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CONSIDERATION OF PROBLEMS IN DESIGN OF INSTALLATIONS MAINTENANCE AND REPAIR IN DEVELOPING COUNTRIES

by

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

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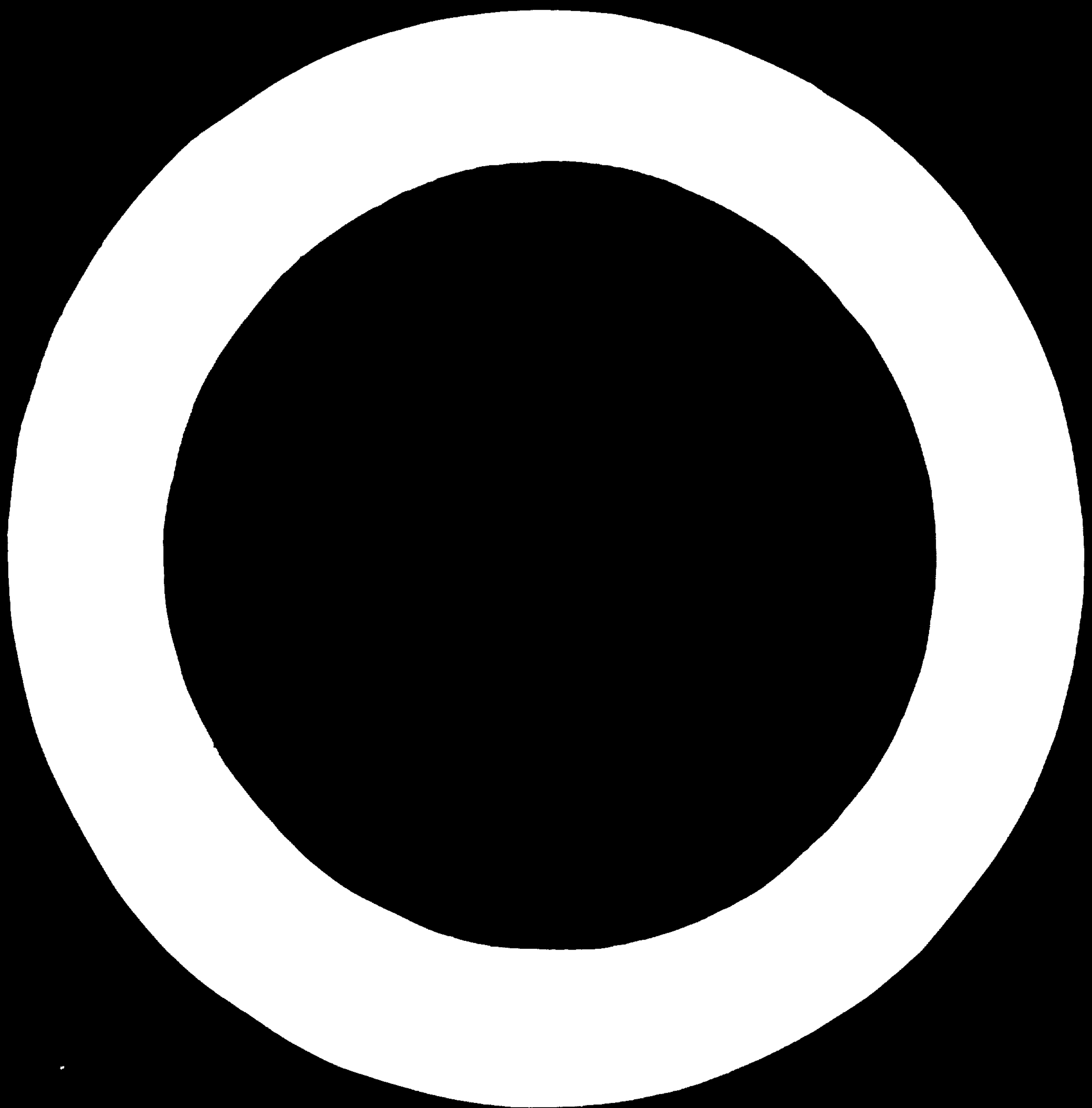

Contents

Introduction

The present work is a basic and initial material intended for the symposium, to be organised on the "Problems of repair and maintenance in projects and installations in developing countries", to take place in 1970 under the auspices of UNIDO.

It contains an interpretation of basic activities and concepts regarding production basis, basic equipment, their utilisation, wear, rehabilitation including organisation, planning and operation of repair workshops, maintenance economics and repairs of basic equipment. The essential part of the volume deals with the methodics and working processes applied in the designing of repair shops. It also includes an outline of training schemes for repair personnel and their qualification requirements.

The volume is to be regarded as the starting and basic materials covering a wide range of problems of repair and maintenance work in engineering production where the repair shops are mostly incorporated in the organisation of engineering plants. The proposed methods and practices are based on Czechoslovak current usage and have been drawn up according to a great many specific projects worked out by Kovoprojekta, designing and engineering organisation, Prague 1, Štěpánská 65, Czechoslovakia.

Kovoprojekta is the largest designing, engineering and consulting organisation for Czechoslovak machine building industry. After the necessary research and examination of the particular conditions and requirements, it can purposefully apply the general principles set forth in the present volume to concrete projects with due regard to the type, extent, organisational and planning conditions prevailing in the respective developing country.

It is understood that in discussions during the symposium the author of this work will be able to explain in more detail all the practicable methods and approaches, as well as the most convenient applications adequate to the specific conditions of the developing country concerned.

Part 1 - Production Basis and Its Renovation.

Basic equipment including plant buildings, structures, machines, appliances and the like, form the core of productive power, thus being an indispensable aid in the development of national economy. It is also one of the means, which provides for a steady rise of social standard in the field of living and culture.

Much consideration should be given to what amount of influence the basic equipment has hitherto exercised on the evolution of man, the forms of his work, and its direct bearing on the actual state of society's material and cultural level, let alone the development and safeguarding of society's existence in general.

In a manner of speaking, the history of basic equipment is the history of man, his evolution and his whole existence. It is this very factor that distinguishes man from other living creatures in that he is capable of producing basic equipment, which on the other hand makes his work easier, more accurate and multipliable, thus enabling him to rule Nature. It is the effort of thousands of man's generations that has brought the very simple implements of man's primeval age up to the basic equipment of today, excelling in a high technical grade and mechanisation.

However, not only basic equipment but also man has evolved because in the course of the thousands of years passed by man and his basic equipment have been exposed to a mutual influence. The evolution of man, his existence and the forms of his life - all these are correlated with the evolution and forms of his basic equipment.

1.1 Basic Equipment (Active, Passive), Its Pattern, Condition, Age and Records

To own some basic equipment is not an end in itself. Every further advancement of society makes it imperative for basic equipment to be perfectly mastered and utilised.

Keeping a certain kind of production afloat cannot be effective without the help of basic equipment which meets both the quantity and quality requirements.

It should not be forgotten that by taking an immediate part in the manufacturing process, active basic equipment, i.e. production machines and appliances, can impress its properties on the product and the technology applied and thereby take its share in the effectiveness of not only the manufacturing process but also its own utilisation. This does not claim to underestimate the services rendered by passive basic equipment, namely buildings and other structures, which does not contribute directly to the manufacturing process, but creates favourable conditions for this purpose.

An inquiry into the fundamental problems of the manufacturing process, results in a conclusion that the age of basic equipment is not always of such importance as has been generally ascribed to it. In addition to the mentioned properties of basic equipment, it may also be its quality and long-term high operational ability that can influence the manufacturing process considerably. With a view to the establishment of such conditions, it is essential for the production basis to be accurately rated, properly incorporated and recorded.

1.2 Utilisation of the Production Basis

The utilisation of basic equipment is to be interpreted as a ratio between its capacity and the amount of work produced within a time unit. The utilisation of basic equipment is of prime importance for national economy because such an activity provides, without the necessity of further productive investment, a considerable increase in the output volume and a relative rise in the effectiveness of production. The time that would be required for the acquisition of a new basic equipment and the setting of same into operation can be saved and utilised in the manufacturing process alone.

The utilisation of basic equipment should be continuously kept under review in the form of standards rated according to the conditions of a particular manufacturing process. Such records should give an account of not onl the utilisation of time, (extensive aspect) but also that of technical parameters (intensive aspect).

1.3 Deterioration of Basic Equipment As One Aspect of Simple Reproduction

Of all basic equipment, machines and other productive appliances are subject to wear by operation. Their original properties deteriorate, their productivity decreases and the quality of their work becomes more inferior. If this wearing process were given a free hand, it would cause the machines to break down occasionally and make them unfit for operation. To prevent this for the sake of maintaining the production capacity, it is necessary to restore the working ability of basic equipment.

One of the preferable methods of retarding the process of deterioration is by taking definite measures of a technical and organisational character, which will maintain the capacity level of basic equipment as long as it is economical.

1.4 Rehabilitation of Basic Equipment As Other Aspect of Simple Reproduction

Though the deterioration of basic equipment may be a long time in coming, it ultimately leads to physical wear, requiring the regeneration of the technical properties. This problem touches the other aspect of the reproduction of basic equipment, namely rehabilitation, which depends on the character of basic equipment, the conditions of the manufacturing process, the extent of wear, and the economic bearing. The method of rehabilitation should be such as to comply with local conditions, e.g. recapacitating of basic equipment by maintenance and repairs, or substituting new basic equipment for the worn-out units, if the latter alternative seems more economical.

To make the reproduction process effective, a combination of both the mentioned methods are usually applied until the exhaustion of the equipment. Rehabilitation by maintenance is carried out to be followed at last by substitution as a means of regenerating the production capacity.

1.5 Maintenance and Repairs As Partial Rehabilitation of Basic Equipment

The importance of maintaining and repairing basic equipment as the bulk of rehabilitation activities lies in the fact that besides disposing of accidental defects, maintenance and repair workers can closely watch the deterioration of basic equipment and slow it down, taking advantage of every short break when the equipment is idle.

1.6 The Principle of Maintenance - Its Purpose and Goals

The maintenance of basic equipment is to be interpreted as an all round activity aiming at the economic aspect to maintain the quantity and quality standard of production. Maintenance is not merely a repair activity, but a bulk of activities aiming at the preservation of basic equipment, in or out of operation. It is the responsibility of the operator to observe the machine of which he is in charge, to ascertain the frequency of cleaning and lubrication. Herein included are also general repairs, which should not only restore the original technical state but also raise the basic equipment to an up-to-date standard. Maintenance may also include all activities connected with the rejection of worn basic equipment.

1.7 Development of Maintenance Capacities for Basic Equipment in Proportion to Development of Production Basis

In order to attain the goals assigned to the maintenance of basic equipment, it is necessary to create favourable conditions under which this activity could develop properly. It is not only the question of acquiring the required area, machines and workers in proportion to the production basis, but attention should be given to the quality of these capacities in accordance with the production basis.

Where there is an intention to enrich the production basis with highly mechanised or even automated machines calling for qualified attendance, competent maintenance crews should be provided to meet the specialised requirements. The maintenance capacity for basic equipment should develop in accordance with the maintenance standards applied by the producer of the particular basic equipment, or by other organizations specialising in this field.

Part 2 - Classification of Maintenance and Repair Activities Concerning Basic Equipment

The organisation of labour undergoing a continual process of perfection has induced industrial entrepreneurs to accomplish an extensive division of activities. Consequently, there is a quest for more economical methods so far as the maintenance of basic equipment is concerned.

Like in other fields of industrial activity, even here it is possible to make use of unification, standardisation and specialisation with the maximum opportunity of assembling production. These leading principles have been examined as to their applicability to various conditions.

General experience gained from this field under examination shows that it is advantageous to practise the maintenance of basic equipment not only in compliance with the conditions of the user, but also the conditions created for the sake of economising the maintenance activity out of his workshop. Accordingly, the maintenance may be classified as 1/ care to be taken by the manufacturer, and 2/ maintenance to be carried out by the user.

2.1 Obligation of Basic Equipment Producers to Users - Service, Spare Parts

Effectively, the growth of repair shop capacities for a user's basic equipment is the extent and mode of securing the working ability and service life b its producer.

This care-taking activity will bring mutual benefit to the user as well as to the producer. It is the purpose of the producer to obtain the maximum working ability of the basic equipment supplied by him. A technical service should be instituted to keep the various machines and appliances in tact. As a matter of fact, it is the producer of basic equipment who - for commercial reasons - is always ready to perform a purposeful unification and typification of his products and improve their quality and reliability.

The importance of the service supplied by the producer is augmented by the results obtained from reviewing the behaviour of machines in the working process under diverse conditions, the influence of cutting-tools, planned substitution of machine parts and the like.

The producer's plant should be located to concentrate on the production volume of spare parts, enabling maximum consumption to be easily traced. The economic contribution of such a centralisation has already been proven. From an economical standpoint, this raises maintenance activity partially to an industrial level.

Analyses of the frequencies of individual types of machines and appliances have indicated that approximately 30 to 45 % of the total number of machines and appliances used in industrial establishments are involved. As for the remainder, it may not be feasible to be involved with a small number of miscellaneous types, to centralise the mentioned services. Such basic equipment will have to be taken care of by the users themselves.

2.2 Maintenance of Basic Equipment at Users' Plants

To perform this activity successfully, it is essential for those concerned to become well acquainted with the whole extent of this maintenance problem. Activities aimed at servicing basic equipment fall into the following three groups:

- service prior to technological operation
- service during technological operation
- maintenance and repairs of stalled equipment

It should be pointed out that neglecting any of the three activities classified above has a direct bearing on the next to follow.

Service prior to technological operation

This type of service may be interpreted as precaution in the purchase of new basic equipment. Requirements of this sort should be covered by the purchase of such equipment which can fully serve the technological purpose. This equipment should possess properties allowing for a service life of at least the length given b the standard and requiring minimum maintenance costs. Those who are concerned should bear in mind that an extensive miscellany of types is a source of trouble for maintenance and repair shops, as well as production technology, therefore, attention must be directed towards the unification of the production basis.

Another action specified in this chapter and calling for the user's attention is the take-over of a new basic equipment. The method to be chosen depends on the basic equipment in question, and also whether the take-over is to be carried out at the producer's or the purchaser's premises. The take-over of buildings and structures is ruled by authorised regulations for approbation and inauguration. The objects should be built in accordance with the drawings and documents agreed upon and that the technological processes applied, comply with the regulations and standards in force.

Special attention should be given to electric wiring, lighting, ventilation and heating.

The take-over of machines and mechanical appliances may in some cases prove more effective if carried out at the producer's premises.

In either case, performance of the equipment should comply with the required specifications and should be stated in the contract before purchase.

The acceptance of every basic equipment shall be testified by a certificate.

Should it be necessary to temporarily store the accepted machine or mechanical appliance, it is imperative to make provisions against any possible damage due to storing.

A new machine shall be handed over to the work-shop, together with its technical documentation and its top utility performed on trial.

The machine shall then be put in charge of an operator who is properly instructed beforehand as to its function, directions for handling and the rules of operation.

The operator's care and know-how of a machine will have strong bearing on the acceleration or deceleration of the machine's longivity.

Servicing in operation

This consists in supervising the operator's care of the equipment, i.e. his practice of utilising, cleaning and lubricating the machine and to the control of the machine during operation. The use of tools, as well as the overall organisation of the working process including the feed of material, depositing of finished work-pieces in the pre-fixed place, removal of metal chips or waste in due intervals and manner, relief of the machine when stalled, timely and careful exchange of coolant, etc. should be part of the operator's know-how as steps in the preservation of the machine's life.

The supervising activity also affects the electric equipment of the machine by way of pre-concerted inspections and overhauls. Special attention has to be paid to lubrication and the principles of its technique. Precautions of both organisational and technical character should provide for a progressive method to eliminate all lubrication failures through signals. Furthermore, there is a progressive lubricant economy which may also be included in lubrication engineering.

The third group of activities concerning the maintenance (in the proper sense of the word) and repair of basic equipment are the subject of the following chapters.

2.3 Repairs and Their Classification

Repairs form a part of servicing activities called maintenance, comprising a total of technical operations aimed at the elimination of the wear by way of repair, or substitution of the defective part and the regeneration of the original technical properties of a basic equipment.

The method of repair should be chosen with regard to the sort of basic equipment, the utilisation of same, etc. so as to meet the requirements of both the manufacturing process and the repair.

All repairs to be considered in connexion with basic equipment may be classified thus:

2.31 Repairs after failure

Repairs of this sort only serve to eliminate defects without preventing them. Their occurence is rather frequent in an out-moded piece-work or small lot production. Such a repair can be carried out economically on condition that it does not hinder the duty cycle of the machine in question, or if another similar machine is available to continue the work while the former is being repaired.

The frequency of machine failures increases considerably towards the end of the machine service life or owing to improper handling, which is especially evident in periods of a higher working load. Repairs of this type should not be applied to machines and mechanical appliances in continuous operation. Excessive deterioration and belated repairing of such machines considerably shorten their service lives, reduce their output capacities and raise their maintenance cost.

Post-failure repairs are therefore admissible only with basic equipment of less importance or occasional use.

It is often stated that post-failure repairs are actually the most economical of all because defective machine parts are fully utilised until their destruction. Such reasoning is far from being correct as the failure of one part usually involves that of others.

According to the theory of reliability, it is the different character of wear on each individual part that makes the ideal trouble-free machine operation unreal. As a matter of fact, failures occur not only with machines in regular use but with brand new ones or repaired ones as well.

It may be therefore concluded that repairing basic equipment after its failure brings no economical advantage and should be approved only in the case of a maintenance capacity shortage, or where preventive repairs would turn out ineffective owing to insufficient technical planning data.

2.32 Repairs after inspection

Periodical inspections, the purpose of which is to ascertain the overall wear and accordingly order specific repairs is to be made in fixed time limits. This pre-failure attendance to basic equipment brings an element of prevention and rough planning into the maintenance activity. Inspections are usually made to cover one year's period. These are to be performed in accordance with short-term operative plans (e.g. inspections of buildings and structures are planned for the seasons of spring and autumn). During such inspections, the basic equipment is visually or mechanically checked in order to supply disclosed defects, substitute worn parts, as well as to make a thorough cleaning and setting up of machines.

The disadvantage of the mentioned servicing is that it only makes possible long-term plans on average general values obtained in the preceding years.

Post-inspection repairs may be applied to basic equipment provided with no repair planning data, or to basic equipment of general use, serving auxiliary purposes mainly, because prevention against their failure may be considerably reduced.

2.33 Regular repairs

Repairs of this sort are based on the following principles:

- repairs are of a compulsory character, to be made repeatedly at regular time intervals without regard to the technical state of the particular basic equipment;
- machine parts listed on schedule are substituted even if good;
- repairs are carried out in accordance with technological procedure sheets stating the extent of repairs and all individual repairing operations in detail.

