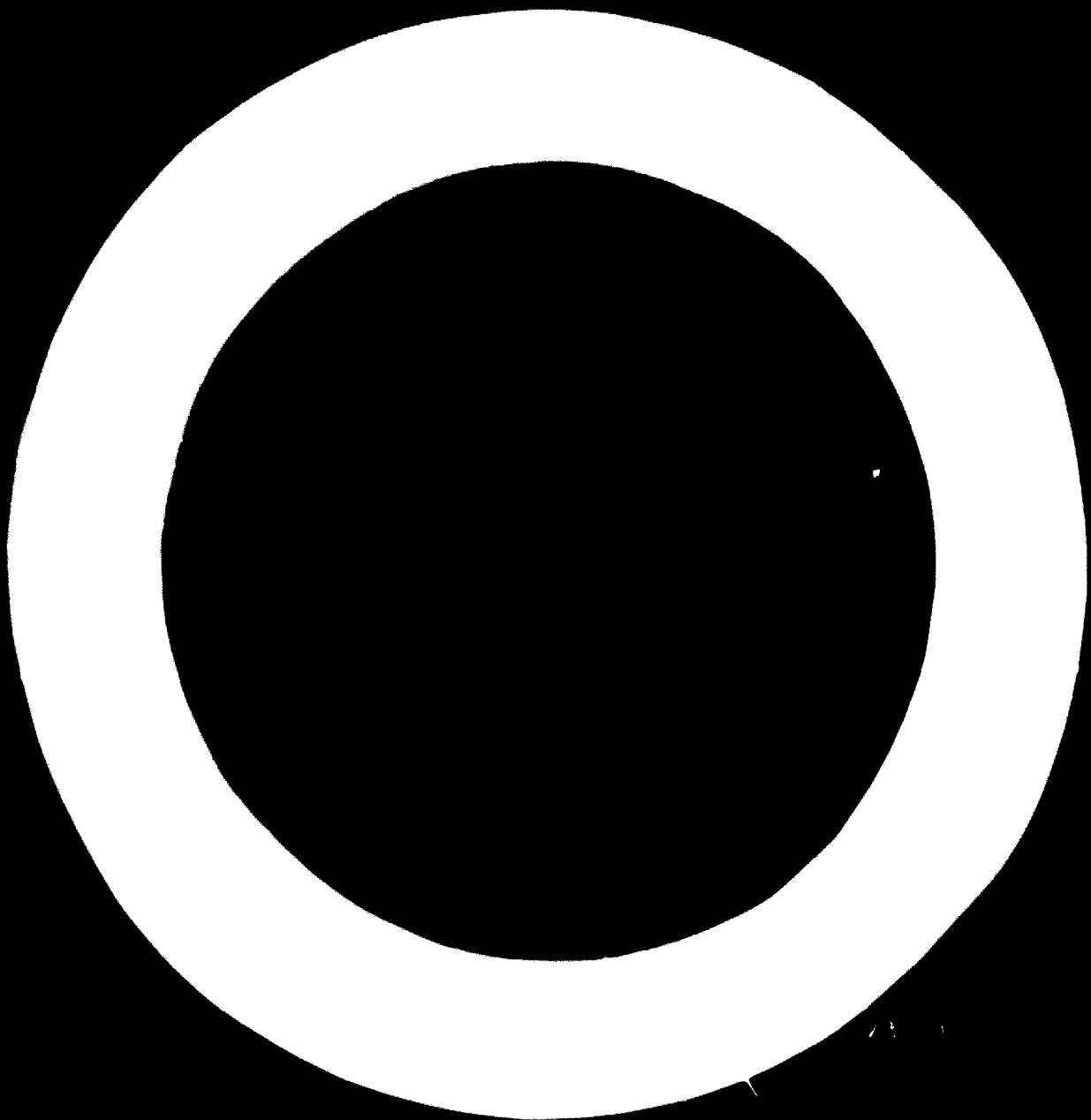
Organised in co-operation with the German Foundation for Developing Countries and the German Association of Machinery Manufacturers (VDMA).



