OCCASION

This publication has been made available to the public on the occasion of the 50th anniversary of the United Nations Industrial Development Organisation.

DISCLAIMER

This document has been produced without formal United Nations editing. The designations employed and the presentation of the material in this document do not imply the expression of any opinion whatsoever on the part of the Secretariat of the United Nations Industrial Development Organization (UNIDO) concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries, or its economic system or degree of development. Designations such as "developed", "industrialized" and "developing" are intended for statistical convenience and do not necessarily express a judgment about the stage reached by a particular country or area in the development process. Mention of firm names or commercial products does not constitute an endorsement by UNIDO.

FAIR USE POLICY

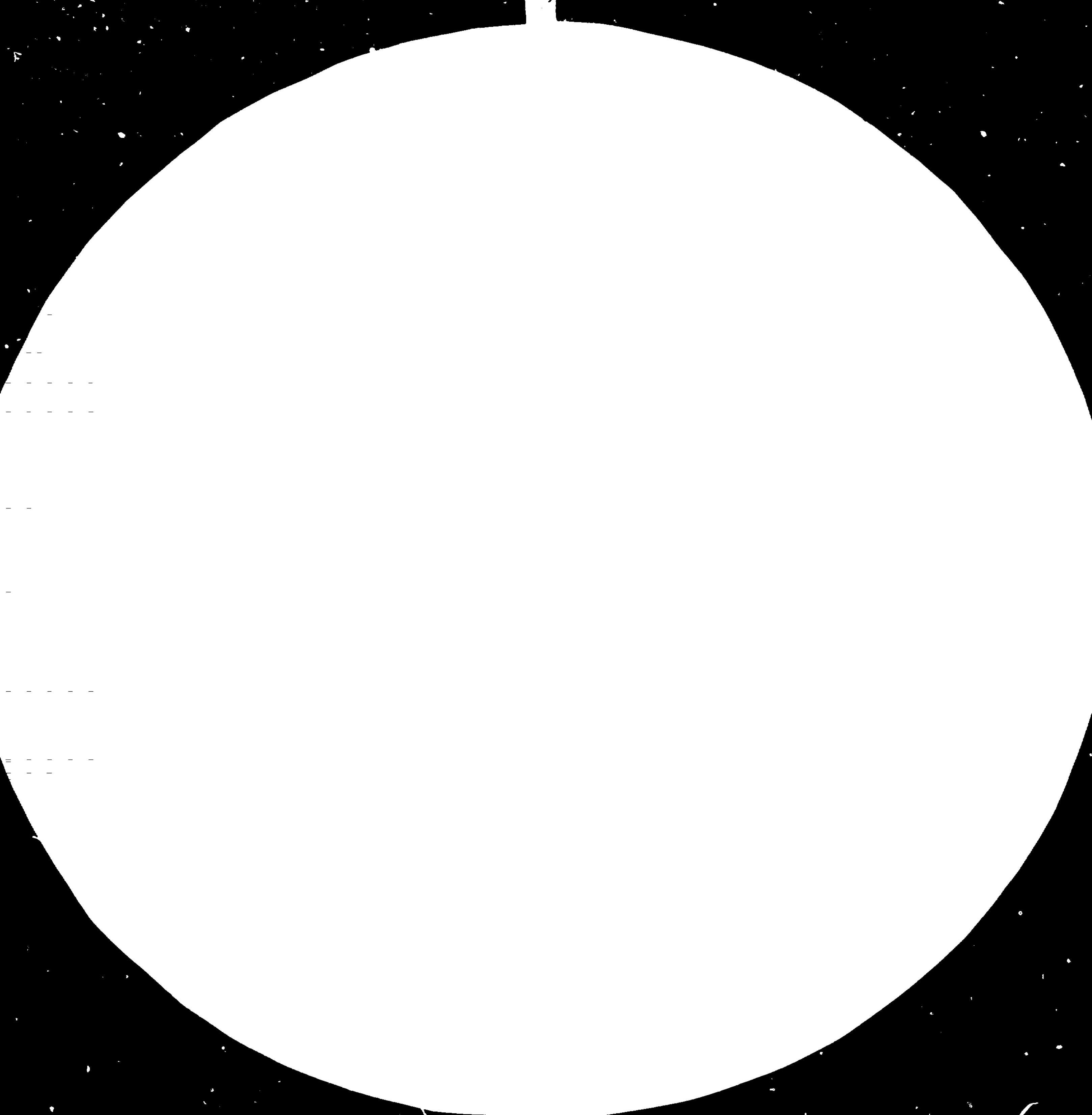
Any part of this publication may be quoted and referenced for educational and research purposes without additional permission from UNIDO. However, those who make use of quoting and referencing this publication are requested to follow the Fair Use Policy of giving due credit to UNIDO.

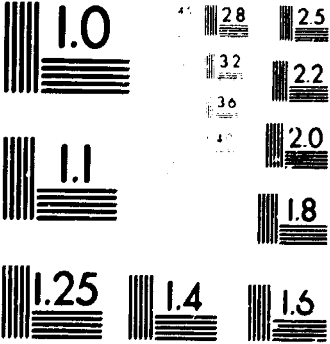
CONTACT

Please contact publications@unido.org for further information concerning UNIDO publications.

For more information about UNIDO, please visit us at www.unido.org

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org




1.0
2.8
2.5
3.2
2.2
3.6
4.0
2.0
1.1
1.8
1.25
1.4
1.6

14351

Distr.
LIMITED

ID/WG.432/2
29 January 1985

ENGLISH

United Nations Industrial Development Organization

Technical Course on Criteria for the
Selection of Woodworking Machines

Milan, Italy, 14-30 May 1984

POWER SUPPLY AND AUXILIARY INSTALLATIONS IN WOODWORKING INDUSTRIES *

Prepared by

Enrico Banfi **

---

* The views expressed in this paper are those of the author and do not necessarily reflect the views of the secretariat of UNIDO. This document has been reproduced without formal editing.

** Expert in woodworking machines, ACIMALL, Milan, Italy.

V.85-21707

TABLE OF CONTENTS

INTRODUCTION

The technological facilities of industrial plants play a major role in the cost effectiveness of the factory management.

If on the one hand machine tools, and, most notably, woodworking machines, determine both production quantity and quality, on the other hand all ancillary systems are designed to provide a flawless operation and a cost-effective management of the productive processes.

The aim of this report is precisely highlighting the technical relevance of the various parts that make up the most common technological facilities in woodworking industries (power supply, steam, water, compressed air) and determining the criteria to choose the most suitable solutions. The first thing to be borne in mind is that there is always a wide range of solutions to a given problem and that, from a strictly technical point of view, they all are equally acceptable. The designer's task is precisely to identify the most profitable technial solution in order to achieve the best possible management performance.

The first step in this direction is establishing an order of priorities among the various parameters to be considered. Of equal importance is envisaging the possibility of modifying or enlarging the plant equipment throughout the years considering that it is supposed to have an economic life-cycle of at least two decades.

These are the fundamentals that apply in the majority of cases. Before discussing the best solution, from a qualitative point of view, the report first focuses on the essential parts of the major ancillary plants.

1. ELECTRIC ENERGY

1.1 General

The power plant is fundamental to all machine-operated productive units and all the more so since it affects their technological systems and facilities, the driving and regulation stages. The advantages of having an electric power supply are mainly as follows:

- ease of haulage
- high energy density per lead volume

1.2 Power generation

In the woodworking business the amount of power supply necessary for the end uses never justifies its self-generation, especially if the supply can be provided by a pre-existing network. In this case a subtransforming station could be connected to the supply mains and step the line voltage down to the desired voltage for the various utilizations.

Fig. 1 shows, from a quality viewpoint, the ranges within which the power supply installed in various woodworking plants is allowed to vary. Should connection to the power mains turn out to be impossible, electric energy will be generated by the power unit.

Power units are usually driven by a diesel engine which is connected to its corresponding alternator.