Regular repairs may be applied to machines and mechanical appliances working under the same conditions, causing approximately the same amount of wear, if the requirement of a trouble-free operation is more important than higher maintenance cost.

The application of the regular repair system must be preceded by a profound study of the wearing process of each particular machine part concerned.

A combination of the regular and planned repair system is often used. Effectively, machine parts subject to rapid wear are treated by regular repair servicing, while the remaining parts are serviced by a different method, e.g. that of planned preventive repairs. This allows for both short-term and long-term planning.

2.34 Planned preventive repairs

The method of planned preventive repairs is based on planning repairs systematically for the prevention of manufacturing equipment failures. It is a complex of all technical and organizational preventive measures, machine attendance and supervision, as well as all sorts of repairs carried out periodically to a definite schedule for the sake of preventing failures.

The manner of repair, the volume and number of repair services, as well as the time-limits for execution are determined by a system of principles, rules, technical and economic standards, marking the maintenance activity with the following features:

- Repairs Are Planned

  For every machine an accurate sequence of repair services is set up according to the wearing process of individual machine parts so as to speed up the repair and cut its cost down to a minimum.

- Repairs Are Preventive

  Although the working state of a particular machine does not call for immediate attention owing to a progressive wear on some of its parts, a preventive repair shall nevertheless be made only to ensure the machine against complete failure and consequential shut-down.

- Repairs Are Periodic

  Every machine or mechanical appliance has its own "repair cycle". This is a summary of successive repair services performed at regular intervals determined by the frequency and progress of the machine part wear.

- The overall volume of a repair and of each of its operations is limited by time-standards.

  The complexity and type of every machine determines the volume and qualification grade of the repair work.

- Every planned repair shall be carried out so as to guarantee the working ability of the machine to last until the next planned repair.

For the practical use of the planned preventive repair system and as an aid in making out individual maintenance schedules for basic equipment, a system of standards has been worked out refering to:

a/ repair cycles

b/ Repair difficulty units

c/ repair operation standards

d/ time-limits of repair operations.

a/ Repair cycle

A repair cycle means a succession of specified repair services within the cycle period extending from the installation of a new machine to the first complete overhaul, or from one complete overhaul to another.

The length of the cycle period depends on the extent of utilization commonly expressed by the number of working hours, shifts, or other factors (e.g. ton-kilometres). This should be estimated so as to correspond with the process of wear of a particular machine. Among the factors influencing the length of a cycle period are: quality and condition of the basic equipment, quality of operator's attendance, overtime work, volume of technological utilization derived from the type of production and the shift coefficient, working ambients, and outage time due to any possible cause. Machines working under normal conditions deteriorate less and the repair cycle period may therefore be relatively long. The more stressing the working conditions, the shorter period comes into consideration: intervals between each two repair services of the cycle become longer.

Machines of the same type working under the same conditions may presumably suffer the same extent of wear and consequently be subject to the same repair cycle.

The interval between two repairs of one cycle should therefore be determined with regard to the process of wear: long enough to secure a reliable operation of the machine at the lowest possible frequency of repairs.

If the repair cycle has been rated correctly, individual successive repairs are always ahead of the culminating point of wear, regularly followed by a rapid decline of the machine condition. Such a timely repair removes the consequences of wear, stops its further growth, and enables the machine to keep its working ability unchanged for some time. Repair services performed in the course of one cycle are classified according to the volume and by the number of worn parts to be substituted or repaired.

Within one repair cycle the following repair services are performed periodically in succession of a definite order:

- preventive periodical inspections (I)
- preventive periodical small repairs (S)
- preventive periodical medium repairs (M)
- complete overhauls (O)

Other repair services, although they form an integral part of the basic equipment service ruled by the planned preventive repair system, are not recorded in the repair cycle.

Equipment working under specific conditions may have - with regard to the aforesaid principles - the following repair cycle:

S-S-M-S-S-M-S-S-O

O-I-I-S-I-I-S-I-I-M-I-I-S-I-I-S-I-I-M-I-I-S-I-I-S-I-I-O

r e p a i r   c y c l e   l e n g t h

b/ Repair difficulty units

A complete overhaul undergone by a particular machine can be expressed as a multiple of a specific unit called "repair difficulty unit". In this way, it is possible to determine the numerical proportion of difficulty between the complete overhaul of a certain machine and that of the machine chosen as standard.

Example: A centre lathe, dia. 360 mm, turn. length 1250 mm has been chosen for comparison and the difficulty of its complete overhaul estimated at 10 difficulty units. The average time needed for a complete overhaul of this lathe has been found to equal 540 hours, so that 1 difficulty unit of the overhaul volume amounts to 54 hours.

The "repair difficulty unit" is used for the evaluation of repair frequency for machines by way of comparing the complexity of their mechanisms to that of the chosen centre lathe, or with the aid of standard comparison tables.

c/ <u>Repair operation standards</u>

These standards indicate a general specification of repair operations applied to machines under the planned preventive repair system, together with the description of each operation. This provides for making technical arrangements in advance. Each standard outlines the sphere of operations to be considered so that a repair may fulfil its task jointly.

d/ <u>Time-limits of repair operations</u>

These time-limits are equivalents of repair difficulty units in working hours allotted to main operations within the individual repair services of the planned preventive repair system. They link up to indexing machines with repair difficulty units and the repair operation standards.

2.25 <u>Evaluation of the main maintenance methods of basic equipment.</u>

The practice of maintaining basic equipment is not uniform, nor are opinions of the advantages that any of them may offer. They change according to the conditions of application, the qualitative and quantitative development of the production basis, the development of production methods, the development of organization and management. They also change in respect to the growth of maintenance capacities, both inside or outside (i.e. of machine producers).

The rapid development of national economy and the need of a well-organized development of the basic equipment economy make it imperative to evaluate, at certain intervals of time, the efficiency of methods applied, and to decide upon the manner of their further development.

A study of the present situation reveals that the post-failure method of maintaining basic equipment is not economically efficient. This may be applied only where losses brought about by failures are admissible, or where the preventive repair system would prove inefficient, owing to a lack of technical planning data.

The advantages of the other maintenance systems and their evaluation are demonstrated satisfactorily in the table below by comparing the different systems.

Symbol - PI - stands for the Post-Inspection Repair System
Symbol - R - stands for the Regular Repair System
Symbol - PPR - stands for the Planned Preventive Repair System

Viewpoint	System	Evaluation
1. Planning of repair services	PI	volume and periods are variable
	R	volume and periods are accurately fixed
	PPR	volume is comparatively invariable, periods are regular
2. Co-ordination of repairs with production plan	PI	cannot be regularly achieved
	R	perfect
	PPR	good and satisfactory
3. Length of outage times with planned repairs	PI	considerable owing to a lack of efficiency standards
	R	considerable owing to comparatively short cycles and big repair volumes
	PPR	volume and cycles are in optimum accordance with service-life of parts
4. Regularity of outage with planned repairs	PI	cannot be guaranteed
	R	repairs are made at regular intervals
	PPR	repairs are made at pre-fixed intervals
5. Outage due to failure	PI	inspector's personal estimate of machine condition may cause longer outage time
	R	none
	PPR	systematic inspections and repairs provide against failures

Viewpoint	System	Evaluation
6. Restitution of properties in respect of technical level of machines	PI	inaccuracies are elimated where necessary
	R	overall high precision is achieved by extensive repairs
	PPR	wear is eliminated by complex repairs
7. Utilization of service life of parts	PI	up to maximum - parts are substituted only after obvious wear
	R	inferior owing to compulsory substitution of working parts
	PPR	most satisfactory owing to substitution of parts or whole part-groups having the same service life
8. Utilization of repair workers' time reserve	PI	low owing to excessive assemblage times
	R	satisfactory owing to shorter repair cycles - excessive demand of labour
	PPR	up to maximum - repairs correlate with need and can be progressively organized
9. Economic evaluation of systems	PI	low repair cost, considerable losses due to outages
	R	high repair cost
	PPR	optimum repair cost and tolerable production losses
10. Reliability of operation	PI	not very high owing to dispersion of repair service
	R	high
	PPR	very high owing to complex repair service

Viewpoints offering evaluation of the systems to keep the maintenance of basic equipment progressive is necessary. A system that meets the actual conditions and brings the maximum benefit should be chosen. It is of no importance whether all basic equipment is serviced by a single or more systems according to the specific purposes of the equipment.

It should be noted that the repair systems described are of the most popular. However, there are quite a number of various combinations and adjustments of these standards.

For instance, despite a shortage of repair capacity, the planned preventive repair system is being applied to all machines in general, but with different attention in respect of the technological importance attributed to each machine.

Repairs can be carried out "on the spot", in own repair shops, in the repair shops of machine manufacturers, or specialized firms. Sometimes, it is necessary to substitute the machine under repair which has been removed for overhaul with the same type of machine.

2.4. Choice of the Most Suitable Repair System

a/ Buildings and structures

This should be maintained by the post-inspection repair system effected in the seasons of spring and autumn. Defects revealed by inspections give ground for repairs or improvements to be made thereafter.

b/ Machines and mechanical appliances

For such equipment the planned preventive repair system is available, especially where a high reliability in operation, short time outage and reasonable repair cost are required.

However, the regular repair system comes into consideration when a constant top working ability of the machines is required, even at higher maintenance cost and with more frequent repairs.

The choice of post-failure or post-inspection repair systems may be applied to diverse mechanical appliances only in the case of a shortage of repair capacity and losses due to the failures being lower than the cost of a different repair system.

At typical engineering works, the application of the mentioned repair systems should be in the following numerical relation:

Planned preventive repair system: abt. 65% of machinery and equipment (bottleneck, expensive and the other items)

Regular repair system: abt. 5% (bottleneck, unique and special units and parts)

<u>Post-inspection repair system</u>: abt. 10% (some supplementary machines of minor importance, machines in the last stage of service life).

c/ <u>Other kinds of basic equipment</u>

It is useful to apply such repair methods which meet the demands of correct maintenance and comply with the type of the particular basic equipment.

Part 3 - Organisation of Maintenance and Repairing of Basic Equipment

The aim of this chapter is not to formulate a type organisational scheme, but to enumerate some circumstances that should be duly considered in the creation of a suitable and purposeful organisation.

3.1 Assignment of Responsibility for the Condition of Basic Equipment between the Maintenance Departments, Power Engineers and Users

This problem should be dealt with in organizational standards of every organisation. Particularly concerned, is the definition of responsibility for:

- the inventory condition of basic equipment
- use of basic equipment
- servicing and maintenance
- utilisation
- technical condition (material and intangible wear and its control
- safety operation of basic equipment to be commissioned.

The abovementioned range of responsibility cannot be covered by one department only. It is essential is assign departments to attend to each of the tasks.

The department dealing with a particular task is responsible for the correct fulfilment of all duties to be discharged within its operational range, even if it has to make use of the services of other departments.

For instance:

a/ the inventory condition of basic equipment (except power one)
  - its usage
  - servicing
  - utilisation

  Responsible is the user of basic equipment.

  This responsibility includes a number of duties such as:
  - correct record keeping of basic equipment (condition and changes);
  - evidence of basic equipment data versus their operation range;
  - manning of basic equipment posts with qualified personnel;
  - optimum utilisation of basic equipment;
  - further tasks.

b/ - technical condition of basic equipment

- safety operation of basic equipment units to be commissioned.

Responsible is the maintenance department (except for basic power equipment). The responsibility involves the following duties:

- to get perfectly acquainted with all the basic equipment items within its control, their technical and functional aspects, material and intangible wear;
- to get acquainted with all practicable maintenance and repair methods, with regard to the specific conditions of use and utilisation, to choose the basic equipment that performs best with the given conditions;
- not to stick to the conventional repair methods in case they may be further improved, bringing the scheduled output as close to actual requirements as possible;
- to work out long and short term maintenance and repair schedules and to provide for their financial and material fulfilment;
- to break down the schedules into working decades and to provide for their materialization by plant capacities or by means of suppliers;
- to check and take over the repairs carried out by the suppliers in order to be able to assume all current guarantees towards the user. Repairs carried out by the own capacities should be done in a quality as required;
- to demand the stoppage of work, the operation of which involves breakdown risks or jeopardizes the safety and health of employees;
- to follow up the technical condition of basic equipment and to utilize the experience for the improvement of maintenance activities;
- ensure the operation of lubrication systems;
- to remove failures and breakdowns, if any, in compliance with the users' needs;
- to commission basic equipment in conformity with the respective technical and safety standards;
- to discharge further duties involved in the specified scope of responsibility.

c/ inventory condition of basic power equipment

- its usage
- servicing and maintenance

- utilisation
- technical condition
- the safety operation of basic power equipment.

Responsible is the power department, because it includes the generation, supply, consumption and transformation of specific kinds of power. In order to cover the abovementioned responsibility, the department must discharge the duties specified under point c/ (user) and b/ (maintenance).

3.2 Organizational Position of the Basic Equipment Maintenance Department at Various Levels of Organization

The scope of activities of the maintenance department will vary with the organizational level within the production and economic unit. Generally speaking, the higher the level, the more methodical activities and the fewer executive tasks it will perform, and vice versa.

E.g.

a/ Trust management

At this level, it will probably be suitable to concentrate only on the problems concerning prospective projects of repair systems. The development tendencies of the respective branch, production basis and supply relations must be taken into consideration. In this case, it is recommended to incorporate the maintenance department into the section "planning of branch development".

b/ Enterprise management

This level is responsible for the condition and development of material property administration, and the character of basic equipment. That is why this level will deal, in conformity with management principles, with the development of repair methods and provide for:

- subsequent check-ups in the plants
- the required control of demands and needs of the plants concerning basic equipment by means of evaluation and acceptance proceedings;
- inflicting penalties for incorrect management and running of basic equipment;
- analysis of indices of production basis and its management and running;
- solution of problems of specialisation and maintenance specialisation;
- some other activities.

Here, the maintenance department could be incorporated into the section "Production basis development".

c/ Plant

The plant is the executive agent, responsible for the operational condition of basic equipment from their commissioning until liquidation. This duty includes the observance of correct economic criteria and other tasks in connexion with proper management.

Maintenance departments are included either:

a/ in the section of the deputy manager for production;

b/ in the section of deputy manager (Technical); or

c/ are directly subordinated to the plant manager.

Sub a/ This is not usual. As a rule, this scheme tends to result in the underestimation of maintenance work as against production itself. We should generally accept the principle that it is not advisable to encumber and distract the production with problems concerning basic equipment.

Sub b/ This is a suitable and most frequent system. The deputy manager (technical), amont other things, is in charge of the development of products as well as the production basis. Frequently, maintenance departments, in addition to their own objectives, are given tasks connected with the modernization of the production basis. Therefore, the connection between the two components is close. Provided there are good working pre-conditions, the maintenance departments in this organizational position can produce good results.

Sub c/ The subordination of the maintenance department to the plant manager is the least frequent form in spite of the fact that this organizational arrangement could bring a number of positive results.

The chief of the maintenance department, being a member of the plant management staff, can directly exert influence on such tendencies that might impair the general level of basic equipment.

He is a well-versed specialist who can essentially contribute to solving issues concerning operational problems. He is therefore able to improve the quality of decision-making in matters of organizational arrangements.

3.3. Division of Work and Forms of Co-operation between the Maintenance Departments and Power System Departments

The division of work and responsibility in large plants is applied in the auxiliary shops themselves wherever there are separate departments for maintenance and power systems.

In this case, the departments have certain different aspects which are to be respected in choosing the best organization arrangement.

Power system department - is not only responsible for the condition of basic power equipment, but is also the main user of this equipment. Its duty is to provide for servicing and operation, with the aim of obtaining maximum efficiency.

It prepares long term perspective plans of power requirements, such as el. current, heat, compressed air, lighting gas, natural gas, producer gas, acetylene, oxygen, drinking and industrial water etc. As the rise in consumption of these energies usually entails expensive investment expenditure, the working character of the power system department, in this field, is to be based on long term planning.

The department deals with a media having close linkage to state energy network, both in the consumption (take-off) and the supply of the plant's own excess energy into the public network. For these reasons, the sphere of power systems is subjected to comparatively strict state standards or public regulations, particularly in respect of general supervision, inspection and utilization of sources.

Similarly, to obtain uniformity in plant organisational standards, the power system department is in a number of cases, subordinated to the maintenance department.

Maintenance department is generally the only methodical agent in these fields:

- obtaining basic equipment and record-keeping
- technical data records of basic equipment items
- inventory work concerning basic equipment
- handling of basic equipment items that are superfluous, unusable or temporarily not required
- uniform financing of maintenance, repairs, etc.

The main objective, that is the operational capability of basic equipment, is the same in both departments. The functions of the departments are therefore to be regarded as an integrated subject. Their activities should be concerted one with another.

3.4 Main Organizational Principles of Basic Equipment Economy

Organisational arrangement of the maintenance department is dependent on specific conditions. These are: production type, plant size, number of basic equipment items in individual classes, repair intricacy and specific amount of work, age of basic equipment, general schemes of production attendance and standards of servicing rendered by manufacturers, etc. Therefore, it is very difficult to draw up a type organisational chart of universal applicability. Nevertheless, we can adopt some general principles based on practical experience. The main working purpose of the maintenance department is to take care of basic equipment. This involves a very large scope of activities which basically include measures aimed at ensuring proper care for the most important parts of tangible property.

The organisation will therefore be based on the following:

- activities connected with obtaining (purchasing, etc.) of new or secondhand basic equipment
- national economic record-keeping of basic equipment and filing of documents
- preventive care aimed at minimizing repair needs (retardation of wear process)
- application of suitable repair methods which remove wear consequences and create optimum conditions for this work (economic relations to financial expenditure)

- preparation of a planning system for maintenance and repair
- rationalization of expenditure spent on preventive care and repairing (financial repair plans) carried out by the plant working capacities or by suppliers
- industrialization through concentration of repairs and their technical preparation
- modernization of basic equipment
- restoration of equipment by replacing old one for new units with regard to an investment construction plan
- handling of superfluous, unusable and temporarily not needed basic equipment
- gradual liquidation of basic equipment
- repairing work properly.

Due to the amount of specific jobs, the organisational scheme will have to undergo modifications so that some jobs will be performed by cumulated functions and others by individual persons or departments.

3.5 <u>Brief Classification of Activities of Basic Equipment Maintenance Department</u>

This department covers a wide range of duties. In addition to a variety of repairing jobs, it provides for a number of non-maintenance activities (not covered by the other departments), such as erection of machinery and equipment, manufacture of plant investment units, co-operation with the technical development department, e c.