INTRODUCTION

One of the subjects least likely to attract interest among managers, engineers and scientists alike is maintenance engineering; in some ways this is understandable as managers are likely to be more concerned with their production efficiency and markets, engineers with new designs and scientists with innovations. Yet few subjects offer such scope for savings of money and manpower by the extensive use of well known methods of organisation and control.

This paper is intended to draw attention to the importance of Maintenance Engineering and to create awareness in management of all levels of what needs to be done.

There are obviously difficulties in relating experience in the United Kingdom to other countries and care must be taken when for example comparing costs, as the extent to which capital equipment is enlarged and the differing cost of labour will radically alter the picture. There are however a number of significant lessons to be learnt from our experience in the United Kingdom in order that they are not rejected.

BRITISH INDUSTRY - ORIGINS AND DEVELOPMENT

before attempting to describe or examine the maintenance situation in the United Kingdom today, it is worthwhile to consider the history of British Industrial development as a whole. This should help to explain how the present situation has evolved and indicate why, with previous experience to draw upon, a developing country should never find itself in the difficulties which beset a pioneering nation.

Industrialisation in the United Kingdom sprang from the need for more products with which to trade. By the beginning of the 17th Century, Britain had developed trading interests in Europe, Scandinavia and Russia and at the end of the 18th Century was engaged in worldwide trade. During this period production, which was originally centred on the family unit, was concentrated in factories where power was available for the improved machines. To begin with much use was made of water power, but later water was supplanted by steam.

As the demand for production increased new and better machines became necessary; fortunately the engineers to design and make them appeared on the scene. They began to use steel in the manufacture of machines instead of wood, which stimulated the steel and coal industries. Out of this, and countless similar chains of dependence, arose the need for ever greater production. Thus in the mid-18th Century the British economy started to 'boom', and the Industrial Revolution began. Without going into too much detail, the important point of the argument is that industrialisation on the scale taking place at that time had never occurred before and no one had any knowledge of the problems that would arise. Indeed no one could foresee where industrialisation would eventually lead.

Legislation, education, transport, industrial medicine, factory townships and so on, all had to develop with the growth of industry, and the importance of many aspects were not appreciated until recent times. In fact there are some which have still not received the attention they deserve and maintenance engineering is one of them. The point to be made is that with vast experience (not only British) to learn from, a nation developing its industry in present times should be able to avoid following the same tortuous path and expect to achieve more satisfactory end results; not that there can be an end to development.

THE DEVELOPMENT OF MAINTENANCE ENGINEERING

Early machines were simple and the skills needed to repair them were well within the compass of the operatives, who did in fact carry out minor repairs in numerous cases. Plant similarly was very simple. However, since the 1920's new industries have developed, the motor car industry, the aircraft industry, the electronics industry, to name but a few. These have demanded new techniques,

and those developed for one industry have inevitably been made use of in others. Plant and machinery have been becoming more and more complex so that in many cases the skills demanded of the productive operator have become less than heretofore, while those needed of the maintenance man have become greater. Unfortunately, this fact has only recently been recognised, and by only a relatively small number of people even now.

The United Kingdom Government, persuaded by the few who did recognise the problem, set up a working party to enquire into the state of maintenance engineering; the first meeting of the working party was held in March 1968.

THE MAINTENANCE ENGINEERING SITUATION IN BRITAIN TODAY

COSTS

The Report of the Working party published last year, together with the material used in its preparation, gives us the information. The main finding was that:-

Maintenance engineering in the manufacturing industry [1] alone costs £1100M pa and it is considered that £200-250M pa of this could be saved by increased productivity. A further £200-300M pa saving could be achieved by improved maintenance management and control.