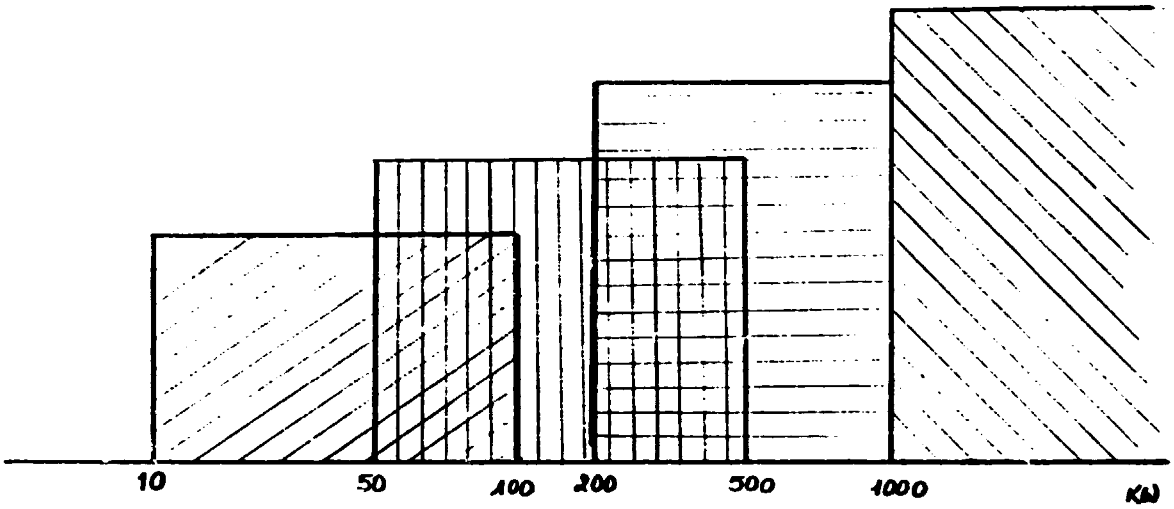


Fig. 1: Power required in woodworking plants

▨ Joiner's shop

▥ Little furniture factory equipped with traditional machinery

▤ Sawmill

▧ Big furniture factory equipped with several complete lines of automatic woodworking machinery; plywood, veneer and particle board manufacturing units.

1.3 Supply

There are two major power supply systems:

(a) a radial system, and

(b) a "ring" system.

(a) With the radial system, the machines supplied with power are arranged in subgroups in the shape of an 'upside-down tree'. We distinguish three different types of radial systems, and more precisely:

1) Power supply at mains end and shunts along the mains (fig. 2 below);
2) Power supply at mains center and shunts along the mains (fig. 3 below);
3) Both power supply and shunts in one single point on mains (motor control center) (fig. 4 below);

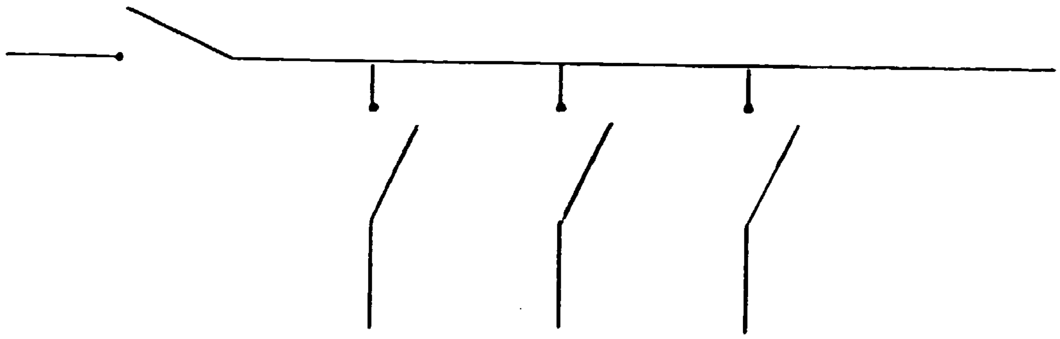


Fig. 2: Radial power supply system with power supply at mains end and shunts along the mains

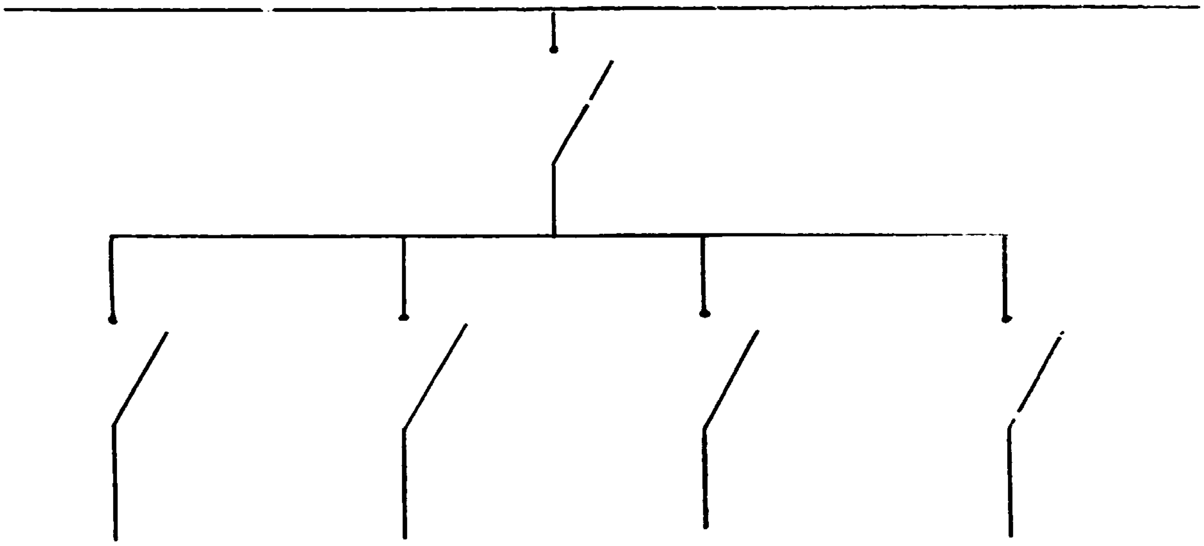


Fig. 3: Radial power supplv system with power supply at mains centre and shunts along the mains

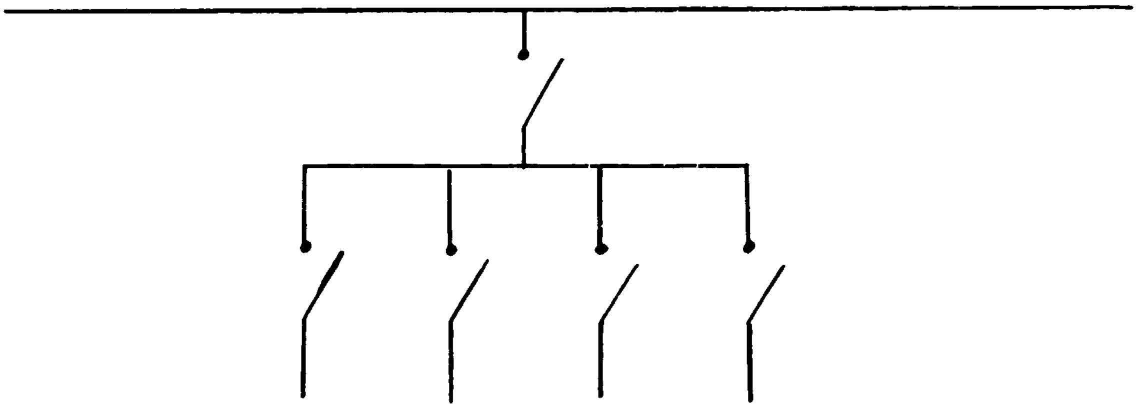


Fig. 4: Radial power supply system with power supply and shunts in one single point on mains

b) The 'ring' system is "closed" and allows getting power supply from two different points of origin (fig. 5 below).