Its work may be conveniently divided as:

a/ <u>According to type of work</u>

- maintenance activities (maintenance fund)
- non-maintenance activities (investment means)

b/ <u>According to execution method</u>

- realization by internal means (plant capacities)
- realisation at an external supplier

c/ **According to execution system**

- scheduled duties
- non-scheduled duties (failures)

d/ **According to volume**

- inspection
- accuracy checking
- adjustment of functions or geometry
- removal of petty defects
- minor repairs
- medium repairs
- overhauls

These intricate and varied activities can only be performed by a well-organized department, in a complex way, as indicated in the following:

e/ **Activities aimed at proper administration**

- technical operative records of basic equipment
- filing of technical documentation
- inventory duties concerning basic equipment
- statistics and analysis
- evaluation of accounting data
- evaluation of economic results

f/ **Retardation of physical wear processes**

- adjustment of machine functions and operation
- cleaning and lubrication
- improvement of operators' qualification
- control of effects tending to speed up wear (mechanical and atmospheric effects)
- publicity of proper care for basic equipment
- adjustments or arrangements prolongating service life of basic equipment.

g/ **Development of the technical condition of basic equipment - supervision**

- checking of operators' work
- checking of the technical condition of basic equipment
- inspections required by standards
- inspections (fire prevention, hygiene, etc.)
- functional and operation tests
- evaluation of failures and breakdowns
- evaluation of causes of excessive wear

A similar complex approach is required for the following fields:

- removal of physical wear consequences
- removal of intangible wear consequences
- proper management of basic equipment transfers
- technical and organisational measures aimed at raising quality of repair work
- planning and financing
- renewal of basic equipment.

Depending on the conditions in which the maintenance of basic equipment is carried out, the classification may be modified in order to comply with the general classification of the organisation concerned (enterprise, plant).

3.6 Specialization and Centralisation of Repair Work

In determining the organisational set-up of the maintenance department, we should bear in mind that in every enterprise there are basic equipment parts that are used by more departments or sections, e.g. roads, boiler houses, power systems, communication facilities, etc. Maintenance of such basic equipment should be carried out centrally by specialists for the different types.

This approach may lead to the establishment of centralised repair departments, taking advantage of specialisation and centralisation facilities such as:

- medium repair shops for machine tools and shaping machines
- repair shops for lifting and handling equipment
- repair shops for electrical equipment and electrical devices
- repair shops for business machines
- fitters' workshops
- specialized workshops for building maintenance (joiner's, painting, plumbers' shops, etc.)

Besides these specialised centres, the maintenance department covers all the administration of basic equipment, filing of documentation, technical preparation of repairs (design, technology, process sheets, tasks). In addition, handling of superfluous and unusable basic equipment parts, lubrication techniques, cleaning of machinery, stores of machines and spare parts, inspection of machines and equipment, all records and economics concerning repair work.

Correctly established specialisation in maintenance work and its centralised practice will essentially influence its efficiency and in many cases, will enable its operation at all.

3.7 Forms of Organisational Set-up of Maintenance Departments

The preceding chapters suggest that the establishment of an organisational scheme for the maintenance of basic equipment in a production plant is no easy matter. As a matter of fact, there are too many aspects, often confliction ones, and multi-stage sophisticated interrelations that are to be considered before we can reach a conclusion in this respect.

Expert sources and our experience suggest three basic organisational forms:

- centralized
- decentralised
- combined.

In order to be able to cope successfully with its tasks, the maintenance department of basic equipment should be organised so as to provide for:

- uniform management of reproduction processes in conformity with the development of production basis
- organising of repair work in compliance with principles of uniform methodics
- concentration of repair work; operative measures concerning the technical condition of basic equipment
- specialization of selected activities
- pre-conditions for systematic unification and typification
- simple management
- co-operation with production shops influencing the process of wear
- observance of principles indicated in state standards
- subsequent checks of economic results.

In practice, it will be necessary to compare the abovementioned organisational arrangements so as to decide upon a form which would give the best results.

For some organisations it may appear:

a/ fairly advantageous to adopt:

Centralised maintenance which facilitates concentrating repair jobs and a better utilisation of labour. Centralised departments make use of division of work and thus can raise repairing productivity and quality. The responsibility for the condition of basic equipment is clearly assumed by the maintenance department. Their duty is to provide for adequate productive capacities for the production section without involving complicated problems.

The people under this system are in respect of methodics and organisation directed by the maintenance department.

b/ less convenient to apply:

Decentralised maintenance: here, the operational capability of basic equipment is ensured by maintenance people who are incorporated in the organisation of production shops. The existence of equipment bei·g used in common by several workshops is generally bound to impair the definition of decentralisation. The assertion that maintenance work subordinate to production sections becomes more operative is not tenable if we realise the maintenance capacities it inevitably entails. Also, their frequent diversion to productive tasks at the expense of the proper care of basic equipment.

c/ fully satisfactory to introduce:

Combined maintenance: Under this system, the maintenance department with technical staff and specialised centres will carry out laborious repairs or technically exacting ones required throughout the whole plant. Individual workshops will include maintenance men to do minor repairing jobs.

d/ more suitable and equally efficient in some cases to apply:

Centralised maintenance with detached workplaces which would combine the advantages of centralisation and decentralisation and eliminate their drawbacks.

e/ Similar advantages may offer also a centralised maintenance with regional arrangement by means of sectional maintenance departments, the competency of which is fixed for definitely specified sections of the plant.

Part 4 - Determination of Capacity of Basic Equipment Repair Shops

To maintain basic equipments in durably good service conditions, repair shops are built. These may be constructed to attend one factory only, or an association of a number of identical factories thus looking after equipment they are able to follow closely in the sence of the foregoing chapters, more or less. Or, they can act as independent units which carry out maintenance for a number of proprietors of basic equipment, their planning being thus more difficult. That is why repair shops operating in a broader field of action in most cases are specialised. For instance, in electric motors, transformers, motor cars, agricultural machines and likewise. On the base of the given assortment of equipment under repair, and the volume of repairs, project documentation would be elaborated for the erection of the shop.

4.1 Basic Data

The repairing capacity of the shop is the main characteristic feature of the plant. With the aim of its determination, definite basic data and informations are to be provided and elaborated beforehand. This will allow the designer to calculate the necessary number of workers, production machines and equipment, the floor areas for production, administration and social installations, the claims for erection sites, outer transport as well as the necessary production materials and energy. The good quality of the basic data can greatly influence the realization of investment items, and above all, their economic effect. In procuring such basic data, one must proceed cautiously weighing critically all conditions that will influence the future plant. For this, a thorough knowledge of technical and economic parameters as well as an objective evaluation of actual conditions are inevitable.

The following chapters contain such claims, as far as basic data are concerned, that are decisive for the most part. The enumeration of these data is not exhausting, as it is necessary in some cases to make use of individual methods. Such a case occurs for instance if the assortment of parts to be repaired is rather variable, the demands of the customers irregular, if very complicated production or testing devices are necessary for the execution of repairs, if traffic situation and the possibilities of procuring production and auxilliary materials or similar condition are difficult. In order to make better use of its capacity, the repair shop itself may produce some of the devices necessary for different purposes (especially such devices that are unique), usually according to technical drawings delivered by the customer.

4.11 Maintenance and repair plan in technical units or financial volume
In erecting a repair shop, we must know which articles, in what quantities and at which time periods are to be repaired. Such data may be obtained most easily in factories having a system of planned, preventive repairs of basic equipment. Every item of the index of machinery for which the repair shop is bound to take care must bear the data concerning the number of complexity units, the category of repair cycle and its period. In the absence of such data, it is necessary to draw up a list of equipment to be repaired, specified according to types, (which is possible to do in specialised shops), or representative items, every one of which represents one group of similar parts from the designer's point of view. Every type of representative item must be accompanied by a number of pieces to be repaired next year. In some cases, this number may be replaced by the financial value of yearly repairs.

The more diversified the assortment of the repaired parts and the more irregular their supply for repairs, the less reliable the estimation of utilised capacity would be and the greater the problems in choosing machinery with respect to its reasonable utilisation.

4.12 Time reserves and working shifts
In determining the numbers of production workers, machines, as well as the manual working plans, it is necessary to establish the so-called effective annual time reserves beforehand. These indicate the number of hours in one year worked by one worker, one machine or one manual working place, under normal working conditions.

To calculate this, one must know:
a/ the number of working days in one year (P)
b/ duration of one working shift in hours (h)

c/ the number of daily shifts (s)

d/ average duration of the pair leave of absence in workers, in days/year (D)

e/ the average losses of working hours in % caused by illness, justified absence and time losses caused by repair of wasters caused by the workers (z)

f/ average losses of the working time of machines caused by the necessary maintenance. They are estimated according to local conditions in % of the overall actual annual capacity (u).

The effective annual time reserves are then calculated from the following equations:

The effective annual time reserves of a worker

$E_d = h\ (P - D)\ .\ (1 - \frac{z}{100})$ hours in a year

The effective annual time reserves of a machine working place

$E_s = h.s.P\ (1 - \frac{u}{100})$ hours in the year

In manual working places the capacity losses caused by maintenance fall off (u = 0), so that the annua time reserve equals to

$E_r = h.s.P$ hours yearly.

4.13 Co-operation possibilities

The economy in operation of repair shops depends on a good and uniform use of machinery. Special attention must be given to expensive machines and equipment, these being generally voluminous machine tools of heavy duty special machines. It is necessary to make sure, after analysing the operation program of the repair shop, if possibilities exist within the given sphere to place an order to accomplish such operations in some other factory possessing the necessary equipment. On the other hand, is it possible to improve the utilization of one's own production means by carrying out partial operations on behalf of external interested parts. Similarly, it is necessary to decide in which way the repairs of sophisticated measuring, control and automation devices are to be secured which necessitate the use of very expensive controlling and measuring devices, as well as experts with high technical qualification.

In using such measures of course, the readiness of the operational management of the repair shop is rendered more difficult. On the other hand, improved economic results and quality of the executed work improves in favour of the customers. From a publicity point of view, this is very advantageous.

In this vain, it is necessary to review the possibilities of securing semi-products such as castings, forgings and stampings from different metals, as well as standardised and spare parts and implements.

The volume of these operations contracted with other factories reduces the demands on the capacity of the repair shop concerned. This reduces also the investment costs for machinery, operation areas, the manpower and individual professions.

4.14 Delivery terms for material, spare parts and standard parts and tools

Trouble-free production and reasonable current repair terms require in addition, a timely supply of production and auxilliary materials and accessories, of spare parts and semi-products and standardized parts, as well as of operational tools. This continuity must be secured by means of properly dimensioned stores. Their size depends partly on annual usage of individual sorts and on variety of assortment. Also, on the terms of delivery necessitated by the suppliers for carrying out the order, and frequently on the limits of the contractor for minimum quantities of individual sorts. Large stocks are of course a good guarantee of a continuous operation but they require more extensive storing areas. Therefore, being more expensive from the investment point of view, binding more substantial financial means. With some sorts of articles there is also a danger of quality deterioration owing to a long lasting storing. In case of low stocks, there is a risk in the continuity of the operation. There may be interruption in case of non-observance in the time of delivery from the side of the supplier, or out of transport motives, or the prolongation of the continuous repair periods. Hence, outage time of the equipment in repair shop and with the customer.

These are reasons why it is necessary to pay due attention to the time of delivery of all material means, when investigating the conditions necessary for building a repair shop. Generally, this investigation results in all characteristic individual types of demands the necessary maximum weights to be stored are to be stated directly or the periods for which individual sorts of materials must be stored in case of regular annual consumption without the necessity to supplement the stored quantities.

4.15 Technical terms for the execution of repairs and their testing.
When repaired parts leave the shop, they must comply with technical conditions. These are a summary of requirements based upon the running qualities of the machine, the careful execution of repairs and the external finish of the machine. These conditions either coincide with normal conditions for new installations or are elaborated separately for the repair shops according to their purpose and importance of the installations. Among the technical conditions and from a technical standpoint, particularly important are the requirements concerning the acceptance of testing materials (where and by what means), inadmissible operations (for instance baking of material, pickling), heat treatment and surface finish (kinds of coats, number of layers, coloured marking, inscriptions) and the list of checking operations before finishing the repair.

On the basis of testing and inspection conditions, the claims are elaborated for implementation in testing rooms, their areas as well as power inputs. In this respect, functioning tests, output tests and very often, also the safety tests (pressure tests of boilers, pressure vessels and fittings, centrifugal tests of rotors) must be considered. When investigating conditions needed for the erection of a repair shop, it is necessary to lay down which tests are possible or indispensable to be carried out in such a repair shop and which of them will be executed under the supervision of experts of the repair shop, in the rooms of the customers, after the assembly has been made.

4.16 Requirement of the rehabilitation of parts.
Rehabilitation of wornout or damaged pieces are made by coating the piece with a layer of metal (using a convenient method), by metal spraying, electroplating, or any other convenient method. The piece then is being machined to original size. For such repairs, special devices are needed,

therefore the decision as to whether renovation will be made in the repair shop or not, is a matter of the original design basis.

Dependent on this decision are economic questions that may have a varied effect in different domains. Generally, it may be said that economic gain from renovation will be greater when the material component of the price is more predominating, or the more complicated is the repaired part. Moreover, very important may be the losses in cases of machine breakdowns or should the delivery time of new spare parts be extremely long.

Convenient for renovation are heavy or insufficiently machined parts in metallurgical engineering, chemical industry, industry of building materials or parts from large lots or line production, where the machining costs are insignificant owing to high mechanisation, so that prices of the spare parts are prevailingly determined by the price of basic materials. It may be advantageous to renovate parts destined for older types of productions, for which it is impossible to secure spare parts from running production. The renovated parts are then usually less expensive than new parts manufactured individually on universal machines.

4.17 Climatic conditions

As far as the influence of climatic conditions of the region on the designing of industrial plants is concerned, the greatest importance have the annual variations in temperatures, the relative humidity, as well as the rate of precipitations. Since these values usually vary greatly, it is necessary to consider the past records and the registered absolute maximum and minimum values. On the base of these values it is possible to make the choice of the values appropriate for the calculations in the project.

Furthermore, the predominant directions of the winds need to be found and in some cases even the annual development of the atmospheric pressure. These values are used in calculating the ventilation and the heating installations, also in the design of air-conditioning plants. Data concerning precipitations are necessary for sewerage projects.

4.2 Determination of the Capacity for Repair of Machines and Equipment, Buildings and Structures, as well as of Other Types of Basic Equipment.

The task to be fulfilled by a repair shop is usually stated in terms of annual production, thus representing its annual capacity. This capacity is expressed in different ways, according to the diversity of basic equipment under repair and its character.

4.21 Machines and Equipment.

The repairing capacity is generally given by a number of machines and equipment or by a financial value of the executed repairs. If a system of planned preventive repairs is established in the factory, the capacity of the repair shop is characterised also by the number of units being serviced annually by the shop. This number expresses the amount of work required in repair work. The amount of work needed is expressed also by the capacity of the repair shop in man hours worked annually. This may be indicated separately for mechanically and for manually operated working places.

4.22 Buildings and structures

The capacity needed for buildings and structures repair, depends, except for the basic equipment, on the quality of materials used in construction and to a large extent, on the climatic conditions in the region. Long term forecasts are unreliable and therefore, the volume of work is determined by a rough estimate of annual supposed costs (expressed in financial units) for the maintenance of buildings. From this, the number of hours worked annually can be derived.

4.23 Other Types of Basic Equipments.

In this group belong mainly the lines (external service lines), waterworks, ships and the like, maintenance of which is, according to circumstances, either maintenance of technological or structural equipment. In a number of cases, it is secured by contracts.

4.3 Calculation of the Demand for Manpower, Machines and Operation Areas.

The main factors in repair shops are the manpower of different skills, production machines and accessory equipment, as well as the working, administration and social areas. These factors are in certain relation to the production tasks of the shop, having been derived from them according to a method stated in chapters 4.31 and 4.33.

4.31 Calculation of the Necessary Manpower.

Production workers (manual and mechanical), overhead workers, technicians and engineers, as well as administrative workers, are calculated separatel .

When calculating the necessar numbers of production workers, one starts from the proposed annual need for piecework hours resulting from the planned tasks of the repair shop. Workers having their permanent working sites in the repair shop and workers whose dut is to carr out side repairs, most frequentl in places where the repaired machinery will be installed, are considered separatel . For the latter group, no machines and no production areas within the shop are needed. Since we rel on the fixed times, we must verif the way in which these times have been determined (b a detailed calculation, on the basis of statistical data, through estimates). According to that, one determines the so-called coefficient of overfulfilment of task time standards (k) indicating the ratio of the number of task time units (seconds, minutes, hours) necessary to carry out a given operation (T_n) to the number of time units that have been spent to execute the actual operation (T_o). Hence, the coefficient of the overfulfilment of task time standards ma be expressed b a relation

$$k = \frac{T_n}{T_o}$$

This coefficient ma var with operations and depends on the method used to determine the time T_n, on professional skills of time keepers and on the conscientiousness of the workers executing the given operation. When projecting, one uses generall the average value k_s which is given b the relation

$$k_s = \frac{T_n}{T_o}$$

where T_n represents the total of all task time standards in the annual plan and T_o the total of hours spent annuall b the workmen carrying out the planned tasks.

The number of production workers (working on machines or manuall) must be classified according to their individual professions and qualifications. Having at our disposal the detailed data on standard times (from which the total number of standard hours (T_{np}) for ever profession and every qualification class ma be determined), the total number of necessary workers in each profession and qualification class D_p can be calculated from the following relation

$$D_v = \frac{T_{np}}{K_s \cdot F_d}$$

On the base of the fundamental data, it is not possible to determine the total number of standardised hours T_{np} for every profession and every qualification class, one may ascertain the total number of production workers D_v out of the relation

$$D_v = \frac{T_n}{K_s \cdot F_d}$$

The distribution of production workers into individual professions and qualification classes is made by means of calculation key determined on the basis of the data obtained either from some similar existing or projected plant, or if need be, by an estimate made by experts.

The number of overhead workers (storehouse and transport workers, tool-issuing workers, tool grinders, lubricators, upkeepers, supervisors, adjusters, charwomen, errand-boys, eventually of other hands, according to the character of the working operations) is calculated in accordance with the character and extent of the operations and on the basis of practical experiences. The number of stores workers is determined, for instance, with respect to the annual turnover of materials that are to be handled by the storehouse, the number of crane-operators according to the number of cranes, the number of lifting truck-operators according to the loading capacity of the trucks, of their speed and on the basis of tons/km handled annually. The number of tool-issuing workers and grinders is calculated according to the number and kind of machines operated and the number of manual working places. Setters, lubricators and upkeepers are calculated according to the number of machines attended by them and the number of supervisors according to the extent of the required inspection operations, and so on. In some cases, besides, it is possible to entrust one worker with the execution of more functions simultanously.

However, in projecting, we sometimes do not determine the number of overhead workers by using the described method, but estimate them, according to our experience, as a definite percentage of the number of production workers. This percentage depends chiefly on the sise of the repair shop, on the weight and the dimensions of the repaired object and on the technical outfit and organisation of the plant.