Table 1 shows how this direct cost of £1100M pa is made up. It will be seen that labour accounts for the greater part of the total and it is probable that this proportion will continue to increase with the increase in automation and the rising standard of living. The spend on contractors is small and indicates that the manufacturing industries still tend to employ their own maintenance staff rather than utilise outside contractors. Three reasons have been advanced for this and there are no doubt others; firstly a number of firms manufacture their own production machinery and feel that they are best qualified to maintain it, secondly there is some fear, not necessarily justified, of industrial extortionate and thirdly firms want to have staff immediately available to deal with breakdowns. Finally, the small proportion of the total expenditure representing maintenance performed by production staff is, perhaps, an indication of the fact mentioned earlier that the skill requirements of production and maintenance are diverging.

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[1] "The Manufacturing Industry" is a generic term covering those industries which make, or contribute to the making of, are end product. It does not include, for example, the service, distribution or building industries. The total figure for all industries including building maintenance has been estimated at £4000M pa.

Turning to table 2 the figures are further broken down between the main sectors of industry. Here there is little to comment on beyond noting the different patterns of expenditure exhibited by the various industries. This, of course, is to be expected when one considers the varying degrees of mechanisation and nature of plant and equipment to be maintained.

Table 3 shows how the sectors vary in the proportion of expenditure between various aspects of maintenance, while table 4 shows the varying proportions of time spent by maintenance departments in the plant engineering functions. In both these tables it is again demonstrated that the utilisation of resources is dependent on the nature of the industry.

Reference to table 5, which provides figures on the sizes of the maintenance forces in the different sectors, shows very effectively which are the industries with a large investment in complex plant. It also indicates that, generally, those industries also have a higher ratio of maintenance staff to maintenance operatives. This is to be expected; complex plant and equipment requires a large skilled workforce with good management support.

Table 6 also shows very clearly the same fact. Furthermore it also highlights that these heavily capitalised industries are those which will show the greatest financial benefit from any maintenance savings which are made.

Of course all these figures by themselves only provide the facts about maintenance costs and do not enable one to make an assessment as to whether the situation is good or bad.

Fortunately the survey was not just concerned with costs; it also investigated all the factors which affected them.

MANAGEMENT

Unless one accepts that the situation is completely uncontrolled, the present state of affairs derives from the attitudes, policies and competence of management. Here we must distinguish between top management, production management and maintenance management in order that we can also look at the way they interact.

Generally, top management seems to consider that maintenance is a necessary evil; an overhead charge of which it would like to be rid, (although it must be said that there are a few exceptions in excellently managed companies). This

attitude stems sometimes from a complete lack of appreciation of the fact that, in an imperfect world, maintenance will always be necessary, and a proper understanding of its effects on profitability is essential. It requires no great immagination to realise that a suggestion that profits might be higher if the maintenance budget were increased would be met with incredulity. What, then, are the results of this attitude? Firstly, of the firms taking part in the survey only about 40% produced useful budgets and a similar percentage had an effective costing system. Only one firm amongst those investigated knew the indirect costs of maintenance; loss of production time, increased scrap rate, etc. Secondly, maintenance staff and operatives are less well qualified, not so well trained and less well paid than their production counterparts. Thirdly, machinery is frequently run beyond its economic life, as maintenance costs are not properly taken into account. It was often found, too, that machinery and equipment is passed on to the maintenance department when it is discarded by production.

Production management seldom appreciates the value of good maintenance any more than top management. It has its own problem, that of keeping up output. The result is that a machine requiring maintenance may be kept running with possibly decreased throughput or increased reject rate rather than allow it to be stopped altogether. Of course, when it is finally taken out of service, the repair problem may be more severe. There are in addition cases where greater than design throughput is demanded by production management regardless of the increased maintenance requirement.

With regard to maintenance management only about 40% of maintenance managers have a qualification as good as, or better than, an Ordinary National Certificate. (This is a certificate for a Technical Engineer) No doubt the poor pay and career prospects fail to attract better qualified men. In fact a maintenace manager is frequently a practical man promoted from the shop floor, and this is just not good enough. Only about half the firms give him any training and much of this is to no set plan. Maintenance managers are, therefore, poorly equipped to plan and control maintenance, and in cases where they are competent they have to contend with the attitudes of production and top managers.