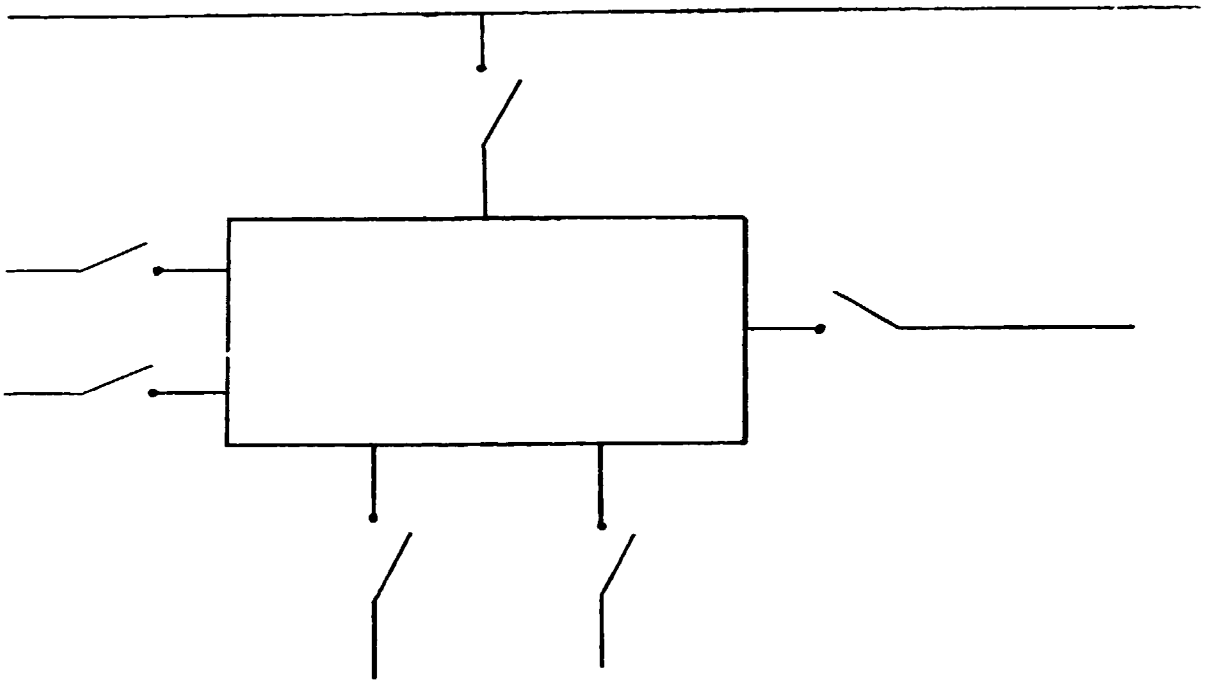


Fig. 5: Ring power supply system

Woodworking plants frequently adopt the 'closed' ring type distribution system. The advantage of the latter being that it provides a two-way power supply thereby making the plant highly reliable. On the other hand, there are more installation-related problems with respect to lead laying. Leads need sometimes to be very long, especially in the case of remarkably big factories.

The lead cross-section area has also to be designed with a view to having to carry the maximum installation current.

Since all machinery units are arranged in series they are not separated.

The most common types of conductors (leads) are protected copper conductors and insulated copper cables that can be laid underground or put in suspended raceways.

In the absence of any adverse side-effects, laying conductors in suspended raceways allows rapid mains connections or disconnections, easy maintenance operations (that can be performed on sight) and works under the floor without running the risk of damaging the supply mains.

In this case, there must be a sufficient amount of heat loss in the surrounding air in order to prevent conductors from reaching unacceptable temperatures. Conversely, if conductors were to be laid underground - either because, due to technical reasons, they cannot be laid in suspended raceways or just to protect them from weathering - pipelines or raceways will have to be used to protect them from any damange resulting from impacts or infiltrations.

1.4 Applications

Asynchronous motors are, almost invariably, the final 'users' in woodworking plants.

Fig. 6 below shows the working mechanics of this type of motor. The static torque is almost equivalent to the pull-in torque and it decreases constantly as speed increases. This type of motor is therefore suitable for machine tools since it is self-regulating, it sets on the desired operating point, varying its speed accordingly and keeping efficiency values close to peak values in a wide range of applications.

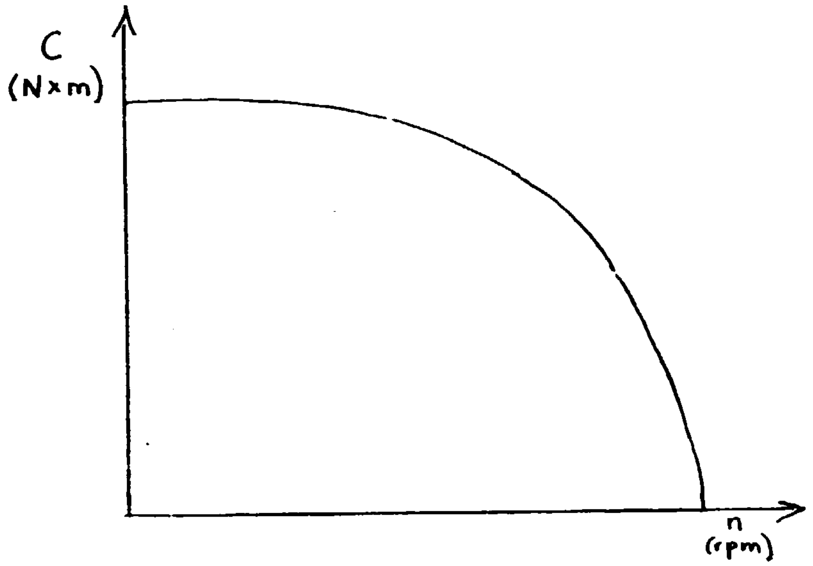


Fig. 6: Working mechanics of an asynchronous electric motor

As for the electric installation the only drawback is that the power factor decreases very rapidly down to low load values, as can be seen from fig. 7 below.

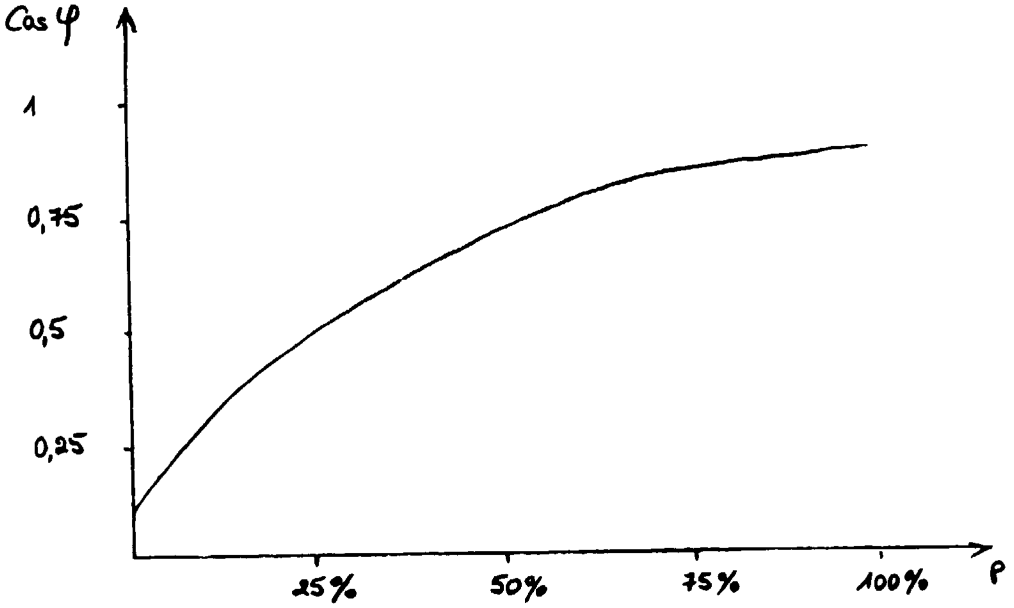


Fig. 7: Effect of load value on power factor (cos. φ)

Special systems are therefore to be envisaged that generate reactive power to be fed into the mains so that the overall power absorbed is reduced and the load factor increased. Suitable static capacitor banks will therefore have to be provided for power factor correction.