The number of technicians and engineers as well as administrative workers are determined according to the organisation of the shop in such a way, that for each group, according to the extent and the character of the allotted tasks, the number and professional skill of the workers is determined. This calculation is based on practical experiences and factors obtained in similar plants. Generally, it may be said that the higher is the level of organisation of production, the higher is the relative number of technicians and engineers required. Even here, it must be considered if some of the functions could be combined and executed by one worker.

In preliminary drafts, the numbers of technicians and engineers may be estimated as a percentage calculated from the number of production workers and the number of administrative workers as a reasonable percentage from the total workers.

Besides the categories of workers mentioned above, which participate in the production process by their individual shares, one may encounter in some cases such categories of workers, whose duty is to take care for the technical training of the personnel or their personal needs (for instance, accommodation, physical culture, health care and so on). The number of these employees is, in all instances, determined individually.

In cases where employment of women must be considered, it is necessary to specify their number in each group separately, to calculate thoroughly the number and size of social, hygienic and sanitary installations.

4.32 Calculation of Machines.

All machines in a repair shop can be divided into two groups:

a) Production machines and equipment characterised by the fact that they serve to carry out operations on units to be repaired, each of them having one or more workers permanently attached. Their working tasks are determined by the production target of the repair, and therefore, their numbers and sorts may be fixed by calculation. This number can be designated as $S\ S_v$.

b) Auxilliary machines and equipment serving the production workers (mostly manual or assembly workers) to carry out some operations in their repair activity (for instance, hand presses and shears, bench grinders and grills, two-wheel grinders and polishing machines, filing machines, etc.) and overhead workers in maintenance and sharpening of tools. These include other machines serving to carry out overhead work. Their tasks cannot be planned and therefore, their number is impossible to determine by calculation. The number of auxilliary machines is designed by the symbol S_p.

In calculating the number of production machines, we start from the planned annual demand for rated machine hours, calculated on the basis of the tasks of the repair shop. As in calculating the number of production workers, we must first determine the value of the coefficient of overfulfilment of job time standards. This coefficient is designated as k_{ss}.

The number as well as the categories of production machines must also be calculated. If we have at our disposal the detailed data concerning machine time standards, the total annual number of the rated machine hours for each type of machine T_{nds} can be calculated and one may determine the number of individual types of machines from the relation

$$S_v = \frac{T_{nds}}{k_{ss} \cdot E_s}$$

In most cases, so calculated number of machines is a decimal number. The actual number must be rounded off to the next higher number, or if there are more types within the given category of machines (for instance, lathes, milling machines), we must add the decimal fraction to the number of machines that has been determined in the same way for the next greater type in the same group. Such a situation can also be solved by choosing greater numbers of shifts for the given type than those considered in calculating the effective time reserves of the machines E_s. This method may be chosen particularly in the case of an expensive machine. If we get a smaller number than 0,5 as a result of the calculation, we must carefully consider if the given mechanical operations can be substituted by others (possibly using special fixtures), or if it is possible to ensure such operations by external co-operation. After having determined the specifications of the machinery, we check the average utilisation for each group separately (machine tools, shaping machines, heat treatment furnaces). The degree of utilisation is expressed by a coefficient 'e' that can be calculated from the relation

$$e = \frac{T_{ods}}{S \cdot E_s} \quad \text{where}$$

T_{ods} = the total number of worked hours on all types of machines in the given group

S = the total number of projected machines in the given group

E_s = annual time reserves on machines.

The value of the coefficient should not be permitted to drop under 0.65, as the small degree of utilization of mechanical capacity of machinery could decrease the economic effectiveness of the repair shop.
It is impossible to determine the total number of the standardized machine hours for every type of machinery T_{nds} on the basis of the initial data. The total number of production machines S must then be calculated from the relation

$$S = \frac{T_{ns}}{k_s \cdot E_s \cdot v} \quad \text{where}$$

T_{ns} = total annual number of standard machine hours necessary to fulfil all planned tasks

k_s = the average coefficient of overfulfilment of time standards

E_s = the effective annual time reserves on machines

v = the average coefficient of annual utilization of working time on production machinery.

The number of machines in individual groups (lathes, milling machines, etc.) is determined by means of a calculation key fround from the already existing or projected plants, or by an estimate made by a specialist. The determination of the types of machines in individual groups is made by analysing the size frequency of parts that would be machined.

4.33 Calculation of Areas

The areas are calculated separately according to the following scheme:

a) production areas for machines
b) production areas for manual and assembl operations
c) auxiliary areas
d) administrative areas
e) social areas

In order to determine the approximate production areas for machines, we must start from the number of production machines and equipment ascertained

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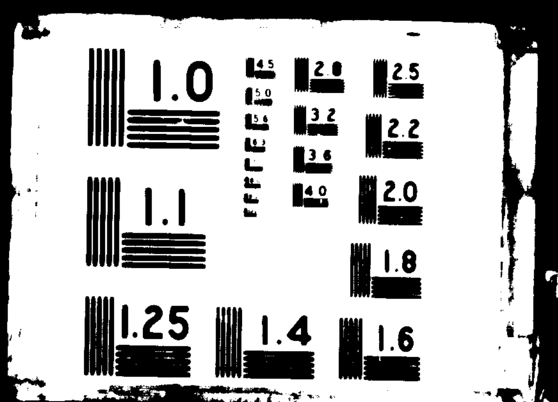

by a capacity calculation and from the so-called specific area, which is the area in square meters alloted to one machine. This specific area includes, besides the place occupied by the machine itself (or the equipment), also the area necessary for the storage of the machined material, tool cabinets, operation area, as well as the necessary space between the machines, walls, columns or passages. The absolute value of the specific area depends on the size of the machine or the equipment. If designated by symbol f_s, the total production area of machine F_s can be calculated from the relation

$$F_s = f_s \cdot S \text{ (in } m^2\text{)}$$

In projecting at large we check so determined production area for machines by drawing in all the machines and equipment to the proposed plan of the workshop, while respecting the safety regulations concerning space between machines, walls, columns and passages (at eventual consideration of moving or pull-out parts of the machines).

We proceed similarly in determining the size of production areas for manual assembly operations, where we substitute the number of machines by the number of manual working places R, and analogging the specific mechanical area by the specific area for manual operations f_r (this being in m^2) corresponding in average to one manual working place. Its absolute value is dependent on the dimensions of the units to be repaired (mainly influenced by claims laid upon the assembly and dismantling operations as well as the extent of surface finishing requirements). The size of the manual production area F_r is calculated from the equation

$$F_r = f_r \cdot R \text{ (in } m^2\text{)}$$

The examination of manual production area is necessary only in specialised repair shops where line assembly is made.

The total manual and mechanical production area

$$F_s + F_r = F_v$$

represents the total production area. This area influences to a great extent, the output of the shop and represents therefore, an essential part of the total floor space.

The dimensions of the auxilliary areas are determined considering the following:

a) Storehouses for basic and auxilliary materials (metallurgical materials, semifinished products, spare parts, standardized parts, subcontractor's supplies, material for maintenance of the repair shop).
b) Spaces for accepting parts to be repaired and expediting of repaired units.
c) Storehouses for parts destined for repairs and for intermediate depots.
d) Tool-issuing rooms.
e) Tool grinderies.
f) Main passages.

In some cases, it is necessary to ensure the space for storage of other materials, such as fuels, liquid combustibles, compressed gases, models, wastes (to be recovered or not) materials for construction service, eventually other substances according to local conditions.

In calculating storage areas, we start from the maximum numbers of items that are to be stored at the same time to secure the continuity of production. These items are divided into characteristic groups in accordance with the method of their desposition (for instance, in heaps on the floor, on treeshaped tool stands, shelves, on pallets) and then the average weight of the stock yard in tons/m^3 for each kind is determined – q_d. According to this value and the permitted loading of the floor (the loading capacity) n in tons/m^3 we calculate the allowed storing height v_d from the relation

$$v_d = \frac{n}{q_d} \quad \text{in m.}$$

In some cases, when the loading capacity of the storehouse is limited in advance, as for instance in stores on floors or on the ground floor, on a ground with a low loading capacity, we choose the storing height and prescribe the load of the floor of the storehouse.

If Q_d indicates the weight of the material in tons to be placed in the storehouse, then the necessary useful storing area for this weight is

$$F_d = \frac{Q_d}{q_d \cdot v_d} \quad \text{in m}^2$$

In some cases, it is possible to calculate the necessary useful storing area from their cubic capacity. So it is, for instance, in cases where units are supplied and stored in crates of known sizes.

After having calculated in this way the useful storing areas for all groups of units coming into consideration and summing them, we get the total useful area F_u in m^2. To this, the passage area (which depend on the handling equipment used and the layout of the storehouse) the floor space necessary for the acceptance of materials (which depends on the maximum daily supply and diversity of assortment) and the area for issuing materials (which is dependent on the maximum daily issue and the diversity of assortment) must be added. After having added these areas together, we get the total operating storing area F_o in m^2. The total operation area of the storehouse is then

$$F_c = F_u + F_o$$

The relation

$$\frac{F_u}{F_c} = k_v$$

is called the coefficient of utilisation of the storing area. In the same way as the index of utilization of the storing area, we also calculate the average load of one m^2 of the total storing area

$$q = \frac{Q_d}{F_c} \quad \text{in } t/m^2$$

By means of this index it is also possible to determine provisorily the size of the operation area of the storehouse by estimating it on the basis of experience. The value F_c may be calculated from the preceding formula.

The area necessary for acceptance of equipment for repair is determined in accordance to the floor space of this equipment and the frequency of repairs. Considering the importance of the shortest possible delay of repairs, it is necessary to secure the continuity of repairs by organisatory means, so that the least number of pieces prepared for repair is accumulated in the acceptance area.

Similarly, the importance of the delivery area is mainly in expediting repaired equipment. This area may eventually be used for the mounting of accessories to the repaired equipment. In repair shops using exchange method, a sufficient area for repaired machines destined to be replaced by other machines brought for repair must be provided. The size of this area depends, first of all, on the specialisation degree of the shop (the smaller number of the repaired types, the smaller the store) and the possibility of storing the machines. Otherwise, the repaired machine must immediately be supplied to the user, installed and put into operation.

Parts destined for repair during dismantling must be suitably stored until the termination of the preparatory and planning operations (that are necessary for the execution of the repair). In order to calculate the necessary storing area, we must determine (estimate) the average weight of these parts pertaining to one machine q_d in tons, the time necessary to carry out preparatory operations for the repair of the set of parts for one machine t_d in days and the number of machines dismantled in one day S_d. The total weight of parts that must be stored before the repair is

$$Q_1 = q_d \cdot t_d \cdot S_d \quad \text{in tons.}$$

With respect to the possibility of irregular takeoff for production, the weight calculated by this method must be increased accordingly. By using the method mentioned in the case of material storage, the necessary area must be calculated from the weights of the parts used.

In the immediate store are placed parts that, during the dismantling operations, were found as not required for repairs and the repaired parts as well as newly manufactured parts. Such parts must be stored in the intermediate store until they can be supplied in complete sets to the assembly shop.

To determine the capacity of the intermediate store, we must know beforehand the following data:

q_m - the average weight of dismantled parts free from defects in t/machine.
t_m - average time necessary to complete the sets, in days.
q_u - average weight of repaired parts for one machine, in tons.
q_n - average weight of freshly manufactured parts for one machine, in tons.

Hence, the weight of parts placed in the intermediate store Q_m is to be calculated approximately from the following equation:

$$Q_m = \left\{ q_m + \frac{q_d + q_n}{2} \right\} \cdot t_m \cdot S_d \quad \text{in tons.}$$

From this value is then calculated the area of the intermediate store by using the abovementioned method.

In order to calculate these areas, a number of values must be determined beforehand, this being of course possible with a sufficient accuracy only in specialised shops. In shops having a broad assortment, such a method would not provide more accurate results than those achieved by estimating by a specialist.

The floor area of the tool issuing room is chosen according to the number of machines to be attended, the number of manual workers (taking into account the equipment of the plant, special tools and fixtures), the number of shifts and the size of the plant.

The area of the tool grindery is determined with reference to the number of machines, similarl as in the case of production machines.

All floor areas mentioned above are independent of the floor space of the building and can be determined without knowing its shape. On the other hand, the areas of main passages are dependent on the form of the ground floor and must be calculated beforehand as a percentage of the total operation area F, which can be calc lated from the equation

$$F = \frac{F_v + F_p}{1 - \frac{k}{100}} \quad \text{in } m^2$$

where F_v - production area in m^2

F_p - total of all auxilliary areas with the exception of the passage area, likewise in m^2

k - the estimated average share of the area of passages in the total operation area,

this being dependent on the width of transport passages, their length and the number as well as the span of the factory hall. Provisionnally, it can be calculated from the relation

$$k = \frac{100\, r}{R} \quad \text{in \%}$$

where r - width of the passage in m

R - span of the hall in m.

The area of the passages is $F_u = \frac{k . F}{100}$ in m^2.

The administrative areas are projected with reference to the number of officials, in accordance with the requirements of individual groups and the operation areas (managers, superintendents, designers, technicians, clerks).

In administrative areas there must also be included auxilliary rooms, such as archives, duplicating rooms, libraries, conference and meeting rooms and the like.

In proposing the dimensions of cloakrooms, we start from the total number of workers, regardless of the number of daily shifts and, unlike when dimensioning the lavatories and hygienic installations, we take into consideration only the number of workers participating in the largest shift. In both cases, we must calculate separately the areas for men and women. The areas and the equipment must be adapted to local conditions.

4.4 Calculation of Energy Needs

For the operation of a repair shop, it is necessary to secure, in addition to the production equipment, sufficient energy. For this purpose, we must first determine the necessary effective power inputs, according to which the power sources are projected and the annual consumption which is important for economic calculations. The procedure involving different kinds of energy is described in the following chapters.

4.41 Electrical energy

Electrical energy in repair shops is used to drive machines and transport equipment, to heat electric furnaces, in electroplating and lighting.

In order to determine the effective power input which is necessary for uninterrupted operation, we must calculate first of all, the so-called installed input W_i. This is determined by totalling all inputs of individual installations given on rating plates (the so-called plate input) and the input necessary for electric lighting. The actual necessary input W_s never reaches the value W_i out of the following reasons:

a) all appliances are never in operation at the same time.

b) all appliances are never switched on their plate input simultaneously.

This circumstance is taken into consideration in such a way that we choose the so-called simultaneous coefficient g, which is expressed by the relation of maximum load measured on low voltage connectors of the transformer station to the total installed capacities of all electric appliances switched on these connectors

$$g = \frac{W_{max}}{W_i}$$

The value of this coefficient is smaller than 1 and varies within a very wide range (0,08 - 0,9) according to the utilisation of the appliances.

With respect to the great variability of the simultaneous coefficient, we must, when calculating the maximum load of the shop, divide all electric appliances into groups, approximately in accordance with equal simultaneous coefficients (machine tools, fans and pumps, cranes and equipment with repeated loads of short duration, electric furnaces, lighting) and determine for each group the total of all installed capacities and then, by multiplying by the simultaneous coefficient chosen for this group, calculate the maximum input for the group

$$W_{max} = g . W_i$$

Summing the partial values for individual groups of electric appliances determined in this way, we get the total maximum power input of the shop. According to this, we choose the sizes of transformers and the dimensions of the distribution network.

In such cases where the details of the production machinery are not yet known, so that installed inputs cannot be ascertained by calculation, we estimate the installed power inputs in individual groups with respect to the roughly fixed number of machines and appliances and according to the estimated average value of the installed input for one unit.

With the aim of determining the installed input for electric lighting, we start from the size of the floor area in separate workshops and the estimated average consumption in watts/m^2. This value may be chosen with respect to the lighting intensity in luxes within the individual work shops.

At some other time, for rough orientation concerning the necessary maximum power input, we start from the size of the floor area by determing the maximum power input for motor drives and furnaces and from the chosen average input for one m^2.

The yearly requirement of the electric energy depends partly on the maximum input of the shop W_{max}, partly on the time utilization of the maximum value during the year υ and partly on the number of hours during which separate appliances are in operation in the course of the year. As machines and appliances are concerned, we may even use the time reserves E_s for this purpose. In lighting, this period is dependent on the geographical position of the repair shop and the number of shifts. The full year's requirement of electric energy is determined from the relation

$$O = \upsilon \cdot E_s \cdot W_{max} \quad \text{in kW/h.}$$

4.42 Thermal Energy

Thermal energy is needed in repair shops according to climatic conditions for heating manufacturing and administrative rooms, for heating of water in lavatories and sometimes also for technological purposes (heating of electroplating baths, washing and the like).

The need of thermal energy for heating purposes depends on climatic conditions of the region, on the size of the structure to be heated, its construction and building materials, on the kind of the operation (clean, dirty, dust producing, with heat and harmful vapours development), on the kind of work (hard, easy). the number of employees in the considered shop, on the length of their stay in the room, on the qualities of the deposited substances and materials, eventually also on other conditions given by local situation.

The decisive factor in calculating the necessary heat to be used for heating and ventilation purposes, is the yearly development of outdoor temperature based on long term observations. On the basis of this, the outdoor temperature is determined, which represents the basis for the calculation of thermal losses and the length of the heating period.

The indoor temperature in the separate rooms is chosen in accordance with the physical efforts workmen must exercise in the given space (the greater the effort, the lower temperature must be chosen). We must also see about the production of heat for technological processes in the shop, as well as to the formation of water steam.

In determing the capacity of the source of thermal energy the hourly heat consumption is calculated from the condition that, at the outdoor temperature t_v, it is possible to achieve the required temperature t_m in the shop. In the construction drawings of the shop, the size of the cooled surfaces F_n in m^2 according to their different heat conductivity is determined, so are their coefficients of light passage k_n in kcal/m^2 with respect to their position (the four cardinal points), the direction of predominant winds and the height of the building. The hourly heat quantity necessary for heating Q_t is then determined from the following relation

$$Q_t = (t_m - t_v) \cdot k_n \cdot F_n \quad \text{in kcal/h.}$$

When calculating the hourly heat quantity necessary for ventilation, we calculate first the hourly quantity of fresh cold air that must be supplied into the space and heated up to the required temperature to guarantee the hygienically best environment. This air quantity V in m^3 depends on the quantity of harmful stuffs produced in the space. The hourly quantity of heat necessary for heating the ventilating air Qv is determined from the equation

$$Q_v = c_v \cdot V \cdot v \, (t_m - t_v) \quad \text{in kcal/h.}$$

where c_v - mean value of specific heat of the air within the temperature range $t_v - t_m$ in kcal/kg°C

v - average specific weight of the air within the same temperature range in kg/m^3.

Hence, the total consumption of air for heating and ventilation per hour equals

$$Q = Q_t + Q_v \quad \text{in kcal/h.}$$

The calculation of heat consumption made by the described method is tedious and the accuracy of the result depends mainly on the correct choice of the necessary constants, the choice of which calls for great experience on the part of the designer.

