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

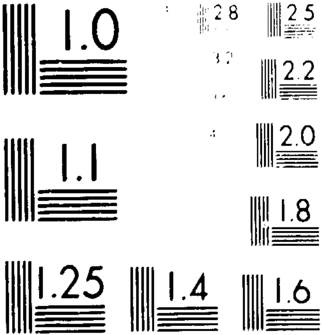
FAIR USE POLICY

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



MICROCOPY RESOLUTION TEST CHART

12867

Distr.
LIMITED

ID/WG.369/10
7 September 1983

ENGLISH

United Nations Industrial Development Organization

Technical Course on Criteria for the
Selection of Woodworking Machines

Milan, Italy, 10 - 26 May 1982

RATES OF RETURN ON INVESTMENT AS A BASIS FOR THE ECONOMIC CHOICE OF MACHINES IN THE FIELD OF WOOD PROCESSING MANUFACTURING. *

by

B. Zarnetti **

* 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 was reproduced without formal editing.

** Engineer, Studio BIS, Milan, Italy.

V.83-61644

TABLE OF CONTENTS

INTRODUCTION

An industry, of whatever sector, puts the goods it produces with the coordinated and efficient use of its resources (materials, manpower, machines, plant, capital) on to the free market.
(see **figure no. 1**)

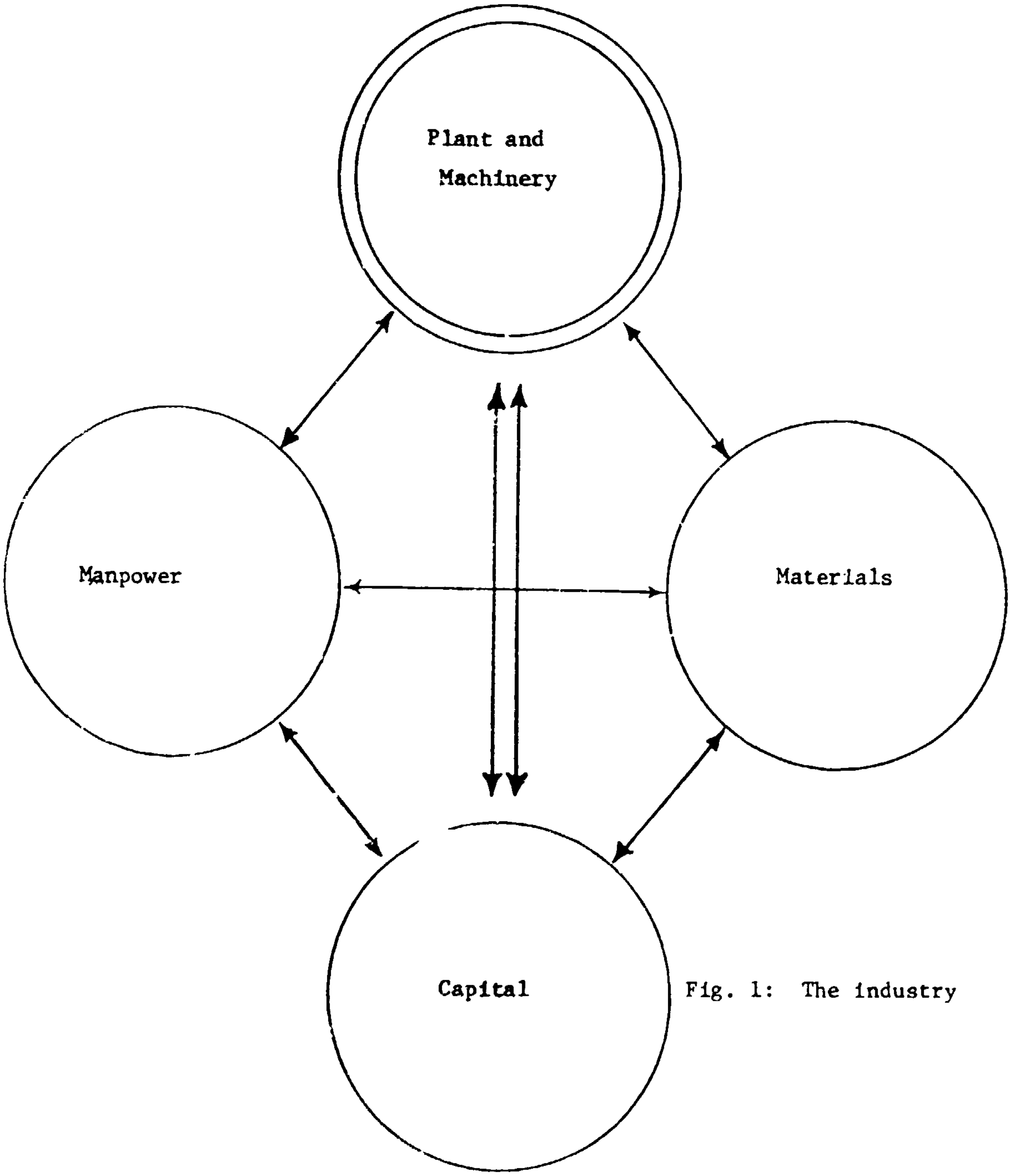


Fig. 1: The industry

The industry is viable and produces at profit if it manages to optimize the use of each of the factors just indicated. The raw material must be purchased at the best market conditions; it must be of a quality corresponding to expectations; it must not generate excessive scrap or waste; it must not be used in excess with respect to the function of the finished product, and it must not lead to unduly high stock levels which cost a lot to maintain. The second factor of industrial production, manpower, contributes to the accomplishment of the entire business cycle: we thus include the blue-collar staff, the department heads, the sales staff, the top management and the owners; all manpower has a cost, a level of efficiency, and a direct influence on the profitability of a business. We then have the machines and the plant, indispensable and decisive in every industrial activity: their shrewd selection, a good level of utilization, their maintenance at a good degree of functionality, are essential factors in every industry. Lastly we find the capital which must finance the industrial process (how it is secured, what rates are paid, how funds are divided between own capital and capital of third parties) is an essential facet in the life of a business.

We have thus put into perspective the place which plant and machines hold in the organization of industry. Clearly, in our albeit simplified outline, we must add that there is an intermingling of extremely strong correlations between all the factors we have indicated.

The mutual relations have, moreover, extremely different consequences depending on the type of business and on the country where it is located.