1.5 Protection and safety measures

Safety measures are to be applied to all feeder lines, machinery and, more generally, to sections of the plant that need to have devices for immediate power supply cut-off in case of malfunctioning. But, most of all, protection will have to be provided to all workers likely to come in contact with live pieces of equipment or installations.

It is worth noting that the strength of the current passing through the human body is precisely the cause of injuries, let alone death.

As the time of passage of current across the body increases, the intensity necessary to cause major physiological damage diminishes. A 100 mA current can prove lethal in a few seconds (see fig. 8 below).

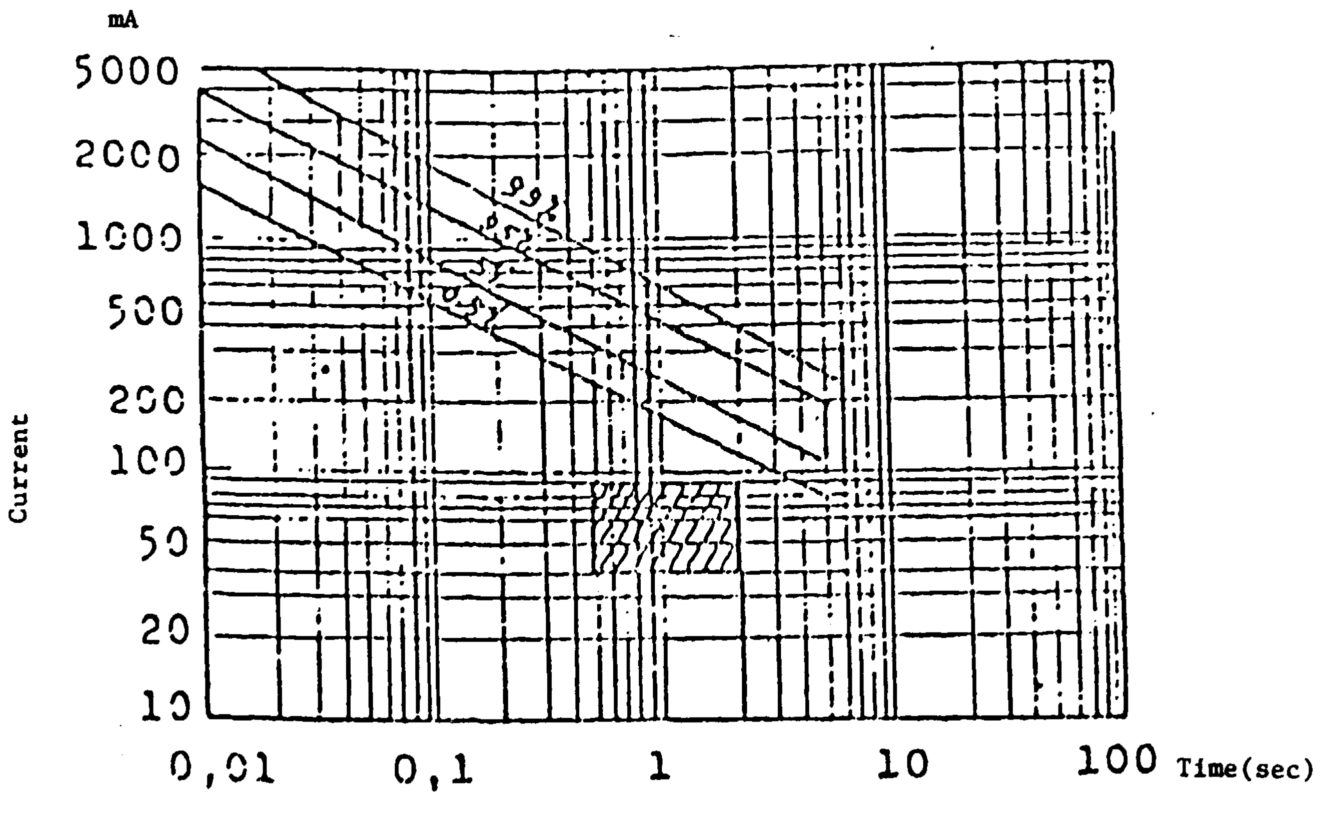


Fig.8: Danger curve according to Dialzel and danger area according to Bodier

Contact of the human body with live pieces of equipment or installations can occur in two major instances:

- accidental contact with usually hot parts (fig. 9), which is a common event during ordinary maintenance operations;

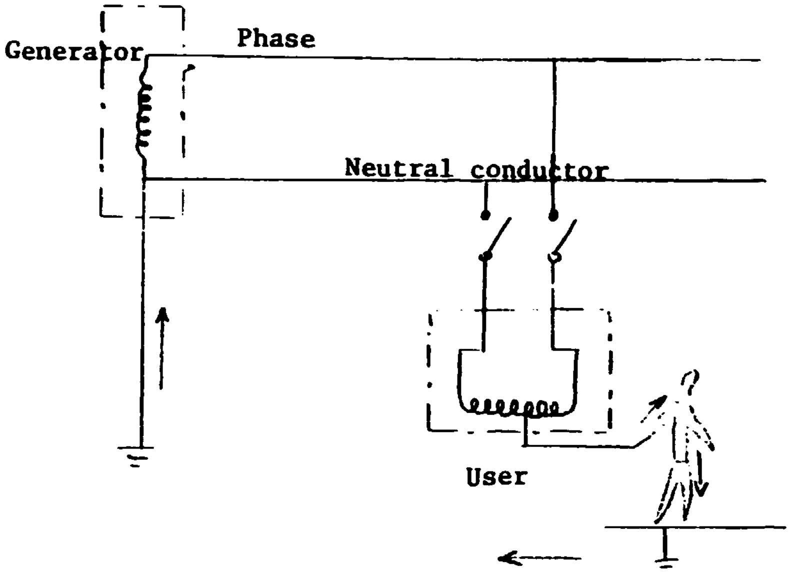


Fig. 9: Accidental contact with hot parts during maintenance

- contact with live parts due to previous failures (fig. 10).

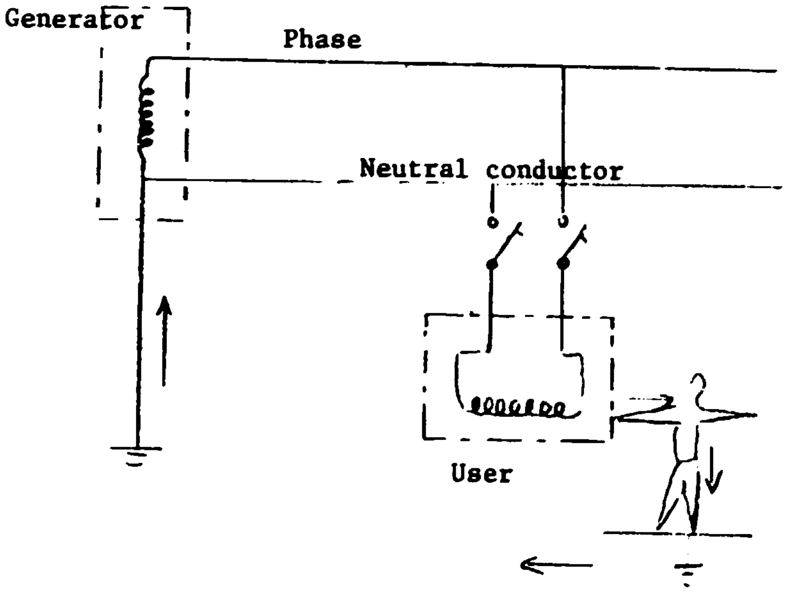


Fig. 10: Contact with live parts due to previous failure.

In the second instance, the danger is higher and more frequent since accidents are not due to disregard of safety rules, but to the bad conditions of electric connections that tend to deteriorate with time.

Consequently, if the above-mentioned cases of accidenc are to be averted, suitable protective measures must be envisaged. For the same reason, the ground power grid has to be correctly designed and accurately sized so that it closes the current circuit in a loop thus preventing current from passing through the body that has come in contact with hot metal parts (fig. 11).