To determine approximately the heat consumption, a simplified method is used in practice, where on the base of experience, average heat losses are chosen for 1 m^3 of the walled-in space, first to cool q_t in kcal/m^3/°C/h and to ventilate q_v the same units. The total cubic volume of the building being V and the temperature difference $t_m - t_v$, the total heat consumption for heating and ventilation equals

$$Q = V \cdot (q_t + q_v) \cdot (t_m - t_v) \quad \text{in kcal/h.}$$

When determining the overall yearly consumption of heat for heating and ventilation purposes, we start from the length of the heating period in days (per year) m, the number of worked hours in the shop in one working day n, and the average outdoor temperature in the course of the heating period t_{vs}. The total yearly consumption of heat is then calculated from the relation

$$Q_{cel} = V.(q_t + q_v) . (t_m - t_{vs}) . m.n \quad \text{in kcal/year.}$$

The heat required for technological purposes results from the hourly inputs of electric appliances installed accordingly to the data supplied by the manufacturers. Even here, it is necessary to take into account simultaneous power take-off and its uniformity with respect to the working cycle of the appliance. With regard to the heat consumption at the time other than the heating period, this is ensured, according to circumstances, by individual power source (electric heating elements, gas).

The consumption of heat for preparation of hot water in lavatories Q_{um} is calculated from the equation

$$Q_{um} = N . H . Z . t \quad \text{in kcal/year}$$

where N - number of working days in the year

H - quantity of hot water for one employee and one day in litres

Z - total number of employees

t - average difference of temperatures of the water for working purposes and the water in pipinge in ^0C. Even this consumption of water is ensured frequently by a separate source of power (electrical and gas tanks for hot water).

4.43 Compressed Air

In repair shops, compressed air up to 7 atmospheres gauge is used for pneumatic clamping, pneumatic hoisters, manual pneumatic chisels, hammers, drills and grinders as well as for blowing off impurities.

The total consumption of compressed air given in m^3 of freely sucked in air per hour (sometimes this value is also given in m^3 per minute) is calculated on the basis of the following data:

a) consumption of individual appliances being uninterruptedly operated q_j in m^3 per hour

b) number of appliances having the same hourly consumption of compressed air N_j

c) simultaneous coefficient of work of all appliances with identical hourly consumption k_j.

Hence, the hourly consumption of compressed air within the same group will be

$$Q_j = k_j \cdot q_j \cdot N_j \qquad \text{in } m^2/h.$$

The total mean hourly consumption of the whole shop Q_d will be the total of all hourly consumptions of individual appliances

$$Q_d = Q_j = k_j \cdot q_j \cdot N_j \qquad \text{in } m^3/h.$$

Calculating the output of the compressor, we must raise the value acquired in this way by adding the losses arising from leakage in pipings and fittings; further, by losses caused by progressive wear of devices driven by compressed air and the compressed air needed by small devices (not considered in calculation, these increase for a certain period, the maximum values unexpectedly). The increase must be estimated as a percentage of the value obtained by calculation. Under certain conditions, atmospheric pressure must also be considered as well as the alteration of temperatures and the relative humidity.

The yearly consumption of compressed air Q_{cel} is determined approximately on the basis of the mean hourly need of the shop Q_d, the yearly effective time reserves of the machines E_s and the coefficient k_r, by means of which the irregular air consumption during the year is expressed by the following equation

$$Q_{cel} = k_r \cdot Q_d \cdot E_s \qquad \text{in } m^3/\text{year}.$$

4.44 Acetylene and Oxygen

These gases are used in [illegible] shops to weld and cut metals and sometimes also to heat materials before processing them by some other method (straightening of sheets and steelwork, bending of tubes and profile materials, face hardening and metal coating). The calculation of acetylene consumption is very difficult being dependent not only on the number of working places, but to a great extent even on the thickness of the processed material. In most cases the consumption of acetylene may be only roughly estimated according to the existing analogous operations. It is useful to choose a greater consumption of acetylene with regard to the cheap price of the equipment in comparison to others.

Oxygen is needed in oxygen cutting or acetylene cutting. Its consumption can be determined in the way already mentioned for acetylene. As a rule, their estimate is made only by the experts.

4.45 Consumption of Water

A sufficient quantity of water for individual use of employees and for operation purposes, must be provided in the repair shops. According to the requirement laid upon the quality and other features of water, the following kinds of water are used.

a) Drinking water, which must be bacteriologically harmless, tasty and cold. It is used for drinking and preparation of meals.

b) Supply water needs to be bacteriologically harmless. It is used in lavatories and in places where the health of workers could be endangered by coming into contact with a bacteriologically impure water.

c) Water which is used for technological purposes. It must be free from mechanical impurities and sometimes, other requirements are specified (for instance hardness, chemical composition, content of gases, etc.).

In cases of sufficient supply of water of superior quality, this may be used instead of the water of inferior quality. This simplifies the supply system.

The quantities of water that must be provided for personal use is calculated with regard to the total number of employees and the average daily consumption per employee, separately for drinking and service. This daily quantity is determined by the kind of service (clean, dirty, dustry or hot) and sometimes it is fixed by hygienic regulations. Otherwise, it must be estimated according to analogous operations within the region.

The quantities of water needed for technological purposes are calculated from the output of individual appliances. The quantity of water needed for maintenance of roads, courtyards and green areas depends on the areas and on the climatic conditions of the region. The quantity of water for fire purposes is given by the degree of fire danger which itself is determined by the size and place of the repair shop, the construction materials used, the space between buildings and the like. It is determined according to experience.

On the basis of analysis of water consumption, a daily balance for each individual kind of water is elaborated. This is the basis for the calculation of average consumption per second, which again is essential for securing the source and for the calculation of the peak consumption per second. According to this, the pipings as well as eventual equalizing tanks for water, are dimensioned. In needy regions, as far as water is concerned, it is often necessary to arrange a multiple utilization of water after its eventual suitable treatment (recirculation).

4.46 Waste Water

The following sorts of water must be drained from the territory of the plant, namely:

a) Waste waters from the works that can be either harmless (cooling water), or polluted (rinsing water of parts washed before dismantling), water from ungreasing baths and from pickling and electroplating baths.

b) Sewage water (from hygienic installations, kitchens and dining rooms).

c) Rain water coming from all the territory of the plant.

All these waters must be drained to the public sewerage system. If the sewerage system constantly has sufficient quantity of water to mix with polluted water without practically deteriorating its quality, the waste waters may be discharged directly without being previously purified. Otherwise, impure water must be purified before leaving the plant. This is done according to the kind of impurities through sedimentation, neutralisation and eventually through biological methods. When projecting such installations (which belong to special hydrographic tasks), we must determine the quantity and the composition of waste waters according to their kinds (mechanically polluted water, acid water, basic water, cyanogenic water, sewage). The quantity of industrial waste water is determined on the base of loads of individual technological installations; for determination of the quantities of sewage waters, the number of employees is decisive. The quantity of rain water is calculated according to the formation of the ground and the precipitations calculated from the long term statistics within the region.

4.5 Technical and Economical Indices

After having completed the calculation of capacities, we set up the main characteristic data into a synoptical table, on the basis of which we can make identical conclusions about the economy of the plant in comparison with other similar shops and the technical level of the project. These data are expressed in absolute units (the so-called basic data) on the one hand and by the relation of several basic data having a definite connection between each other on the other hand. In repair shops, the most frequent of these would be:

A/ **Basic data:**

a/ **Volume of annual production in financial units;**

b/ **weight of consumed materials in tons/year;**

c/ weight of purchased finished products and products supplied by subcontractors in tons/year;

d/ number of worked hours necessary to fulfil the yearly plan in h/year;

e/ number of shifts;

f/ total number of production workers, the number of those working in the main shift stated separately;

g/ total number of overhead workers, the number of those working in the main shift stated separately;

h/ number of engineers and technicians;

i/ number of administrative employees;

j/ number of production machines;

k/ number of manual working places;

l/ production area for machines in m^2;

m/ production area for manual work in m^2;

n/ auxilliary area in m^2;

o/ operation area in total in m^2;

p/ area for offices and social installations in m^2.

B/ Derived data:

a/ Percentage ratio of the numbers of production and overhead workers;

b/ number of workers appertaining to one technical or engineering worker;

c/ number of workers appertaining to one clerk;

d/ percentage ratio of production area to auxilliary area;

e/ floor space of the machines in relation to one production machine in m^2/machine;

f/ production area for manual operators in relation to one manual site, in m^2/worker;

g/ production area appertaining to one worker of the main shift in m^2/worker;

h/ operation area appertaining to one worker of the main shift in m^2/worker;

i/ volume of yearly production in financial units, appertaining to one square meter of the operation area;

j/ volume of yearly production in financial units, appertaining to one worker;

k/ volume of yearly production in financial units, appertaining to one employee;

l/ worked hours appertaining to one unit of yearly production;

m/ time utilization of production machines in %.

Part 5 - General Ideas for Design of Basic Equipment Repair Shops.

The organisational structure and location being in rather close connection are very important in establishing a repair shop. Preliminarily, the whole region with future customers must be taken into consideration as far as their local distribution, communication means, procurement of labour, connection with energy sources and the possibility of acquiring a suitable erection site are concerned. The fundamental demands, as far as workers, land and energy are concerned, are given in chapters 4.3 and 4.4. Furthermore, it is necessary to shape these demands into a concrete conception of the future plant, which is the main objective of the project designing activity. The main principles to be observed are introduced in the following chapters.

5.1 Layout of the Building

The repair shop may be situated either in an independent building or in a convenient common building. It is necessary to pay attention to the fact that several plants placed in one building, unfavourable interfere with each other, for instance through noise, impacts, dust and the like. An important criterion is the floor space of the building, its organisational structure (independent repair shop, a shop affiliated with an industrial enterprise) and the possibilities arising from its location. With the exception of specialised repair shops for parts of fine mechanics, electronics and similar, in which case a multi-storeyed building may be used advantageously, we choose for the repair shops a ground floor building with one or more bays.

The chosen shape of the groundplan must, if possible, be very simple and mostly rectangular. Advantageous is a good utilisation of the building plot, a very simple design and the building may be easily extended. In regions where the rooms must be heated in winter, the relative thermal losses can be decreased. Only in special cases, a groundplan constructed from rectangles in the form of block letters L, U, T, E is chosen.

The ground dimensions are being chosen according to the total need for operation area, determined by a capacity calculation. First of all, we choose the width of the bay (span) R in m, with respect to the size of machines to be installed in the bay and according to the size of the items to be repaired. This width generally is not unplanned; it is differenciated gradually in definite series within the individual regions that must be kept, above all with respect to the span of the overhead travelling cranes, if such cranes are to be installed. The length of one bay hall having a required operation area F m^2 would be

$$L = \frac{F}{R} \quad \text{in meters}$$

If this calculated length surpasses the necessary length for the technological sequence of operations, we choose a hall with several bays, while the length of the building must be also accordingly selected. Even such a dimension is not arbitrary, but must represent a whole multiple of the chosen spacing of columns, for which also definite gradings are determined. A hall with several bays must be chosen sometimes even with respect to the given size of the building site. In a hall with more bays, the width of the bays need not be the same, and sometimes, it can be more advantageous for the location of several lighter operations to choose a smaller width. Offices and social areas are located in buildings that are either adjacent to the main building or are a small distance away. In such buildings, a transformer station may also be located.

Energy producting equipment (boiler house, compressor station and sometimes even transformer station) is installed in the independent building. In case of need and for safety reasons (fire), even acetylene stations and depots for combustibles and storehouses for compresses gases are being projected in independent buildings. The size of these buildings is given by the sise of the given installations and by the quantity of the stored supplies.

The height of the bays depends on the height of the installed machinery, on the sise of the parts to be repaired, on the means of transport and hoisting devices, on the development of harmful substances and on climatic situation. The minimum height is given by the requirement concerning the lateral natural lighting and, in some cases, even by reaching the definite minimum cubature per worker.

In buildings with more bays, the height of all bays need not be the same. It is not recommended, however, to choose a greater number of different heights, if they are not distinguished clearly from each other, as the design of the structure may be complicated and the economies achieved of the investment costs use to be insignificant in such cases.

In choosing the type of the building, it is important to know, if in all places a natural lighting is required or if artificial illumination is needed too. If natural illumination is required, the halls with several bays cannot manage without skylights. Their design must offer a sufficiently high luminous intensity in all sites and secure its greatest uniformity upon the whole ground plan. Another demand concerning the natural light is that the direct sun rays do not penetrate inside as it could cause a dangerous dazzle to the workers. Besides, the natural light must facilitate the natural ventilation of production rooms.

In regions with long heating periods, a building with no windows and no natural light may appear to be economically advantageous as it has smaller thermal losses caused by the cooling off the walls and therefore, a little consumption of heat. The annual economy encompassing heat and cleaning costs as well as maintenance of glazed surfaces may, in some cases, outweigh the increased costs for a greater consumption of electrical energy in case of a permanent artificial lighting and the increased requirements of airconditioning.

5.11 Groundplan of Areas for Production and Auxilliary Purposes.

After having chosen the shape of the ground floor and the size of the building, we can proceed to the elaboration of a project for a layout of individual production and auxilliary areas, without solving for the present in detail the layout of the machines. As a starting point, we use the size of floor spaces of individual sites found by means of a capacity calculation while observing the following principles:

a) Keep the shortest possible flow of materials and parts through production lines, beginning from the supply of items to be repaired and materials into the shop, until their final assembly and expedition. The flow of materials should hereby cross the least frequently passages used by people and in case of a greater number of employees, they should not cross them at all.

b) Shops in which harmful substances develop, as well as those with a danger of fire or explosion (varnishing shops, impregnationstations, hardening shops and the like) should be located near external walls to facilitate a good ventilation, and in case of an emergency, a direct escape into the free space for the employees. The coherent succession of the production flow should be, to the extent possible, preserved.

c) To separate the operations according to weights and sizes of the items to be repaired, to better utilize the lifting capacity of the cranes in plants with several bays. Also, to concentrate operations that do not require cranes.

d) To concentrate operations that must be separated from each other by using partitions for fire and safety reasons.

e) To place tool issuing rooms near the centre of consumption and, as far as possible, out of the area serviced by cranes.

f) To secure the access to all operation areas directly from the main passage.

An example of a projected layout of the operation areas in the building is given in this text. In the attached figure are drawn in the main transport roads and transport equipment connected with the design of the building, such as overhead travelling cranes, overhead railways, roller conveyors and transporters.

5.12 Location of the Building.

The general principle for the location of the building for a repair shop is to have it connected with the outer communication means. The condition of connection with the railway system must be mey only in the case of repair shops for rail vehicles. Also, in other cases, this may be advantageous, for instance for the transport of heavy equipment. When situating the building, we must consider the four cardinal points and we should always try to leave free space for the eventual future expansion. This expansion is drawn into the plan, and the area can be utilized temporarily as a stock-yard for materials.

If it is necessary to erect further smaller buildings (boiler house, compressor and acetylene station, stores for combustibles and compressed gases), these may be situated in one row which is parallel to the longer side of the building of the plant, while observing the fire and safety regulations. This row of buildings can be situated in the direction of the prevailing winds, so that harmful substances developed during the production could be carried away outside the plant. The grounds not taken by buildings, storehouses and communications, can be arranged as parks to achieve better appearance and to lower dust development. In the case of an independent repair shop, we propose a fencing of the whole area of the plant.

5.13 Selection of Construction Elements.

In buildings, we distinguish foundations, supporting structures (columns, beams, lintels, roof trusses and the like), floorings, peripheral covering, roofing and indoor partitions.

The foundations are made mostly from simple concrete, exceptionally they are lined with quarry stones or hard burnt bricks.

The elements of the supporting structure can be made of wood, steel or reinforced concrete. The columns of smaller and less loaded buildings may be made even from brickwork or stone masonry. The wood is used for supporting structures only in places where wood is very cheap, its great disadvantage being inflammability and short durability. The most convenient material for industrial buildings is steel, as it facilitates easy reconstruction, frequently necessitated by changes in production programmes or technological process. A combined construction is very often chosen, for instance columns of reinforced concrete and roof trusses of steel or wood.

The most convenient floorings in shops, where no work with fire or liquids is done, are those made from blocks ran into asphalt on concrete plates or from mastic asphalt. The advantage of such floorings is a dust free operation and, in cold regions, their low coefficient of thermal conductivity. If such materials are not at our disposal, we project concrete floorings with surface resistant to abrasion. For surfaces exposed to heat, either concrete or paving stones are chosen. In departments in which the workers use caustics, the most convenient materials are ceramic tiles. Besides the abovementioned materials, there are others used for particular purposes - rubber, linoleum, xylolith, boards and the like.

The peripheral covering is either lined with brickwork or shaped bricks, or is made from ceramic or metallic panels having different surface finish.

In regions where no effects of thermal insulation by means of peripheral coverings are necessary, the corrugated sheet or eternite, eventually other materials according to local conditions, are used. In the peripheral coverings, windows play an important role. Windows with steel frames and simple or double glasing are used in most cases in accordance with climatic conditions.

Roof is an important and also a very delicate element of a building (especially that with several bays where skylights and gutters must be used). The choice of materials depends on the demands for roofing, such as tightness, carrying capacity (load caused by snow), thermal insulating capacity and non-inflammability, as well as on local conditions. Usually, combinations of wood, tar, tar cardboard, slate, eternite or cement tiles, roof panels with different characteristics and design, sheets from different air resisting metals, eventually other materials, according to local conditions are used.

Material for the manufacture of indoor partitions and their thickness is chosen in accordance with the purpose of partitions. The most important are fire partitions that must be made of tiles or other fireproof materials of sufficient thickness. They have their own base and must be lead out until over the roof. If the necessary holes are already provided, they must be covered by solid steel doors in fireproof door frames.

If a partition is to fulfil a function of sound protection, special sound absorbing panels are used. When partitions are used only to separate several operations or rooms from each other, wood is used, eventually in combination with glass. Lightened walls of different materials and of different designs and in shops, mostly wire netting is also used.

In choosing the type of structural elements and their materials, we must always start from local conditions, habits and sources of raw materials. The price of building materials being low in relation to the price of machinery, it is necessary to consider transport charges to the erection site, which sometimes may be rather important.

5.14 Energy Supply.

The most advantageous for the operation of the repair shop is the possibility of consumption of all kinds of energy being covered from foreign sources. The motives are that the energy required is not great, the proper sources would have small outputs and the proper production price for a unit of energy would be considerably higher than that calculated by a power plant. Besides, the construction of proper energy source requires relatively great financial means. Proper energy sources are built, therefore, only in such cases where another solution is not possible or where the price of a service line would be very high (or the price of purchased energy too high). Such cases are known especially when the foreign source is remote or where the investment costs for a proper source are low. Such is the case of compressed air, acetylene and sometimes even heat. The production of oxygen is expensive and of the necessary equipment, is not taken into consideration in repair shops.