MAINTENANCE OPERATIVES

Like the skilled production operative, the maintenance worker learns his trade by serving an apprenticeship, which then enables him to practise as a fitter or a plumber or an electrician, etc. Because many managers consider it difficult to measure maintenance work, while the production man may be on a

measured-work incentive payment scheme, the maintenance operative will be given a bonus or virtually uncontrolled overtime to give him rough parity of earnings. This coupled with production management's reluctance to release plant for maintenance means that the maintenance man is only about 60% as productive as he should be.

OTHER FINDINGS OF THE SURVEY

The survey also discovered that organisation structures are on the whole good, and so are industrial relations. Maintenance facilities, space and methods are generally poor and trade demarcation is sometimes a problem. This latter is yet another contributory factor towards low productivity. It was also reported that the design of plant and equipment did not present many problems for easy maintainability. It is more probable, however, that many maintenance engineers accept poor maintainability, having been insufficiently trained in critical examination.

Three topics vitally affecting maintenance engineering in Britain were not covered by the survey, and these will be mentioned to complete the picture.

EDUCATION AND TRAINING

The minimum school leaving age is 15 which means that all but a few teenagers leave school equipped with the necessary knowledge to live in society and play some part in the nation's activities. In addition there are technical schools which impart the basic knowledge to students who will enter industry, technical colleges and Polytechnics which provide full-time, part-time and evening classes, enabling students to obtain recognised engineering and technical qualifications, and there are Universities which provide education leading to the award of first and higher degrees in engineering. One interesting aspect of the educational system is its flexibility: there is no set route through the levels of higher education, and a student may have been educated in different ways at various times. These various forms of education are almost invariably preceded by, concurrent with or followed by an apprenticeship which imparts the basic skills.

An important part of education is supplied by companies themselves or at least by those whose products or processes are in any way complex. The education provided may range, for example, from half a day on the company's organisation to several months on computer maintenace. This latter type of course is normally interspersed with periods of "on-the-job" training, where the man uses the skills he has been taught.

The more enlightened managements also organise refresher courses for their

staff, to up-date their knowledge and to expand it, thus making their staff more useful. This supplementary education may be provided by the company itself, or by any of the educational bodies already mentioned.

Now where does the maintenance engineer fit in? In general he is a man who will have had a formal training and possibly education in electrical or mechanical engineering but none in maintenance as such, since only recently have courses in maintenace engineering been provided. It seems obvious that such courses are vital for a man who may be concerned with maintaining such a diversity of equipment as steam raising plant, electrical generation and distribution, machine tools, transport, air conditioning plant, electronic systems and so on. This is especially true if the equipment which will be developed in this "Automation Phase" of the Industrial Revolution is to receive the necessary high standard of maintenance.

On the shop floor, British craft training is almost exclusively the apprenticeship system whereby a young man is trained in general workshop practice initially, and subsequently in the skills necessary for the exercise of his particular craft. During his apprenticeship he will be released perhaps one or two days a week to study at a technical college to acquire the theoretical background to his work.

Unfortunately this method of training, together with the Trade Union structure, does not provide maintenance craftsmen suited to the automation age. The requirement is for multi-discipline craftsmen.

TRADE UNIONS

Having mentioned the Trade Union movement it is appropriate to take a brief look at their activities.

In part due to the organisation of the mediaeval craft guilds such as the Butchers, Chandlers, Stonemasons, etc. and in part due to the manner in which British Industry developed, the Trade Unions coalesced as individual bodies representing the craftsmen of a particular trade. Each union, of course, in protecting the interests of its members, sees any attempt at breaking down demarcation lines as a threat to the livelihood of its members. To some extent their views are correct because only by improved training and education is it possible for many craftsmen to work outside their prime trade. However it is essential that these attitudes be changed in order to improve productivity and thus to secure higher standards of living for all. Since the beginning of

the Industrial Revolution the Trade Union movement has been instrumental in securing a number of rights and conditions of work which are now taken for granted. Although these are far from perfect and indeed are still being evolved there must be adequate legislation to cover conditions of work, employment of women and children, education and training in safety.