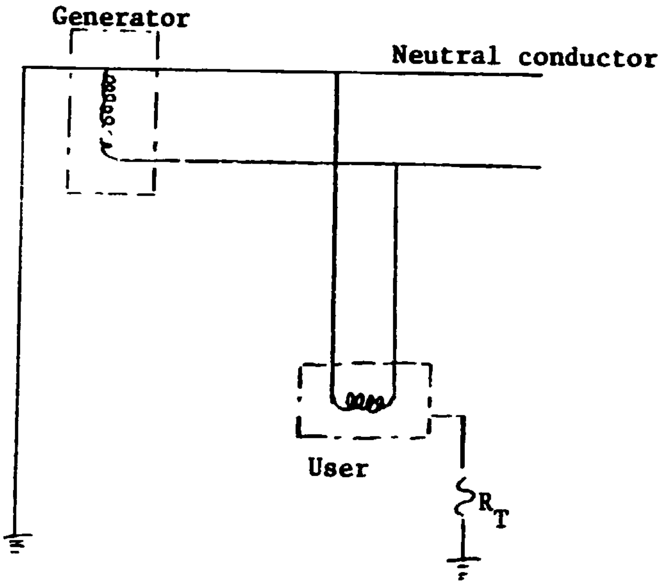


Fig. 11: Correct ground power grid.

2. COMPRESSED AIR SYSTEM

2.1 General

Compressed air is one of the most largely used forms of energy in woodworking industries due to its unique qualities that are essential in such processes as clamping of workpieces, piece handling, lacquering, conventional and portable tool operation, part adjustment and positioning.

This is true despite a relatively low overall efficiency, meaning by that that the ratio between the pneumatic power supplied to the various machines and the energy absorbed by compressor-driving motors is low.

The most outstanding advantages of compressed air are as follows:

- easy handling of pneumatic motors;
- easy adjustment by simply opening or closing nozzles;
- protection from processing overloads.

Two powers of magnitude express the pneumatic power supply of a plant, namely:

- actual working pressure required (kg/cm^2)
- air flow rate required at full load (Nm^3/h)

In most cases, the pressure required is some 7 kg/cm^2 while consumption varies depending on the type of utilization. We are now going to look into the major parts that make up a pneumatic system (i.e. compressors, distribution lines, actuators). In doing so, we will confine ourselves to saying just a few words on the number of fittings (suction filters, coolers, separators and steam traps, pulsation dampeners, buffer tanks).

2.2 Compressors

We consider four different types of compressors, namely:

- reciprocating compressors;
- rotary positive displacement blowers;
- turbine compressors (axial or centrifugal)
- screw compressors.

These are the criteria to be considered when making a choice:

- maximum delivery pressure
- required capacity
- isothermal and adiabatic efficiency
- expected machine life
- vibrations produced.

Table 1 provides a tentative picture of the above mentioned criteria. The type of compressor that is most largely used in woodworking industries is the reciprocating compressor which can be driven either by a motor or by an internal combustion engine or else by a diesel engine.

Table 1

Type	Pressure		Approximate values at 7 kg/cm^2				
Air compressor	Maximum kg/cm^2	Utilization Kg/cm^2	Maximum Airflow m^3/min	Weight/power kg/kW	Economic life h	Vibrations and plant complexity	Compressed air contamination
Pistons	350	7	500	40-70	20.000	A1/	Oil
Rotary blades (volumetric)	30	7	100	27-35	10.000	B2/	Oil
Centrifugal	12	7	160-2000	20	(20.000)	C3/	--
Rotary screw	30	7	300	15	(25.000)	C3/	(oil)

1/ A=maximum 2/ B= medium 3/ C= minimum

We suggest using single action compressors for upto a power of 25 HP and double action compressors beyond 100 HP. Either compressor can be used for the intermediate power range.

If the distribution network has been properly sized and accurately serviced, pressure drops will tend to be low, so that it is advisabe to provide a delivery rate that is about 40 percent higher than the actual requirement and to allow for air leakages that become more frequent with the passing of years. Screw compressors are the latest, and therefore, most advanced generation of compressors. They have been made far less complicated than previous versions but their installation costs have obviously risen.

Compressor regulating devices deserve special attention since the machines of woodworking plants mainly run at a lower capacity than peak capacity and compressor utilization values are relatively lower than steady-state values. Hence, in order to have low operating costs, regulating devices will have to be designed in such a way that they do not excessively undermine efficiency when operating conditions depart slightly from optimal working conditions. The compressor/motor (or engine) coupling can be of three different types:

- direct,
- with reduction unit,
- with driving belts.

Direct coupling makes the whole system extremely compact. However, it requires motors with a low number of revolutions and a highly accurate system assembly so as to prevent the motor shaft and the compressor from being misaligned. The coupling with reduction unit and gears allows using high-speed motors and to keep the unit quite compact, however the reduction unit cost is quite high.

The belt-driven system is much more flexible in case of abrupt changes in the rotation speed. It also makes it possible to vary the gear ratio by replacing pulleys. Its installation, however, calls for a larger room and the power it absorbs is greater than in the previous two cases. The compressor units will also have to be properly fed with a suitable coolant which is usually water flowing in a closed circuit. Compressors must be cooled for three major purposes:

- to lower the final temperature of the air so as to avid putting the material under intolerable stresses;
- to achieve an isothermal type of compression to the greatest possibl extent, with a resulting higher efficiency;
- to cause vapour to condense so that it can be exhausted on line.

The design of the suction system will have to combine two major elements: simple construction features and the possibility of feeding at a low temperature impurity-free air. The reduction of compression is proportional to the temperature of sucked-in air. Instead, growing impurities cause filters to produce unacceptable head losses although their efficiency is enhanced.

2.3 Delivery and distribution systems

The compressor unit will have to be placed in an explosion resistant area. The distribution system starts from the flange of the on-off valve to be positioned outside the partition wall.

If the tank is far from the compressor, the diameter of the delivery piping will have to be the same as for the compressor outlet, otherwise it is suggested to expand the piping storage capacity by increasing its diameter by some 20 percent.

As in the case of the power plants, the distribution network may be equipped with:

- a single manifold and its branches,
- a double manifold and its branches, or
- a ring circuit.

Thanks to the current reliability of main and branch devices, distribution through a single manifold is common since it also allows remarkable savings in terms of installation costs. An "upside-down tree" type of distribution is nonetheless recommended, i.e. with various operating sub-units upstream divided by the line branching-off points. This avoids having all the operating units cut off in case of failure, if failure does not occur upstream from the point where shunts branch out.

Rigid pipelines can have a smooth surface and are jointed with head flanges, welded, or threaded. Threaded pipes are easier to assemble but more likely to bring about air leakages. Flexible rubber or synthetic material pipe fittings will have to be used for connecting parts in relative motion. The pipe sizing is used on a permissible pressure drop ranging from 0.3 to 0.5 kg/cm^2, depending on the distances, for distribution systems having a 7 kg/cm^2 pressure value.

2.4 Utilization

The following are the major tasks fulfilled by the pneumatic system:

- piece handling,
- tool driving

During the piece-handling operations, pneumatic parts fulfil a wide range of tasks: control of workpiece position, machine feed, on line machine linkage, piece clamping. Conversely, tool-driving operations are almost solely designed to provide the tool feed motion, whilst cutting motion is operated by electric energy.

Figs. 12 and 13 show two different pneumatic systems similar to those used in ordinary woodworking machines processes. Accumulators (storage cylinders) will have to be located upstream from pneumatic actuators and serve as regulators (equivalent to a flymodel for rotary motion). Indeed since operating trends are not always steady, a storage unit must be provided in order to regulate the air flow and to avoid designing the network on the basis of the sum of peak loads of each machine.