It will probably be always possible to secure the supply of electrical energy from the public electric network, but only the smallest plants will be able to be connected to the low voltage network. In greater plants, it will be necessary to count with a connection to the high voltage network through a transformer station of the plant. In cases of sudden interruption of supply of electric current from the network, it would be necessary to secure at least an emergency energy source for the factory, so that the employees could leave the plant safely. The emergency lighting is mostly provided by a storage battery, exceptionally by a combustion power unit, which starts automatically in the case of a voltage drop in the network. Only occasionally, the emergency set must have a greater output to also secure some of the other appliances from sudden stops which could cause damage. The maximum output for such emergency power source must be taken into account when one considers its low utilisation with respect to its use. The water supply is important. In a repair shop which is part of an industrial plant, water from the factory piping may be sufficient. If it is independent, the simplest solution is to connect the shop to the public water piping. If such a solution is impossible, it is necessary to install a proper water piping and the intaking and treating equipment. In the case of underground waters, intaking devices are wells or a system of wells, whereas in the case of surface waters, the intaking devices are natural or artificial basins, in which water must reach the depth necessary for takeoff and the purpose of which is to make up for irregularities of inflow and takeoff. The aim of the treatment device is to grant the necessary qualities to water, depending on its use. The water piping may be either gravity piping or delivery piping. In the latter case, it is necessary to erect a pumping plant and also a water reservoir, which are relatively expensive devices. Therefore, due attention should be paid to the problem of water supply of the plant, which may influence the choice of the building ground.

5.15 Outside Communications.

The network of communications of the repair shop is not complicated, with the exception of shops for railroad repairs. In most cases, highways are sufficient and work sidings are built only when the connections with the railway system are very favourable, the condition of a sufficient turnover of the railway cars being met. Highways are projected as twoway roads, whereas the secondary rarely used roads serve as oneway communication roads. The surface of roadways should be sutfree and made either from asphalt, concrete or paving stones. The loading capacity of the raodways should correspond with the weight of the heaviest fully loaded vehicle.

5.2 Principles for the Layout of Production and Power Equipment.
Machine tools are most frequently situated in groups, according to the kinds of machines, such as lathes, milling machines, etc. We also consider the sise of these machines and in larger repair shops, groups of heavy and light machines are being established, which in halls with several bays, are separated into the individual bays.

These are then equipped with corresponding transport and hoisting devices. Similarly, we concentrate presses for cold shaping, eventually for hot shaping and if large quantities of sheets are being worked, a specialised plate shop and a welding shop are installed. According to the character of the work, special departments are projected, such as for piping system, electrical appliances and so on, equipped with necessary machines which are laid out so that the flow of materials would be uninterrupted, without unnecessary returns. Precision machines are placed at a sufficient distance from the machines producing impacts (planning machines, slotting or shaping machines, presses and power hammers).

In specialized repair shops, at least some of the equipment should be placed according to the sequence of regularly repeated operations, whereas the intermediate transports between individual operations are secured by conveyors.

During the elaboration of the layout of machines, we pay attention to a satisfactory utilisation of floor space and an easy transport of materials to indivdual sites. In order to facilitate the work, we make use of templets of individual machines printed upon translucent foils. For the same purpose, three dimensional models are rarely used.

5.3 Economising with Recuperable Waste Materials (Thrown out Parts and Production Waste).
In repair shops, metalic waste is created (damaged parts and in the form of waste from machine tools and shaping machines). This waste should be regularly carried away from the shop. One should, however, consider the possibilities for its further use and the financial implications. If great interest in the region exists in the metalic waste, sorting by individual metals, when necessary even according to chemical composition,

should be made on the spot. For depositing waste materials, special stockyards are established according to the quantities and the kind of waste. In the case of large quantities of coiled metalic turnings within the plant, one should install a crusher or a baling press. If there is no interest in waste materials, the waste must be put away unsorted and deposited on a predetermined spot near the shop and occasionally transported [illegible] to a stockyard outside the factory.

5.4 <u>Estimate of Investment Costs.</u>

The total investment costs are important for securing financial means, on the one hand, and for the purpose of economic considerations on the other hand. That is why it is necessary, when elaborating the estimate of investment costs, to take into consideration all costs connected with the future realization of the building. They may be divided into the following groups:

a) Costs for the purchase of the ground. These depend on local conditions and are influenced by the quality of soil for agricultural purposes and its location with respect to public roads and civil settlements.

b) Costs for investigation and project work including geological investigation, measuring of building ground, as well as elaboration of project documentation. The total costs are determined on the basis of tariffs or quotations made by individual organizations.

c) Building costs, including expenses for surfacing the ground, for buildings, roads, water piping and sewerage, fencing, eventually heat and gas distribution etc. They are determined preliminarily with respect to rough dimensions, the average of which has been calculated for the given region and definitely, according to the detailed schedule of building operations.

d) Costs of equipment such as working machines, transport and handling equipment, power plants and distribution equipment, equipment for storehouses, test rooms and laboratories, the initial equipment and tools and other auxilliary appliances necessary to put the repair shop into operation. These are determined according to the price lists or quotations from suppliers. It is necessary to take into consideration even the costs of transportation and installation of machines (including foundations).

e) Other costs (according to local conditions) such as erection of temporary buildings, contributions to different organizations, bank interests, insurance costs of building assembly supervision, etc. It is recommended to include a definite sum for unforeseen expenditures especially if pricing documents known in the period of elaboration of estimates are not obligatory, or if there are other uncertainties present in the documents.

Part 6 - Operation of Repair Shops

When considering extensive repairs as a factor of care in the maintenance of basic equipment, it should be noted that maintenance of basic equipment does not represent the bulk of work in large repair workshops.

Complete overhauls are the largest and most expensive repairs performed, mostly to remedy the effects of long term wear and to renew the qualities of the machine in question.

The task of repair work concerning basic equipment items is very important and this importance grows ever more under certain circumstances. This is true above all because these shops are a very efficient factor of rehabilitation while complying adequately with the needs of production, where they can contribute to a large extent to the rationalisation of the manufacturing process. An advantage of complete overhauls of process equipment can also be seen in that they enable - owing to their unusually small requirements of both materials and energy - a substantially quicker development of the manufacturing process.

Considering the kind of basic equipment items, their size, their character (modern or outmoded types), one should decide which kinds and types would be repaired externally by other organisations and which of them in own or other specialised repair workshops. When carrying out such repair work, it is recommendable to adhere to the following principles.

6.1 Planning and Releasing Machi... for Repair.

The repair plan is prepared according to the general planning method. A basic condition of this activity is the preliminary co-ordination of the repair term plan with the manufacturing schedule of the enterprise and with corresponding partial manufacturing plans of individual workshops from which the machines are taken for repair. Such co-ordination should be performed with sufficient time reserve to allow the production and planning departments of the enterprise sufficient time for organisation and planning and for preventing any interference in fulfilling the production scheme. An even flow of machines into the repair workshop must be secured without any troubles in repair planning.

Special care should be taken of the unique and bottle neck machines when preparing the repair plan. It is necessary to take all the precautions that the repair is really perfectly done on all machines. Many factories fail to overcome the troubles and ensure proper conditions for releasing machines for repair. This is sometimes postponed until a serious damage occurs on the machine. Such accidents cannot only distrub the operation of the enterprise, but lead directly to the damage of capital investment assets.

6.2 Technical Preparations of the Repair Work

Before removing a machine for repair, technical preparations for the repair operation should be made, i.e. preparation of technical documents, spare parts, materials and work planning. The technical preparation should assure a continuous and trouble free repair process after the machine has been taken for repair.

A systematic performance of planned preventive maintenance and repair should follow a timetable that allows all repair work to be done well in advance with a considerable time reserve which helps to obtain a smooth course of all repair work.

During all repair work, i.e. inspections, current repair, checks, preceding a major repair work, the attention is already drawn to the approximate volume of the larger repair work to come, to the specification of spare parts, bearings, V-belts, castings, forgings, specialised tools or services required from external manufacturers.

A specification of required parts, drawings for delivery of forgings, castings or spare parts having a long delivery term is drawn at that time. A preliminary order for the delivery of parts, semi-finished products, materials, specialised tools or external services is prepared so as to assure their timely delivery.

As far as the repair of machines that are not included into the PPR system (Planned Preventive Repair) is concerned, machines in question must be submitted to a preliminary inspection in order to ascertain the main parts, forgings or castings needed, for which an advanced order must be drawn. This is mostly an inspection requiring no difficult dismantling work. The preliminary preparative work may vary in the way it is prepared and in volume; it should, however, be performed as early as possible so that the machine is not switched off the scheduled work except during the planned maintenance operations.

For unique or bottle neck machines and for machines working in a highly exposed place in the production line, this preparatory action must be performed with extreme care and systematically. In such cases, extraordinary measures according to an accurate time schedule are taken. If necessary, a gradual almost complete dismantling of individual mechanisms is performed and drawings of spare parts are prepared. When performing this inspection, the work should be planned so that the time of interruptions of work should be first utilised without switching the machine off from regular service.

6.3 Taking Over the Machine for Repair.

The machine is taken over for repair only after the preparatory work is completed and spare parts, semi-finished products and materials representing the material base of the repair work are supplied.

A note on transmitting and taking over of the machine for repair is written. This is performed by foremen from the department sending the machine for repair, by the maintenance programmer who planned the preventative and repair work on the machine, a representative of the technical inspection service from the maintenance and repair department and by the foreman of the repair workshop entrusted with the repair work.

The mentioned note should contain:

- a description of conditions of the machine and its defects,
- a specification of accessories transmitted simultaneously for repair,
- special requirements of the user's workshop for modernisation or changes in function or dimensions of the machine or other minor changes or adjustments (e.g. change of feeding speed, increasing or reducing of rotational speed, adjustment of stops, measures preventing leakage of lubricant, etc.).
- date of transmitting to and from repair (as planned).

A certificate of precision tests and certificates from preceding inspections illustrating the technical conditions of the machine (an inspection of precision according to Schleisinger standards) are compared and the deviations revealed and entered onto the certificate on the condition of the machine. These documents give the first impression on the general character and volume of repair work. The machine should be taken over for repair, as far as possible, during the operation of the machine, in order to test the function of the machine under true service conditions and to gather valuable information by interviewing the operator.

6.4 General Sequence and Repair Work Schedule.

For the repair process, a type sequence and a timetable should be written and adhered to. Immediately after taking over the machine for repair, a process time schedule of the repair is drawn, where terms of individual operations are outlined so that they follow correctly each other. Partial operations to be accomplished before the repair specification should be outlined. After completing the inspection and repair specification, all remaining processes and operations are outlined in accurate terms.

An example of a type sequence of repair work can be thus outlined:

- taking over of the machine for major overhaul.
- complete dismantling and cleaning of machine parts.
- preparing for general inspection and specification of complete overhaul, performing general inspection and specifying all repair operations.
- process preparing (process, task times, calculation, drawings, orders or repair of existing partly damaged parts).
- manufacturing new parts and repairing existing parts on machine tools.
- hand work of repair fitters and assembly workers.
- checking for precision and test running of the machine.
- coating of machine.
- delivery of machine for operation.

To the sequence of work listed, partial operations that are highly important for the repair and can exert a serious influence, e.g. grinding of seat by external service, rewinding of electric motor, grinding of compressor cylinder, etc. are included. Following the detailed analysis of the character of individual items of type sequence and considering their mutual relations, a detailed schedule of work, i.e. process schedule of the repair work, is drawn.

6.5 Process Time of the Repair Work.

The process time of the repair is a time period during which the machine is switched out from regular service, i.e. the time period necessary for the repair work. It is expressed by a number of working days. The process repair time is calculated from the moment the machine stops, to the time it is delivered for operation purposes.

An adequate duration of repair process time has a considerable influence on the quality of repair, on its cost, on the production capacity of the factory and also on the production capacity of the repair workshop. The repair process time should be as short as possible. It is influenced, however, by the standard of the technology and by the organization of work in the repair workshop.

Efforts to achieve maximum reduction of repair process time neglecting the true standard of technology and organization of production can exert an adverse influence on the quality and cost of repair. They lead to hasty and rash operations without due technical preparation, to improvisations injuring mostly the basic rules of quality and economy. Also an excessive repair process time has an adverse influence on the quality and cost of repair work.

A long repair process time suggests that the repair work is not continuous, that considerable time waste arises, that work is frequently interrupted. This involves the loss of continuity in individual operations, considerable time losses, lack of quality and increased cost. When proceeding to a repair it is necessary to assure above all that, once the work is assumed, it is no more interrupted, that individual operations follow continuously after each other without time losses.

The economic meaning of the repair process time is, however, not limited to the repair economy proper owing ot its substantial influence on the production capacity of works. By switching off individual machines for repair machine time losses occur, troubles arise in production planning and production capacity of factories drops.

The capacity planning provides for the necessary time for repair work in reserving a part of the overall operation time of machines for their repair cycles. The useful time fund of a production department characterizing the total capacity of the enterprise is calculated with the regard to the time necessary for the repair of machinery.

In reducing the repair process time not only the losses of production capacities are reduced, but moreover the releasing of further machines for repair is made easier.

6.6 Number of Repair Men Working Simultaneously on the repair of a machine is prescribed regarding the manpower requirement of the machine under repair and advantage of combining manpower in the work of a given degree of difficulty. For the repair of smaller machines involving a relatively minor volume of repair work a smaller number of simultaneously working fitters is used than for larger machines.

An improved organization of repair workshops, a sophisticated technical preparation of the repair process and application of a higher repair mechanization enables employing a larger number of simultaneously working fitters by which the repair can be finished in a shorter time. In case of a less perfect organization of repair work it may prove better to employ a smaller number of fitters working simultaneously at the repair.

Overfilling of performance standards depends on the technical preparation of work, on the standard of repair mechanization and organization, on the competence of repair men, etc.

6.61 Number of working shifts of repair fitters

Well organized repair workshops having a good technical preparation of repairs organize the work of repair men in shifts. Two or three shifts of repair men work on the repair of the same machine, thus reducing the repair process time by one half or two thirds. In case of imperfect organization of work this working method can be assumed in rare cases only. Under the conditions of a poor organization of repair work considerable time losses arise from the work in shifts, costs are increased and the quality of work suffers. These time losses cannot be outweighed by the advantage of partial reduction of overall repair process time. In large factories the two-shift operation should be the target and all necessary technical and organization conditions therefore should be systematically provided.

6.7 Lost Time

Only a part of the repair process time is utilized for the repair work proper. Another part of the repair process time is used up for preparatory work, by waiting for spare parts, for completing of preceding operations, etc. - i. e. lost time. The length of lost time can be determined by an analysis of the true repair process time. The repair process time is given by the number of working days during which the machine has been in repair. This number of working days represents a certain working time. If e. g. the process time of repair amounts to 9 working days, then the total length of working time available in a two-shift operation will amount to 9 x 16 = 144 working hours. Only 40 working hours of fitters are however, employed. If two fitters work simultaneously at the repair, the true duration of repair work proper is 40 : 2 = 20 hours.

From 144 working hours spent by the machine for repair purposes only 20 hours were utilized for the repair work proper, the rest being lost time.

The utilization of repair process time = $\frac{20}{144} \cdot 100 = 14\ \%$

A reduction of repair process time can be achieved in the following way:

- reducing the number of fitters standard working hours by the mechanization of repair operations or reduction of physical wear of machines, thus reducing the material volume of repair;
- increasing the number of repair men working simultaneously
- overfilling of performance standards above all by an improved technical outfit available for repair men

- increasing the shift factor of repair men
- reducing lost time.

It is a pressing task in organizing the repair work to reduce the repair process work to the necessary minimum by gradually providing for still better technical and organization efficiency.

6.8 Method of Performing a Complete Overhaul

6.81 Total dismantling of machine for complete overhaul

As the first phase of the complete overhaul a total dismantling of the machine to individual parts is made so as to enable a thorough cleansing and individual inspection of every part. The dismantling should be performed immediately after the delivery of the machine for general repair. Dismantling of riveted and firmly pressed-together pieces and joints is made only after special decision reached during inspection.

6.82 General cleansing of the machine

A thorough cleansing of the machine and of all its parts is performed. The cleaning is an inevitable condition for a good repair. It is best to boil all parts and - if possible - also the bed of the machine in a bath or washer containing a solvent or degreasing agent. If such method of washing is not feasible, a thorough cleansing with conventional materials should be performed. Be sure that all cases, chambers, channels are quite completely and reliably cleaned. The cleaning operation should be performed immediately after dismantling of the machine.

6.83 Preparing the machine for inspection and repair specification

To assure a good and reliable inspection of machine and specification of the repair it is necessary that the machine - or its individual functional assemblies are synoptically displayed or lightly assembled to its initial condition before the inspection is started. Only so the correlation of individual parts and their cooperation can be correctly considered.

It is therefore best after the cleaning operation to assemble the machine by merely grouping the parts in their initial position. No tightening and no pressing is required, the assemblies must enable taking them apart easily by hand during inspection. Preliminary assembling for inspection is necessary above all if the machine proper is not well known. The assembling should be done immediately after its cleaning. The dismantling, cleaning and reassembling operation should follow immediately after each other.

6.34 Inspection of the machine and repair specification

A good inspection, correct consideration of function and of the principle of cooperation of the parts and a correct decision as to what adjustments or exchange of parts should be performed are the basic conditions for a correct complete overhaul.

The inspection must be done systematically and carefully. No part must be omitted. Each part must be carefully examined, competently considered as to its wear, the necessary degree of precision, its function in the operation of the machine or equipment and load to which the part is exposed. Expensive and functionally important parts must be measured and their play and clearances considered. Also fatigue factor must be taken into account. Mutual relation of clearances and play in engaging parts or superposed parts should also be considered. It is recommendable to keep in mind the result of the preceding inspection of the machine and the content of the note with which the machine has been submitted to complete overhaul.

The inspection is made step by step on individual subassemblies and the record is composed according to the main assemblies of the machine. One proceeds normally along the direction of acting force to which the assembly given is exposed or from the basic part. Individual items of the record are marked with ordinal numbers. It is recommended to mark the same ordinal numbers on the parts relating to the written item.

When making the record the material, its dimensions and numbers of drawings and other required data should be recorded.

It is necessary to keep in mind the reconstructions required, the modernization and further useful improvements of the machine, adjustment of the machine for the organization of lubricating service and improving the security of operation.

The record should always be written down by a good specialist available together with the foreman of the team entrusted with the repair of the machine. If necessary, a designer and a task setter are asked for assistance.

6.85 Preparing the work

Documents necessary for a qualified technical preparation of work in complete overhaul services are: the note on submitting the machine for complete overhaul with enclosed note on the preliminary inspection and advanced orders, with inspection certificate, further a specification of all necessary operations as written down during the general inspection of the machine.