INDUSTRIAL LEGISLATION

Much of the law relating to industry is embodied in the Factories Act which is enforced by Her Majesty's Factory Inspectorate. It is not possible in this paper to give more than a brief summary of its scope and this can be done under several headings.

1 Safety

Safety regulations in the law are concerned with the adequate guarding of machinery, the provision of eye protection for certain operations, the precautions and equipment necessary if work is to be done in hazardous or hostile environments.

2 Fire Hazards

Under this heading the Act is concerned with the adequacy of fire exits, the provision of fire fighting equipment and, in certain instances, the practising of fire-drills.

3 Health and Welfare

This aspect includes requirements on the adequate cleanliness and heating of factories, provision of ventilation and proper exhausting of fumes and dusts, and the reduction of noise. Indeed the whole question of pollution in the factory is under review and this is an aspect to which we believe engineers must pay much more regard.

4 General

Finally there are requirements for the registration of certain types of plant, safety devices and regular testing and inspection.

THE FUTURE OF MAINTENANCE ENGINEERING

As a result of the Report of the aforementioned Working Party, the United Kingdom Government had discussions with leading industrialists, educationalists and prominent engineers on what was to be done. In brief the conclusions were reached that maintenance had too long been treated in isolation and that insufficient attention was given during design, installation and commissioning stages to the easing of the maintenance problem. In order to draw the

distinction between this new concept and the older one of maintenance, it was felt a new word was necessary; the appropriate authorities suggested Terotechnology. This word is derived from the Greek TEREIN which means to watch over, to guard, to monitor, to look after. Terotechnology is defined as:-

"The technology of installation, commissioning, maintenance replacement and removal of plant, machinery and equipment, of feedback to operation and design thereon, and of related subjects and practices".

In addition the Government set up a Committee on Terotechnology to advise on the different aspects of terotechnology and on the best means of introducing terotechnology to industry. In order to do this the committee, which has recently begun its deliberations, intends to investigate all aspects of education and training, the activities of the professional engineering institutions, the need for a national advisory service, information services and government sponsored research projects.

As yet it is much too early to comment on the work of this committee; suffice it to say that the maintenance engineering problem is now recognised as being one which is of great importance to the economy of British Industry.

CONCLUSIONS

So far as the United Kingdom is concerned we are clear that a good deal has to be done to improve our standard and effectiveness of our maintenance engineering. The paper is not therefore offered as an example but rather as one from which lessons can be learnt.

Without doubt many improvements can be made by the wider application of concepts which are already well tried without the addition of any new principles. The first essential is to train people from manager to shop floor level in maintenance, emphasis being laid on a multidisciplinary approach which cuts across existing demarcation lines. The work must be planned, measured and controlled, and attention must be paid to replacement of equipment on the proper lines.

In the longer term we must look for additions to the educational system to enable part first degree training to be given.

We must look too at the possibility of grouped maintenance facilities (both for men and materials) and no doubt further research will be required into techniques

of work measurement and control hold of finance and planning.

As we enter an automated age it is the maintenance engineer or terotechnologist who will become all important. He must be fully equipped for the task and must be given the authority to do it.

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TABLE 1

BREAKDOWN OF DIRECT MAINTENANCE COSTS

	£M p.a.
Direct Labour	489
Direct Materials	285
Payments to Contractors	41
Maintenance done by Production Staff	5
Direct overheads	266
Total	£ 1,086

TABLE 2

[illegible]

ON PLANT AND EQUIPMENT (£million p.a.)