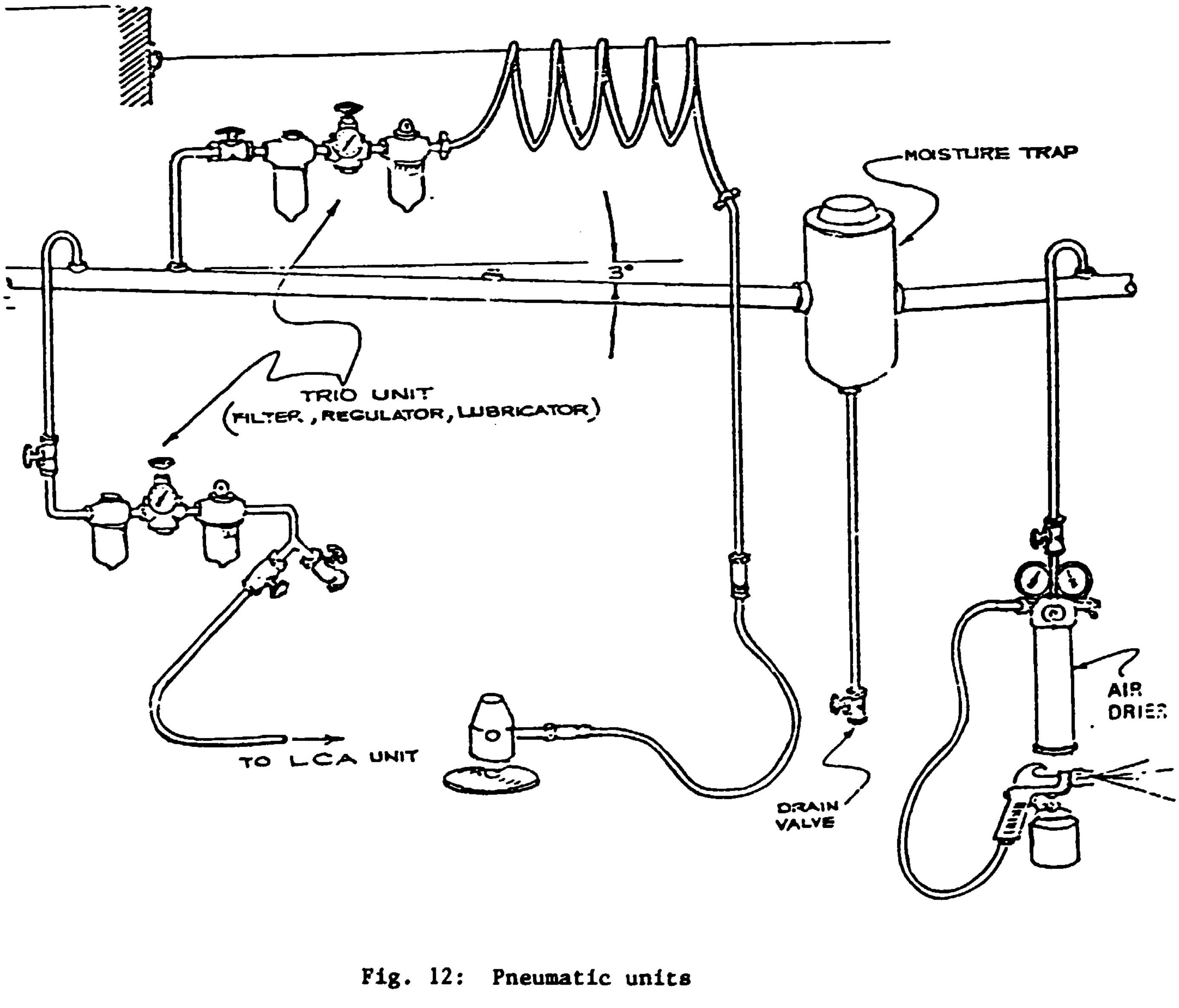


Fig. 12: Pneumatic units

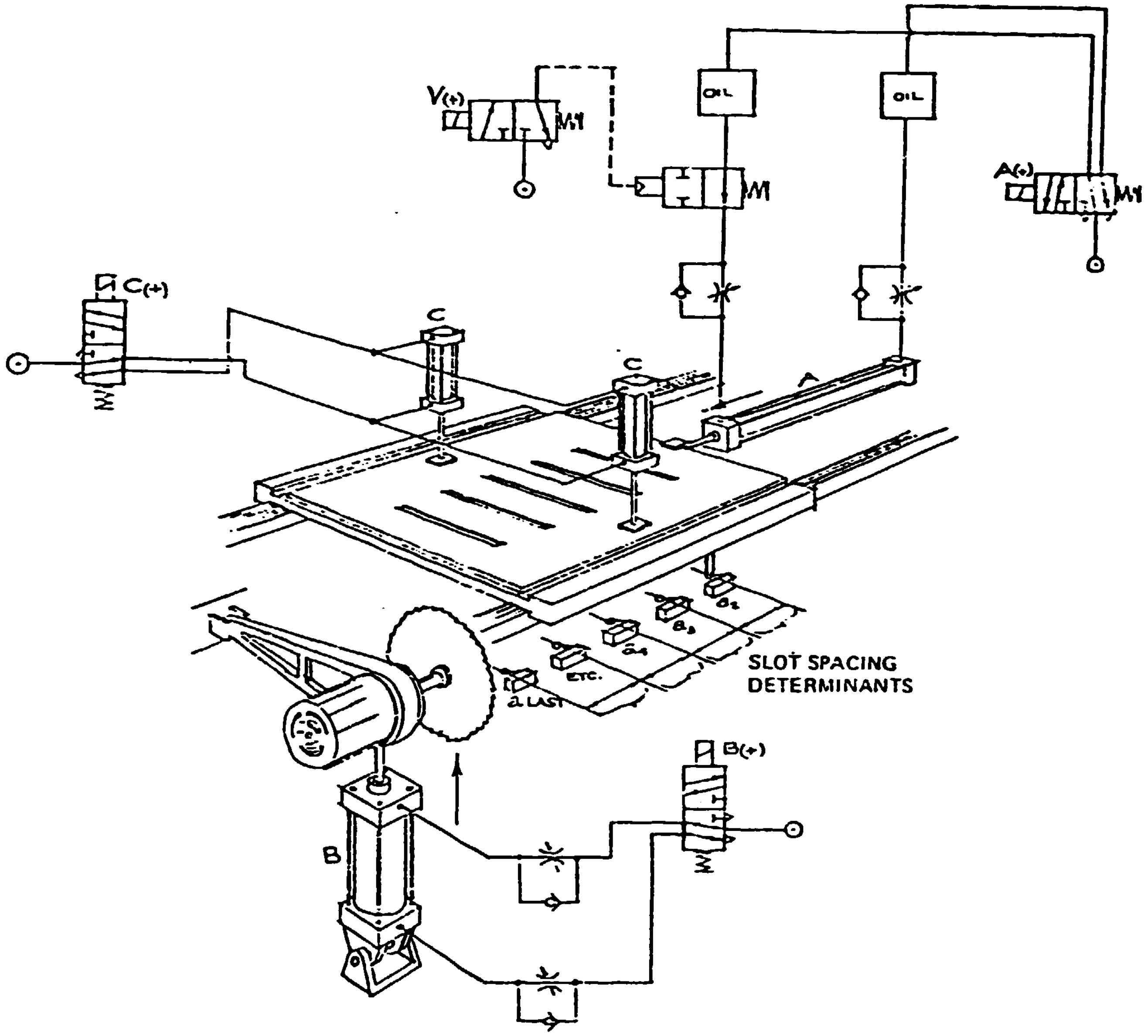


Fig. 13(a): Pictorial diagram and pneumatic circuit for a radio-TV cabinet slotter