Immediately after having written down the specification all necessary documents should be issued, i. e. material issue slips and operation order slips, drawings of spare parts, process slips, then the material required should be issued and a plan of repair operations stated.

The preparation must be made in a very short time so that the work on the complete overhaul may start immediately and proceed without any interruption.

In the factories it is highly recommendable that the most part of the technical preparation of work is performed in advance to make the preparatory operations during the repair work proper as quick as possible and to assure high quality of preparatory work.

The working documents for the first days´ work must be issued immediately so that the work may start immediately after the inspection. The rest of working documents and other preparatory work must be performed so that the continuity of repair once started is fully assured.

5.86 Performance of complete overhaul

Repairing - i. e. above all measuring and checking. Therefore, before any work is started, the method of working, measuring and checking must be completely clear.

When scraping slides or any guide surfaces, every partial operation must be individually measured and checked. Especially all shafts and spindles must be measured, even if no wear nor deformation is apparent on them. Also the inspection of their quality is purposeful. In this way a lot of unuseful work is saved, as in opposite case much repeated reassembling may be inevitable. No part which has not been duly checked, inspected and, if necessary, repaired, must be mounted into the machine.

High quality of general repair depends largely on the carefulness of all those taking part in the repair work. Therefore the factories must select for such activity only workers who have proved their carefulness and professional reliability. Such workers must be systematically briefed and their qualification and scope of experience should be continuously improved.

6.87 <u>Test running and inspection of machine after complete overhaul</u>

Every workshop performing complete overhaul is obliged to test-run and inspect the repaired machine before its returning into operation. Tested are the efficiency and reliability of all functions of the machine, pull of clutches, noiseless operation, correct function of recirculating lubrication system, correct gear control system operation, function of end switch stops, electric controls, cooling system, all gears of rotational speed, all feeds and easiness of control. For this purpose a test bench or a possibility of engaging the drive of the machine proper should be given.

The inspection of the machine is made according to corresponding standards. The inspector must make sure that all speed and metal cutting labels of the machine coincide with actual situation. He must check the parameters of the machine according to the technical documentation and enter all deviations revealed or missing notes. The inspection department transmits all manufactured spare parts to the spare part store.

All old parts not used for assembling of the machine are checked and sorted thus:

a/ auxilliary reserve in the store of spare parts

b/ material for further use

c/ scrap

It should be a principle that all material left after the finished complete overhaul and all parts that have not been used for the assembling of the repaired machine should be removed and transmitted to corresponding places according to their character.

6.88 **Return of the machine from the complete overhaul into the plant for operation**

Transmitting of the machine back to the plant can be made with a record. After setting of the machine on its site the machine is demonstrated in operation to the foreman of the user's department, to the attendant worker and to the maintenance fitter. All adjustments and changes are explained and a record on the inspection of the machine is presented. Volume and character of repair work performed is explained in detail. If no test equipment for load testing of the machine is available a test period can be stated during which the operator records all possible concealed defects for their consequent remedy. Repair shops give a guaranty for the transmitted complete overhaul to their own costs for a reasonable time - mostly up to 6 months.

Part 7 - Training of Workers

Industrial plants are mostly provided to a high degree with basic equipment. A qualified administration of this valuable, complicated and heterogenous property, the care of its maintenance, perfectioning and rehabilitation of these assets is a very important and technically exacting activity. Considerable amounts of money are spent and many workers are employed in the maintenance and repair of basic equipment. The mentioned facts alone require that the quality of managing and the technical care of these assets are as efficient as possible in order to assure reliable conditions for improvement of utilization efficiency of basic equipment and economy of its operation.

7.1 Qualification Requirements for Employees Working in Maintenance and Repair of Basic Equipment

A number of various branches and professions, various technical means and processes take part in the maintenance of basic equipment in every factory. High requirements are laid on the qualification of management and of operators of maintenance service. These workers must master the maintenance problems proper and also the technical means of the factory. Apart from basic professional education these workers must have special knowledge from some other branches of economy. Only then can they fulfil duly their tasks.

7.2 School Education of the Specialists in Public Schools

In a number of countries having a high level of education and highly developed pedagogy such deep specialization is not covered by public schools. The school system leaves this specialized education either to specialized institutes with single-purpose orientation or to institutes upheld by enterprises or industrial groups. We consider this orientation as highly purposeful also for the reason that both theoretical and practical training is indispensable for a specialized training program of a number of professions. Anyway, it is necessary to provide by any other means for such training that is not object of the education program of public shools and that is nevertheless very urgent for improvement of professional qualification.

7.3 Specialized Educational Program for Basic Maintenance Professions in the Care of Specialized Maintenance Factories and Other Similar Organizations

Regarding the facts mentioned above and further requirements for a multipurpose training of manpower and improvement of qualification it seems to be purposeful to organize a specialized training program for management of basic equipment service.

It should be the task of this educational and training program to provide above all the higher staff in the branch of basic equipment management with specialized knowledges necessary for mastering of this difficult service and, last but not least, to improve their konwledge in the sphere of management, public relations and constituting a good working environment. The training program can contribute efficiently to the promotion of technical development and development of rationalization of basic equipment management.

In order to assure that the educational and training program may comprise all recent progressive state-of-the-art, it seems to be useful that the educational program, its organization, methodics and matter to be studied is prepared by a team of best specialists of the branch under professional backing by so-called "Directing Commission" composed of best specialists from selected enterprises, industrial group managements, universities, research institutes, ministry, etc.

It will be suitable to organize the education program in the form of four-semester remotely studied cycle practised in three-day meetings convocated every month except vacations.

The methodics of the study will be based on existing general practice in training and education of adults.

As the form of remote study is adopted, the training unit will be a "Consulting Lesson", i. e. directing and controlling the independent studying activity of participants. A "Consulting Lesson" will comprise:

- Explanation of topic (limited to substantial and highly difficult parts of the topic)
- Examination (control of independent work of participants)
- Instruction (methodical instruction to the study).

The Consulting Lessons will be completed by a rich program of training (under this simplified notion there should be understood all seminaries, co-papers of participants, discussions, technical excursions, demonstrations and similar activating methods).

During the studies the knowledges of participants are continuously controlled by written of oral examinations. The topics or their parts (according to the education plan) are concluded by an oral examination. To the end of the whole program a topic for a written technical paper is prescribed to all participants after an agreement with their employer. This paper is presented in written form in a prescribed term and is discussed with a test panel during final examination.

The studying program requires - as a preliminary condition - a knowledge corresponding to a complete high-school industrial education. Further conditions are the knowledge of theoretical and practical management of basic equipment service at least corresponding to the subject matter volume of the basic seminary course of "Basic Equipment Administration".

The applicants must submit an application form in a due term. Applicants having submitted in time their application forms are invited to an introductory examination. During this discussion the applicants are informed more in detail also on the aim of the educational program, on the plan of subjects and on the organization of the studies.

At the examination of applicants and determination of their order of incorporation into individual courses the commission also considers reasons of public interest, professional background, function and qualification of the applicant and specific need of his studies in favour of his employer factory.

For a practical training, the teaching center has a possibility to reserve a certain number of hours for passing in a plant of the required character.

7.4 Professions

To give a more concrete picture on the distribution of studied subjects and on the volume of all the matter to be studied a plan of specialized educational program titled "Management of basic equipment service" - intended for a future chief of the department "Machinery and equipment" - is given as an example in the following table.

Ord. No.	Subject	Total hours	Hours per semestre I	II	III	IV
1.	Function of industrial plants in social production and reproduction of the production process	24/8	24/8			
2.	Basic equipment - design and building of mechanical engineering and metallurgy plants	16/8	16/8			
3.	Principal components of working environment, factors of comfort feeling of workers, human relations and psychology of work	24/8	24/8			
4.	System and methods of organization of plant management	24/8	24/8			
5.	Production equipment of plants and their technical and economic functions	46/8		46/8		
6.	Power and materials in the operation of mechanical engineering and metallurgy plants, industrial waste and exhalations	34/8		34/8		
7.	Technical and organization characteristics of basic mechanical engineering works and of their production processes	16/8		16/8		
8.	Organization, technology and economy of a plant	44/8			44/8	

Ord. No.	Subject	Total hours	Hours per semestre I	II	III	IV
9.	Organization and economy of maintenance service and repair of basic equipment and principles of costing of maintenance and repair	40/8			40/8	
10.	Facilities and technology of maintenance of basic equipment	80/8			20	60/8
11.	Technical excursions to industrial plants	26				26
12.	Prescription of specialized technical paper	8				8
	Total	460	120	120	120	100
13.	Presentation of technical paper	Final examination				

Notice: All subjects are concluded by examinations; the number of hours written below the brake are intended for final consulting lessons.

7.5 Establishing the Qualification Grade for the Performance of the Function

Regarding the specialized knowledge needed for the performance of the function of chiefs in the maintenance service it is purposeful to include an additional requirement "Complementary specialized training in management of basic equipment service" in addition to the requirements "Graduation" and the corresponding years of practical background into the System of evaluation of technical and economic officials in commercial organizations.

An example:

Function No.	Function	Class	Rate class in the category of organizations 01	02	03	Qualification required: Educ. in corresponding branch	Years of background	Other requirements
2711	Chief of basic equipment maintenance service	I	11	12	13	Grad. +	8 years	Complementary specialized training in management of basic equipment service

"Rate class in the category of organizations"

For the classification of the employee into a salary rating class the functional position occupied by him is of decisive importance.

The classification of the organization into categories is made in Czechoslovakia according to:

- the technological difficulty and complexity of production
- the technical difficulty and complexity of assortment
- volume of import and export tasks
- volume of investment assets
- character and volume of research and development activities
- volume of gross income, volume of basic equipment, factor of equipment of workers by machine tools etc.
- magnitude of the organization (number of employees)

For the classification of a chief of department "Machinery and equipment" e. g. the volume and complexity of basic equipment under his administration is of primordial importance. Thus, the classification of an official of the department "Machinery and equipment" into a pay class depends, in the vertical sense, on the functional position occupied by the official and in horizontal sense on the volume and complexity of basic equipment he takes care of.

Explanation of symbols used in the column "Qualification required" in the preceding table:

Grad. - graduated specialist (university, technical university, economic faculty, pedagogy of arts), having passed all prescribed final State Examinations.

\+ - For functions marked in this way a successfully finished educational program at an institute directed by an industrial group or by a branch organization of enterprises and covering the specialization in question, or a successfully passed specialized technical and economic course comprising at least four semestres and organized at a University can - for a certain time - be accepted as fulfillment of the required university graduation. This "certain time" should be understood as the period during which the official performs successfully the function for which the University graduation has been prescribed.

In the column "Other requirements" as a "Complementary specialized training" in the branch of "Management of basic equipment service"is quoted.

For officials over 45 years of age, where the appointed man did not pass University graduation and where it is no more economic to undertake these studies, the specialization training program mentioned above can be accepted as "+".

If the basic salary depends on the fulfillment of qualification requirements, it is necessary to determine the extent to which equipment" into a pay class depends, in the vertical sense, on the functional position occupied by the official and in hori- zontal sense on the volume and complexity of basic equipment he takes care of.

Explanation of symbols used in the column "Qualification requi- red" in the preceding table:

Grad. - graduated specialist (university, technical university, economic faculty, pedagogy of arts), having passed all prescribed final State Examinations.

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In the column "Other requirements" as a "Complementary specialized training" in the branch of "Management of basic equipment service" is quoted.

For officials over 45 years of age, where the appointed man did not pass University graduation and where it is no more economic to undertake these studies, the speciali- zation training program mentioned above can be accepted as "+".

If the basic salary depends on the fulfillment of qualification requirements, it is necessary to determine the extent to which the specialized education will take part in the determination of the basic salary.

7.6 Determining of Titles for Officials Having Passed the Specialized Education Program

Apart from the establishment of qualification grade as mentioned in the preceding paragraph it is required that those who passed all examinations prescribed and defended their technical paper are entitled to use a lower technical graduation (e. g. title: graduated maintenance engineer etc.).

The qualification grade and a lower technical graduation title will motivate the maintenance officials to pass the educational program along with the performance of their job to render their task easier and to contribute by a competent performing of their function to an improved management of basic equipment within their employer's enterprise as well as in favour of the national economy.

Part 8 - Conclusion - Brief Evaluation

The problems of improvement of the care of basic equipment are highly important in the current economy of industrial and commercial organizations and represent a topic of continuous interest. This is true not only for the problems of a better economy in maintenance and repair service, but in the first place for those of a higher efficiency of this service in favour of perfect condition of basic equipment with the aim of safeguarding their maximum operating efficiency. These problems are still more pressing to keep abreast with the technical development, with the introduction of new and highly efficient machinery and also with the intensification and improvement of the productivity of the whole of manufacturing process.

8.1 Establishing and Evaluating of Conditions for a Proportional Development of the Basic Equipment Maintenance and Repair Service

The development of the repair and maintenance activities is frequently hampered by a lack of repair facilities due to an imperfect organization and concept of repair service.

Requirements for repair facilities are stepped up also by imperfect design of machinery, by a slow renewal rate and late scrapping of outdated investment assets.

The expansion of facilities of maintenance departments under construction is always retarded in relation to the requirements to their service.

Another limitation hampering the development of maintenance service can be seen in a high diversity of types of machine tools and equipment owing to which the repair activities cannot assume an industrial character and a purposeful and efficient storage service is made impossible.

The development of repair services is further blocked by an inefficient and poorly equipped research base solving maintenance problems and repair topics. Insufficient attention is paid to everyday servicing of machines, especially to the lubrication service, which exerts a serious influence on the wear process. Under various circumstances a disproportional development of maintenance can bring about many further adverse effects. To find a remedy it is necessary to reveal these adverse phenomena, to analyse them and to find a way of their removal. This is the only way of securing favourable conditions for improvement of the state.

8.2 Economics of the Basic Equipment Maintenance and Repair Activities

The efficiency of the maintenance activities proper depends on

- the production base
- the measures taken to slow down the wear process
- the specialization and centralization of work
- suitable maintenance methods.

A newly built and well equipped production base will surely present smaller requirements to the maintenance service than an old production base where the renewal has not been sufficiently performed and where also the maintenance service did not suit the wear process.

By properly servicing the machines and equipment, correct cleaning and lubrication the wear process can be slowed down mostly by as much as 25 %. Reduced wear involves a reduction of cost of remedy of wear.

A suitable composition of machinery and equipment comprising large numbers of identical types enables to organize an efficient activity of specialized maintenance teams and to produce and store economically the spare parts, to perform repair using an industrial or even a new-for-old system of rehabilitation.

A substantial improvement of the efficiency of the maintenance activity proper can be helped by a suitable maintenance process method and its differentiation according to the operational conditions of the production base.

For the purpose of an account and evaluation of the efficiency of proper maintenance activities it is necessary to keep records on all data necessary for analysing of the activity, to reveal adverse influences and to suggest measures for their remedy.

8.3 Economic Effect of Basic Equipment Repair and Maintenance on the Main Manufacturing Process of the Organization

Should the "basic equipment maintenance" be defined as all activities aiming at and acting to the maintaining of basic equipment in such condition that the production ability of the organization or company are always kept at a constant production efficiency and precision without hampering the production, then the main factor of efficiency of this activity must be seen exactly in how much this aim has been satisfied.

Outage time of machinery and equipment, especially if in production lines, in case of unplanned stoppage, will bring about much more serious losses than cost of a maintenance operation intended to return the machine into operating condition. E. g. an unplanned outage time in an automated production plant of a motor car factory can, depending on the size, cause losses that are ten thousands times higher as the cost of the maintenance operation necessary for remedy of the defect. It is therefore clear that all activities of the maintenance service must be subordinated to this main criterion. The degree of attention and volume of maintenance service are differentiated according to the importance of individual machines in the production process.

8.4 Extended Life of Basic Equipment and Safeguarding of their Serviceability - Main Merit of Maintenance Activities

Right or wrong maintenance of basic equipment exerts a serious influence not only on overhead costs, production losses owing to outage time necessary for maintenance operations, but it can substantially influence also the life period of the equipment unit as a whole.

This fact is most important above all where obsoleteness of the production equipment cannot substantially influence the results of the production process and where such equipment can be efficiently utilized also in the case of its transfer from main production lines into auxilliary workshops.

A proper maintenance of basic equipment can extend the service life approximately by 25 - 30 %. Regarding extremely high cost of basic equipment this represents considerable savings that can be gained by a thorough maintenance.

Main efficiency of maintenance activities should therefore not be seen in its internal economy and efficiency, but in the outer efficiency, representing maximum reduction of outage time of production equipment and extending of its service life.

Though the improvement of productivity of the maintenance activities proper is frequently subject to considerable efforts of technical staff, it must not be solved at the cost of overall afficiency of the maintenance service which becomes only evident outside of this activity.

Note

The proposed conception of repairing and maintenance of basic equipment refers to the machinery and equipment in well-organized engineering corporations and plants. The principles set forth in the preceding chapters may be conveniently applied or introduced gradually, as mentioned below.

The principles of maintenance and repairing of basic equipment in developing countries are to be interpreted as prospective criteria of the targets specified for every particular project. They should be determined with such progressive approach as to remain effective after being introduced for practical application.

The materialization of projects in the field of maintenance and repairing of basic equipment is a complex problem taking a very long time to complete; it is recommended to carry it out in stages. Each stage is to be correctly linked up with the other so as to achieve a complex fulfilment of the targets laid down in the project.

It is therefore essential to base the work on the present conditions in production basis, production processes and their organization; on the planning of development of these fields; on the principle to proceed in a differentiated way according to the conditions in which the production takes place.

For instance, the first stage should be focussed on the realization of basic measures determined by an analysis of the existing conditions in production basis, production organization and the standards (level) of the maintenance of basic equipment as carried out in specific conditions.