INDUSTRY	SALES 1968	TOTAL SPEND ON MAINTENANCE	INTERNAL MAINTENANCE DEPTS	LABOUR	MATERIALS	OVERHEADS	OUTSIDE CONTRACTORS	MAINTENANCE AGREEMENTS WITH SUPPLIERS	OTHER CONTRACTUAL WORK	MAINTENANCE DONE BY PRODUCTION
Food, Drink and Tobacco	4,820	93.4	92.5	39.5	27.5	25.5	0.6	0.2	0.4	–
Chemical and Allied Industries	3,690	215.3	209.0	66.0	78.0	65.0	5.5	0.3	5.2	0.8
Metal Manufacture	3,460	164.4	151.2	47.0	34.5	69.7	11.1	3.3	7.8	0.1
Non-electrical Engineering	3,540	121.4	109.2	42.5	22.5	44.2	12.0	0.5	11.5	0.2
Electrical Engineering	2,990	59.6	44.9	20.5	13.0	11.4	3.3	0.1	3.2	1.4
Shipbuilding and Marine Engineering	425	3.7	3.4	1.0	1.5	0.9	0.3	–	0.4	–
Vehicle Manufacture	3,850	89.8	87.0	33.5	18.0	35.5	1.8	0.3	1.5	1.0
Metal Goods Manufacture	1,770	48.7	48.2	25.0	2.5	20.7	0.3	0.1	0.2	0.2
Textiles	2,330	73.7	73.4	29.5	26.0	17.9	–	–	–	0.3
Leather, Leather Goods and Fur	135	3.8	3.8	1.5	1.0	1.3	–	–	–	–
Clothing and Footwear	910	22.2	22.2	7.5	8.0	6.7	–	–	–	–
Bricks, Pottery, Glass and Cement	1,080	61.7	60.6	18.0	26.5	16.1	1.0	0.1	0.9	0.1
Timber, Furniture etc.	855	20.9	20.6	8.0	5.5	7.1	0.3	0.1	0.2	–
Paper, printing and Publishing	1,660	64.3	59.5	30.5	14.5	14.5	4.6	0.2	4.4	0.2
Other Manufacturing	1,080	31.9	31.5	15.5	6.5	9.5	0.4	0.1	0.3	–
Total, All Manufacturing	32,515	1084.8	1039.0	387.5	285.5	366.0	41.2	5.3	35.9	4.3

TABLE 3

DIVISION OF MAINTENANCE SPEND BETWEEN VARIOUS ASPECTS

INDUSTRY	TOTAL SPEND £m p.a.	PLANNED MAINTENANCE %	BREAKDOWNS %	MINOR REPAIRS %	MINOR IMPROVEMENTS %	OTHER
Chemical and Allied Industries	215.3	57	14	21	5	3
Paper, Printing and Publishing	64.3	49	11	26	11	3
Food, Drink and Tobacco	93.4	41	30	14	8	7
Metal Manufacture	164.4	41	32	18	9	-
Bricks, Pottery, Glass and Cement etc.	61.7	41	41	10	7	1
Electrical Engineering	69.6	29	39	23	7	2
Textiles	73.7	26	34	21	16	3
Vehicle Manufacture	89.8	26	42	18	7	7
Shipbuilding and Marine Engineering	3.7	25	24	15	18	18
Clothing and Footwear	22.2	23	35	14	22	6
Metal Goods Manufacture	48.7	20	63	8	8	1
Non-electrical Engineering	121.4	16	46	25	12	1
Leather, Leather Goods and Fur	3.8	11	64	13	9	3
Timber, Furniture etc.	20.9	3	71	14	8	4
Other Manufacturing	31.9	16	55	19	8	2
Total, All Manufacturing	1084.8	35	32	20	8	4