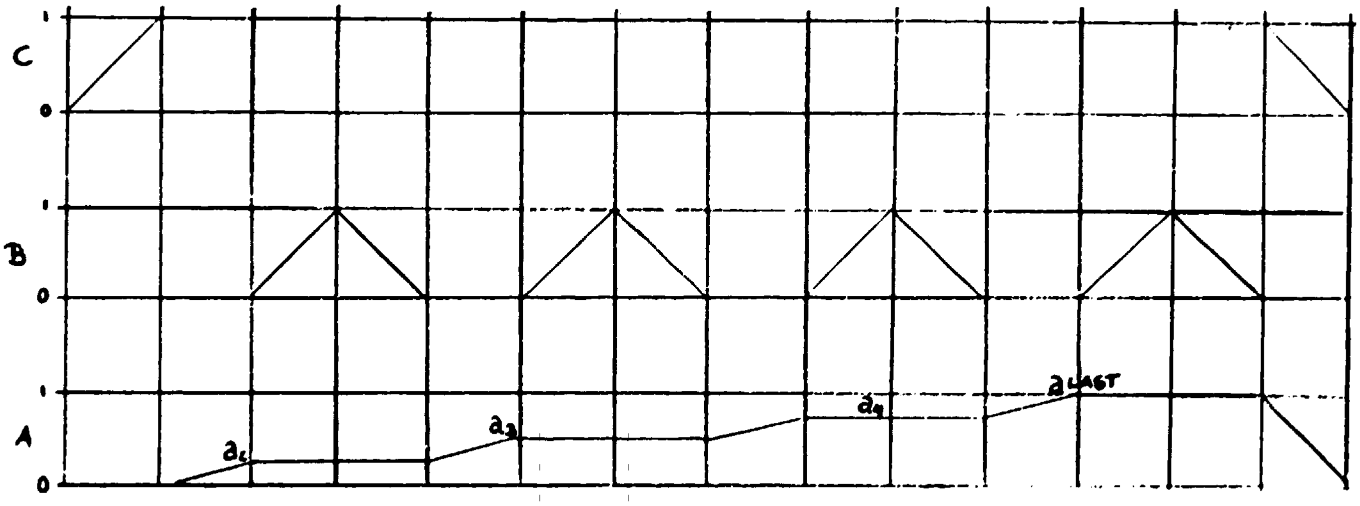


Fig. 13(b): Time-motion diagram for a radio-TV cabinet slotter

3. TERMAL PLANT

3.1 General

Thermal energy is necessary to any plant for technological purposes (presses, driers, lacquering equipment, etc.), for factory facilities, for people's comfort (sanitary facilities, heating, etc.) and for air-conditioning of the work sites.

3.2 Generating plant

The potential of the power generating unit will be reckoned on the basis of the peak simultaneous load coming from the various operating units.

Hence the utmost importance of having a power generating unit is also highly efficient in conditions other than the rated operating conditions. The current trend aiming at optimizing the use of all processing waste materials strongly suggests a tilt towards boilers that can be fed with wood chips, sander dust, sawdust, bark, wood off-cuts and edgings and any other processing waste. The heat value of all tese elements being generally insufficient to cover alone the required thermal energy, a feeding system based on traditional fuels, needs to be installed and used as a stand-by.

Beside the traditional water-tube and smoke-tube boilers, woodworking plants can also resort to diathermal fluid boilers that are largely used to convey heat to platens of presses used in the wood based panel industry. The economic advantage of shifting from a smoke tube boiler to a water tube boiler is of the order of 6-7 million kCal/h.

Fig. 14 shows the construction diagram of a smoke-tube boiler (diathermal fluid boilers have construction and operation features similar to those of pressurized water boilers). Steam or water boilers will have to be equiped with a treatment plant for filtering and purifying the feed water to make it absolutely pure.

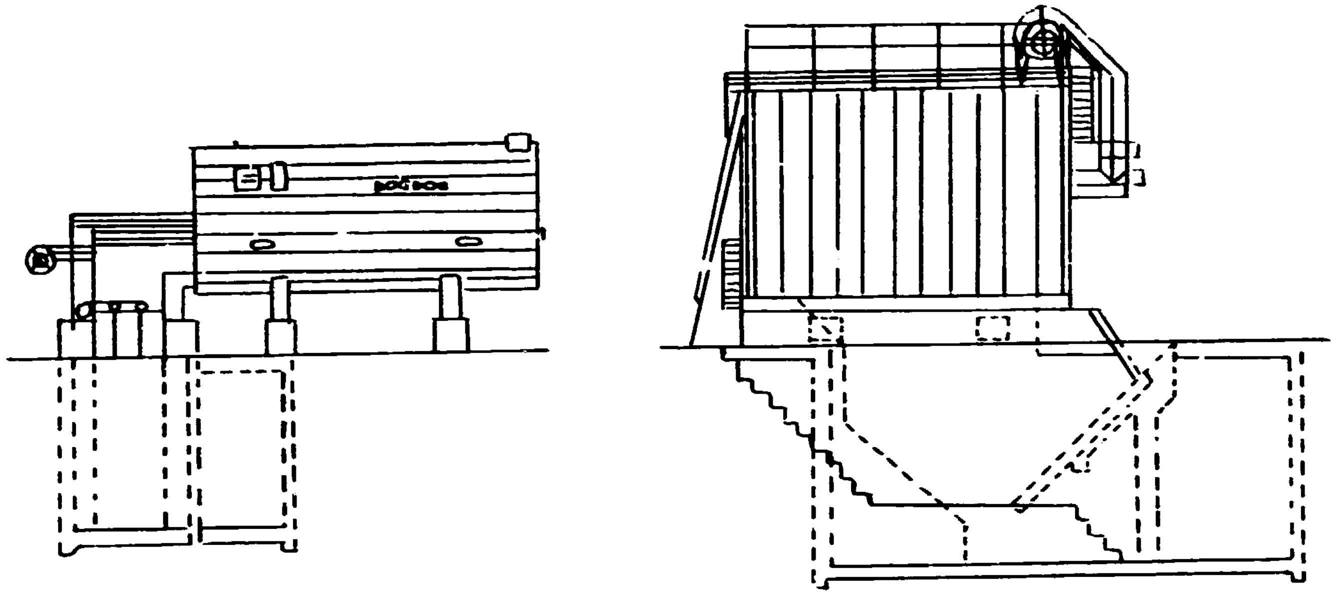


Fig. 14: Construction details of a smoke-tube boiler

3.3 Distribution

Distribution systems differ remarkably depending on the type of fluid used for carrying energy.

In the case of steam boilers, costs are higher due to the need of having bigger pipes and a material that can withstand mechanical and thermal stresses as well as corrosion which is more likely to occur during changes in the water phase. Special attention should also be given to studying pipe geometry to minimize localized head losses in order to avoid formation of condensate under pressure drop conditions.

Hydrostatic or hydrodynamic steam traps will anyway have to be envisaged to have the steam phase only within the pipe. A centrifugal or positive displacement pump supplies the energy necessary for conveying the mass. In this case, the pump is obviously placed on the return of water in the liquid phase.

The regulating system must ensure that the head necessary to the various machines, is transferred at the required temperature and must therefore interact with the combustion process. For this purpose, it first acts upon the water-steam balance in the boiler and then on the burner metering the fuel flow.

Pipe sizing is easier when the energy carrier is in a liquid phase (pressurized water or diathermal oil), although the system thus acquires greater inertia on the varying of working conditions.

In order to get an instant response of the plant to load changes, it is suggested to mix the fluid between the boiler's inlet and outlet with three or four-way valves.

Subsequently, the operation's efficiency can be further improved through precision regulation by acting upon the fuel entry into the boiler.

3.4 Utilization

A major distinction must be made between technological machines and factory facilities which have to be provided with thermal energy (heating, sanitary facilities, water, etc.) The two major woodworking plant units that need thermal energy are driers and presses.

Peeled and sliced veneer driers need to be supplied with large amnounts of steam whereas for lumber kiln drying thermal energy is often obtained through hot air that is produced by unit heaters.

Other sawn lumber kiln drying processes (condensation, vacuum) consume little energy given the efficiency of the thermo-dynamic cycle that determines the process parameters.

Hot presses that are used for production of wood based panels and their upgrading require an amount of heat which is proportional to:

- the weight of hot-pressing surfaces;
- the thermal capacity of the material they are made of;
- the maximum temperature reached.

For this utilization, the heating fluid can be steam, superheated water or diathermal oil. Diathermal oil has the advantage that it poses no problem of plate corrosion and does not need skilled personnel to operate the generator.