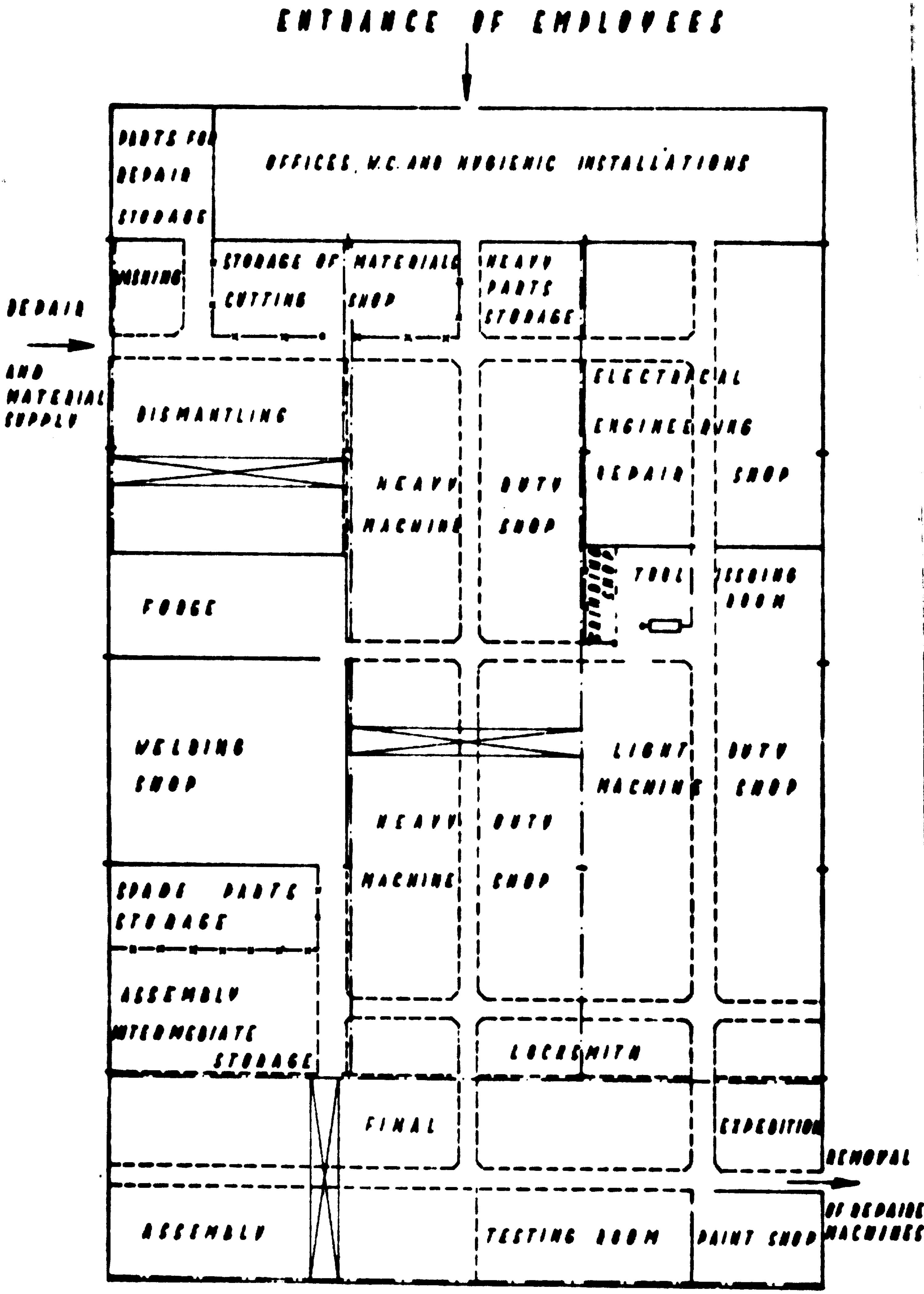
Simultaneously the general aim of the project should be kept in view so that the first stage can also create pre-requisites for the subsequent stage.

The second stage should include measures aimed at specialization and the resulting rise in maintenance and repairing efficiency, which again leads to the required growth of production basis level, improvement of its operational ability and rise in the quality of maintenance work itself.

The third stage is intended to finalize the project in the envisaged form.

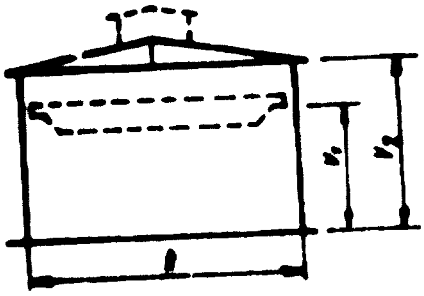
The present volume does not apply to the repairing of automobiles and consumer goods, such as wireless sets, TV sets, refrigerators, vacuum cleaners etc. which are subject to specific conditions both in production process and the maintenance practice as well.

Kovoprojekta with its long past experience, however, can render consulting services even in these branches, or it can work out studies and technical reports for all other types of maintenance and servicing.

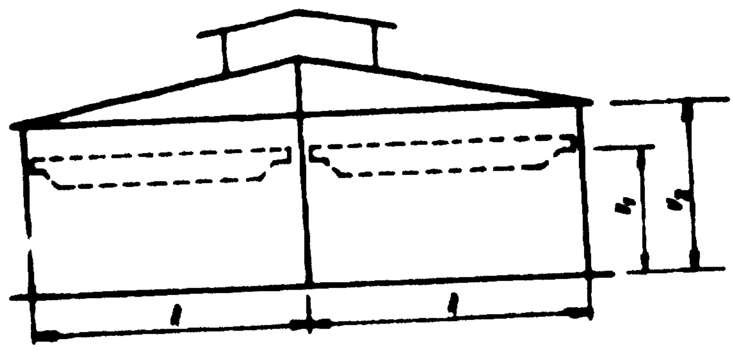


EXAMPLE OF REPAIR SHOPS LAYOUT IN THE PLANT

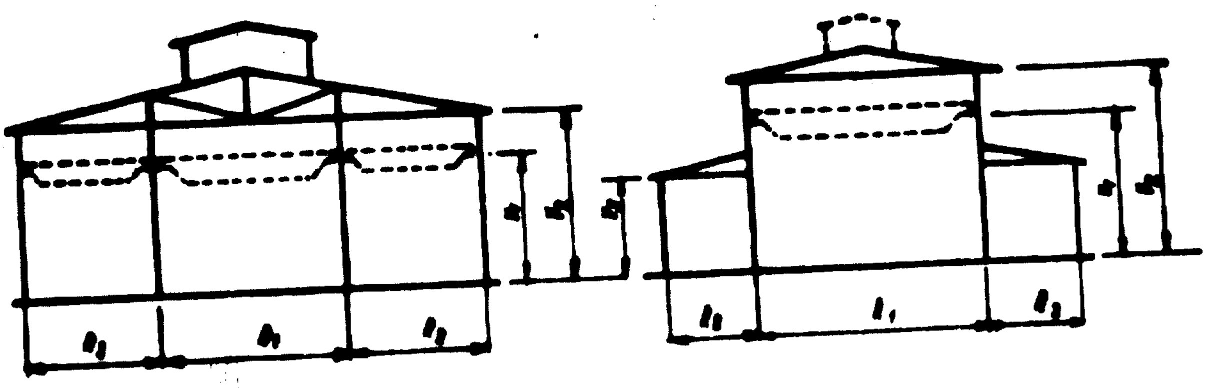
EXAMPLES OF OPERATING GROUNDFLOOR STRUCTURES PROFILES



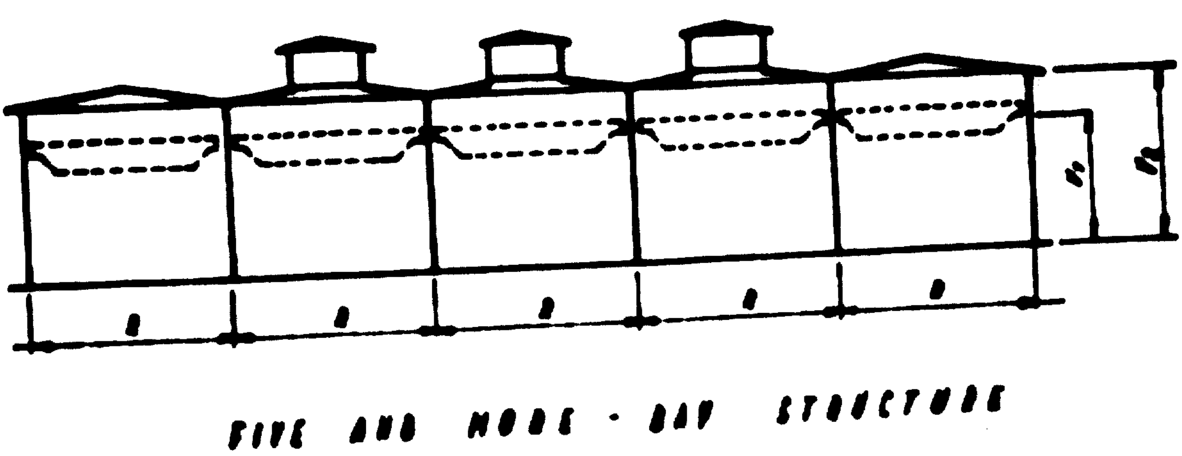
ONE-BAY STRUCTURE



TWO - BAY STRUCTURE



THREE - BAY STRUCTURE



FIVE AND MORE - BAY STRUCTURE

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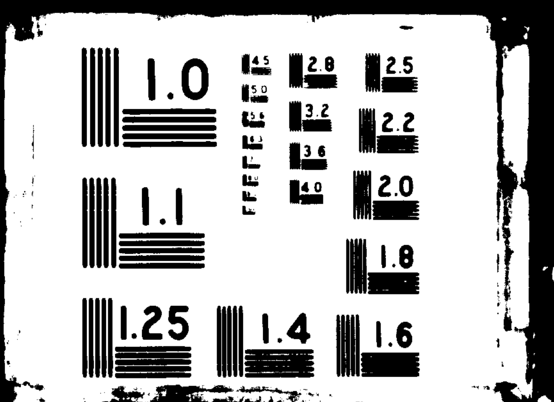
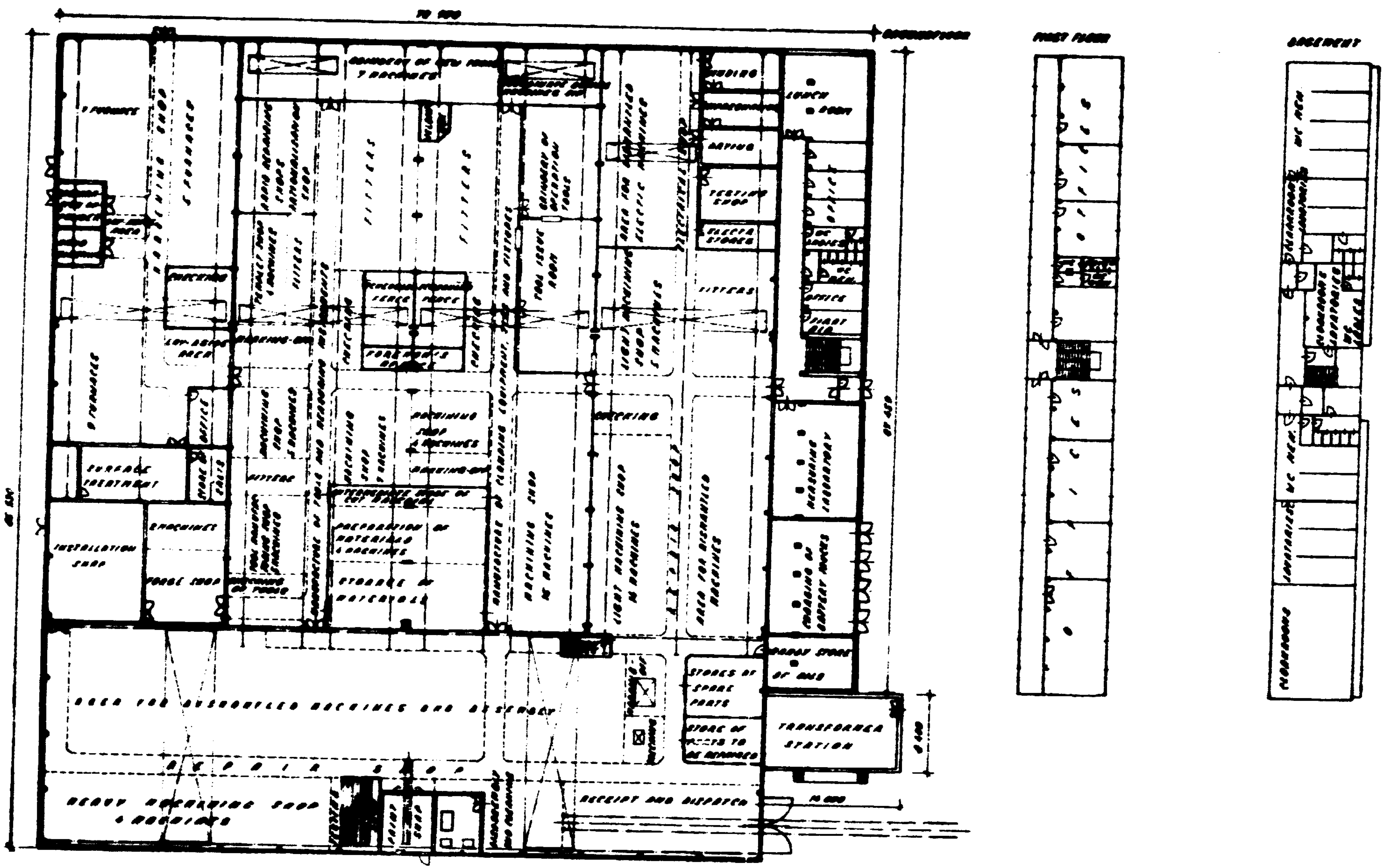
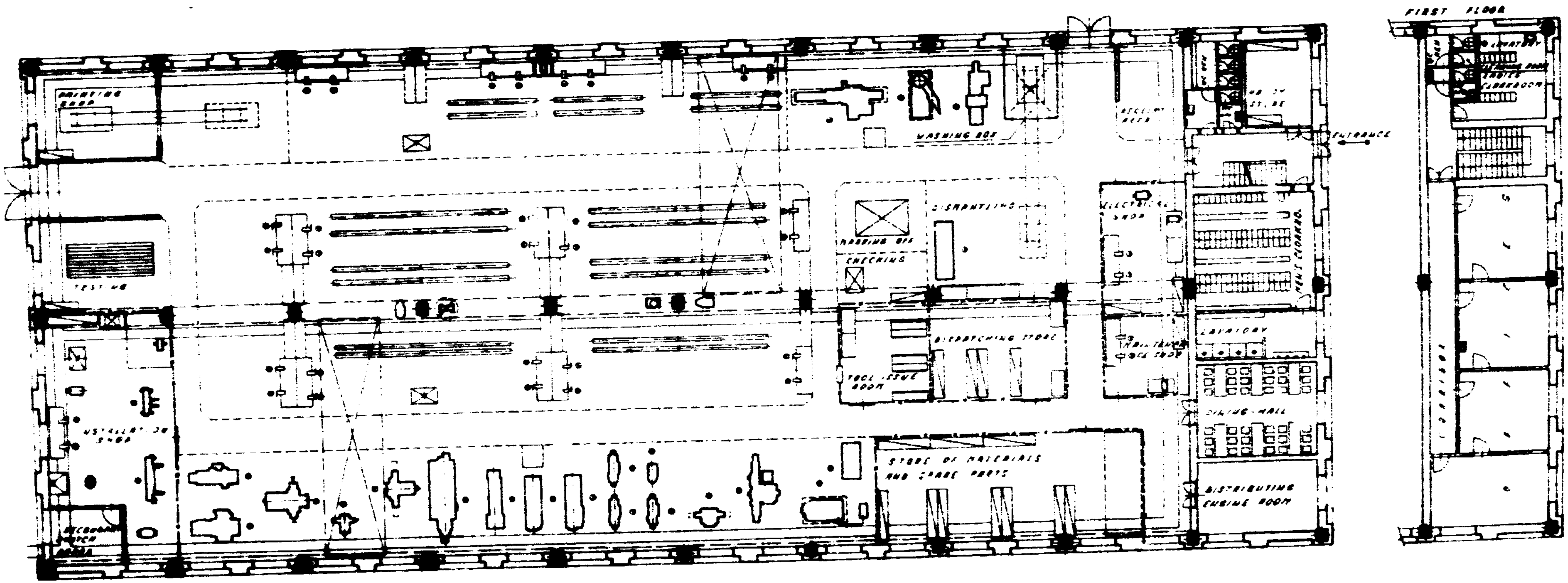
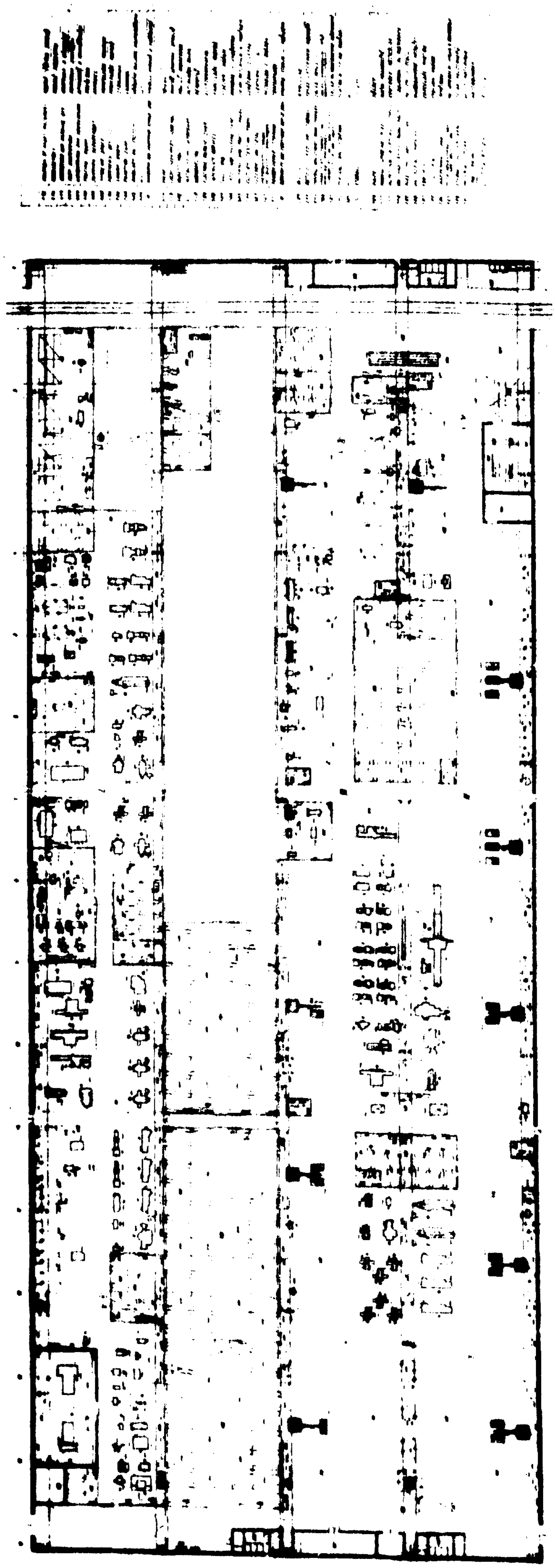


REPAIR AND TOOL WORKSHOP IN CEMENT MACHINES MANUFACTURING PLANT



REPAIR WORKSHOP IN MACHINE-TOOL FACTORY





AUXILIARY WORKSHOP FOR HEAVY POWER EQUIPMENT PLANT

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