TABLE 4

PERCENTAGE OF TIME SPENT BY MAINTENANCE DEPARTMENTS ON THE VARIOUS PLANT ENGINEERING FUNCTIONS

INDUSTRY	TOTAL	PLANT AND EQUIPMENT	BUILDINGS	CAPITAL WORK	SERVICES	OTHER
Food, Drink and Tobacco	100	57	7	13	16	7
Chemical and Allied Industries	100	75	4	12	6	3
Metal Manufacture	100	73	6	7	13	1
Non-electrical Engineering	100	52	19	13	12	4
Electrical Engineering	100	73	11	5	6	5
Shipbuilding and Marine Engineering	100	50	16	9	24	1
Vehicle Manufacture	100	52	6	24	13	5
Metal Goods Manufacture	100	70	7	11	8	4
Textiles	100	68	17	5	9	1
Leather, Leather Goods and Fur	100	56	16	3	22	3
Clothing and Footwear	100	68	15	6	10	1
Bricks, Pottery, Glass, Cement etc.	100	69	14	7	9	1
Timber, Furniture etc.	100	41	15	15	24	5
Paper, Printing and Publishing	100	62	12	7	17	2
Other Manufacturing	100	64	8	13	13	2
Total, All Manufacturing	100	63	10	13	10	4

TABLE 5

STAFF ENGAGED IN MAINTENANCE

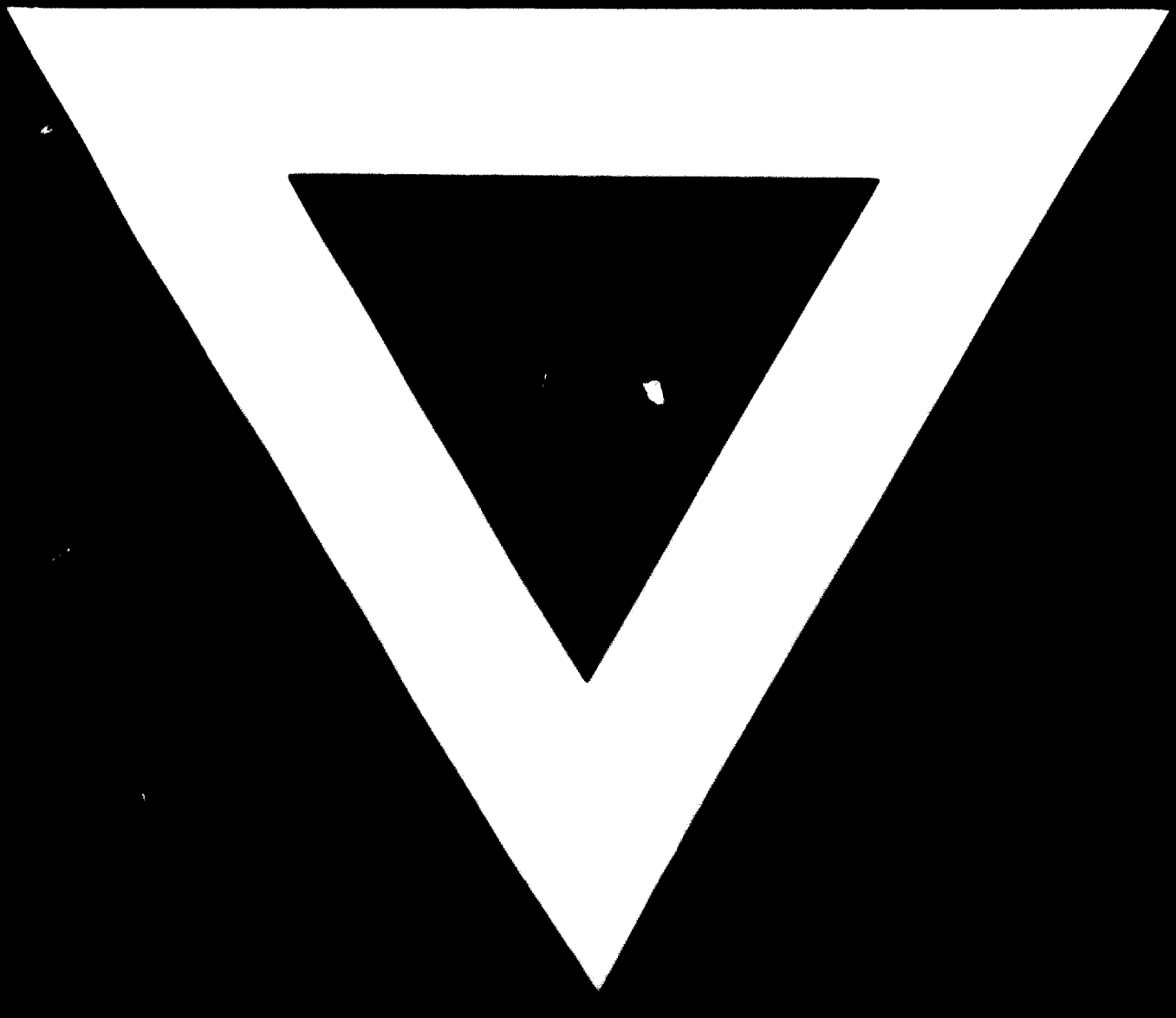
INDUSTRY	OPERATIVES THOUSANDS	STAFF THOUSANDS	OPERATIVES PLUS STAFF THOUSANDS	MAINTENANCE OPERATIVES AS % DIRECT LABOUR	MAINTENANCE EMPLOYEES AS % OF ALL
Food, Drink and Tobacco	60.6	8.8	69.4	12	8
Chemical and Allied Industries	85.8	17.2	103.0	16	21
Metal Manufacture	43.0	7.3	50.3	20	13
Non-electrical Engineering	75.2	15.6	90.8	11	7
Electrical Engineering	39.7	6.5	46.2	10	5
Shipbuilding and Marine Engineering	7.0	1.1	8.1	5	4
Vehicle Manufacture	42.1	6.1	48.2	13	6
Metal Goods Manufacture	33.6	5.7	39.3	13	7
Textiles	41.0	5.8	46.8	10	7
Leather, Leather Goods and Fur	2.3	0.3	2.6	6	5
Clothing and Footwear	11.0	2.4	13.4	4	3
Bricks, Pottery, Glass, Cement etc.	17.0	2.5	19.5	15	8
Timber, Furniture etc.	8.1	1.1	9.2	9	5
Paper, Printing and Publishing	32.5	4.8	37.3	9	7
Other Industries	16.8	2.4	19.2	10	7
Total, All Manufacturing	315.7	87.6	403.3	13	7