4. TECHNICAL AND ECONOMIC CRITERIA FOR ASSESSING PLANT PARTS

The major concern of a designer is minimizing production costs. To do so, in considering the extremely wide range of technical solutions, he will have to choose those solutions that will make it possibe to achieve the greatest cost-effectiveness in the production process.

The traditional approach to the study of the various solutions available is breaking down costs into capital and running costs. Capital costs relate to all preliminary activities that have to be performed in oder to set the operating unit going (design, construction, materials, manpower, machinery, etc.). Once the plant starts operating, its running costs will have to be assessed. There are two kinds of operating costs: fixed and variable costs.

The analysis of all these aspects makes it possible to determine the cost per unit of output which will serve as the basic parameter to be considered for making a highly competitive production plant. This criterion applies in the majority of cases and should also be adopted in selecting every single part of the plant. The following headings will describe the approach to the qualitative solutions of two problem based on the previously-mentioned concepts.

4.1 Pressure losses

The fluid circulation under pressure is provided by water power, thanks to a driving force which is usually a centrifugal or positive-displacement pump. This power determines the flow rate which has to be supplied to the various machines under a certain given pressure. The flow rate is determined by combining the area of the section through which the fluid flows with its speed. At this point, the major problem is minimizing the energy cost caused by pressure losses resulting from the friction along the pipe walls. In this case, capital cost is accounted for by the piping system and can be illustrated as in fig. 15.

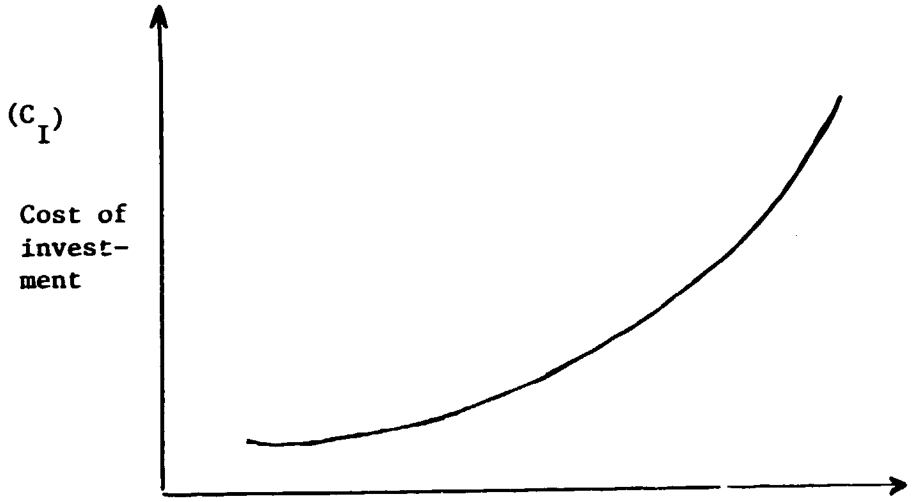


Fig. 15: Size of pipe or thickness of insulation capital cost of piping system.

Indeed, the larger the diameter, the higher the costs, since the material weight will be heavier per unit length and parts will have to be bigger in size (valves, pipe fittings, flanges, etc.). Conversely, the speed necessary to deliver the required flow rate increases with smaller pipe diameters and, thus, smaller flowing areas. Since the upward trend of pressure losses is a function of speed, the operating cost trend involved in recovering the lost power can be illustrated as in fig. 16.

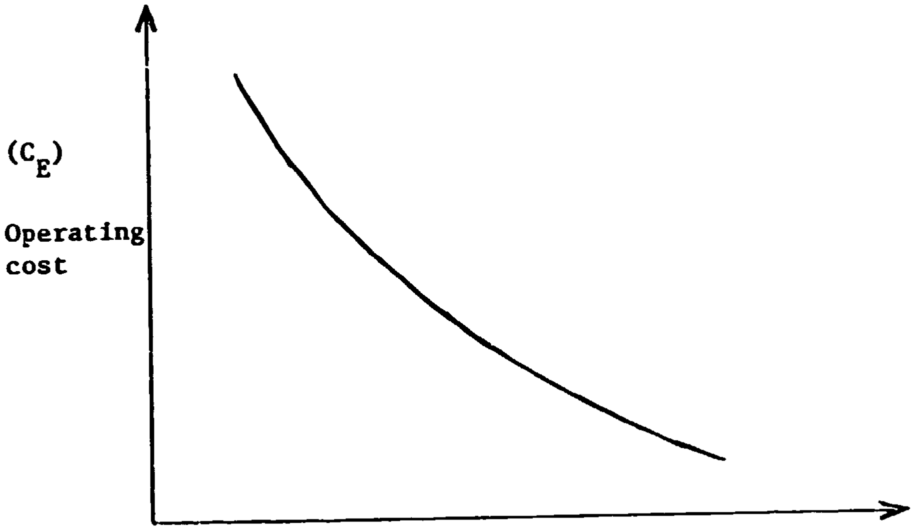


Fig. 16: Operating costs of a pipe system

Once again, the plant's overall cost will result from the combination between capital and/or operationg costs and its relevant curve can be seen in fig. 17.

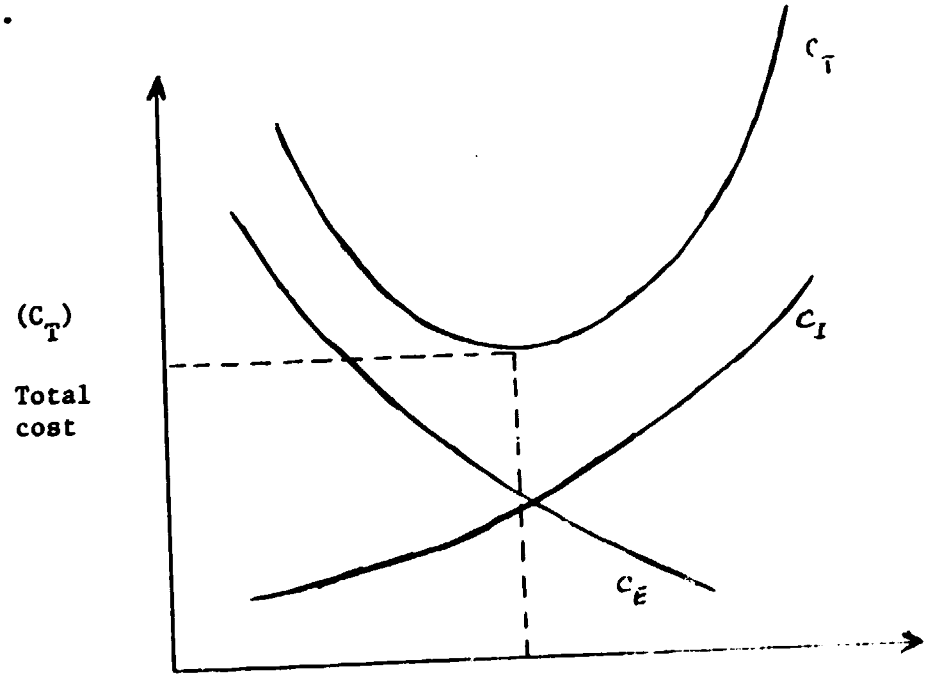


Fig. 17: Operating costs

4.2 Heat loss

Let us now consider the case of a piping containing the heating fluid of a press surface. During the shift from the heat generator to the machines, a certain amount of heat is transmitted outside the piping system and is therefore lost. This amount of heat has to be made up by the thermal energy generator, in addition to the heat quantity actually needed. As a result, heat losses have to be minimized so as to curb the costs involved in extra energy requirements. This is achieved by coating the fluid pipe with low thermal conductivity insulating material. Fig. 15 shows the cost trend of insulation which rises as thermal insultation thicknesses increase. This virtually accounts for the capital cost. Conversely, operating costs that are further compounded by heat losses to the surrounding environment, rise with the decrease of insulation thicknesses, as can be seen from fig. 16. The sum of the resulting curves provides the overall investment cost as shown in fig. 17. The optimum thickness value can be read at the curve minimum. The same approach of these two cases will have to be applied in solving any other technical problem, always with a view to achieving the highest management cost-effectiveness so as to get the desired product at the least cost.