TABLE 6

ENGINEERING MAINTENANCE COSTS RELATED TO NUMBER OF EMPLOYEES, SALES AND NET OUTPUT

INDUSTRY	MAINTENANCE COST PER 1000 EMPLOYEES	MAINTENANCE COST PER £1000 OF SALES	MAINTENANCE COST PER £1000 OF NET OUTPUT*
Food, Drink and Tobacco	130.7	19.4	69.2
Chemical and Allied Industries	423.5	58.5	156.8
Metal Manufacture	246.1	47.5	140.0
Non-electrical Engineering	86.1	34.4	76.0
Electrical Engineering	64.9	23.6	42.7
Shipbuilding and Marine Engineering	20.4	8.7	17.0
Vehicle Manufacture	108.1	23.3	62.7
Metal Goods Manufacture	92.6	27.5	72.6
Textiles	122.1	31.6	86.2
Leather, Leather Goods and Fur	71.4	28.0	83.4
Clothing and Footwear	46.4	24.4	53.5
Bricks, Pottery, Glass and Cement etc.	180.2	57.3	102.2
Timber, Furniture etc.	67.8	24.2	52.9
Paper, Printing, Publishing etc.	125.0	38.7	81.7
Other manufacturing	107.0	30.6	60.2
Total, All Manufacturing	127.4	32.9	82.7

* Net Output is Value of Sales less cost of materials and fuels.



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