This paper will not analyse the choice of machines in relation to materials, nor in relation to manpower. Other papers report on the best plant for cutting, on production lines for panels, on sawmills, on machinery for the furniture industry or for doors, windows and their frame. They indicate the criteria of choice in relation to the availability and quality of raw materials or to the availability and cost of blue-collar staff.

Here we shall mainly give evidence of the relations existing between plant and machines on the one hand, and capital on the other: in this sense we are speaking of the rates of return on investment.

It would also be advisable to make a detailed study of the basic criteria for the finding of capital, on account of the strong influence which these choices have upon the evaluation of the rates of return on investments. There is, however, not sufficient time to analyse all the ways and means by which capital can be found: underwriting by shareholders, bond loans, loans at facilitated rates normally set up by governments, medium-term loans to be found on the market of the financial institutions, short-term credit obtainable from banks.

We have focussed on the subject in the following way: After an examination of general types, we shall give specific examples in the sector of machines of the processing and manufacturing of wood. However, we must state that all the concepts which will be expressed hereinafter are absolutely general and, as such, are not specifically related to the sector of wood processing machines. Indeed, we would like to point out that the universal nature of the subject must involve all industries, including those businesses which produce wood processing machines. They have fixed assets and must calculate their investments in machines and equipment in full compliance with the economic rules.

Only incidentally do we refer to a recent very detailed economic study on the sector of machines for wood. It is observed in the study that this sector is characterized by a lower intensity of fixed capital compared to the wider group of mechanical industries and also compared to the collateral sector of the producers of machine tools. There is, therefore, space and opportunity for valid investments by the manufacturers of woodworking machines and the criteria of choice of investments, the subject of this paper, is thus important for them. If we then observe that the manufacturers of woodworking machines have an asset structure which permits good development rates of the business without serious worries in terms of finding financing, we realize that for them the criteria of a good choice of fixed assets from the rates of return point of view prevails.

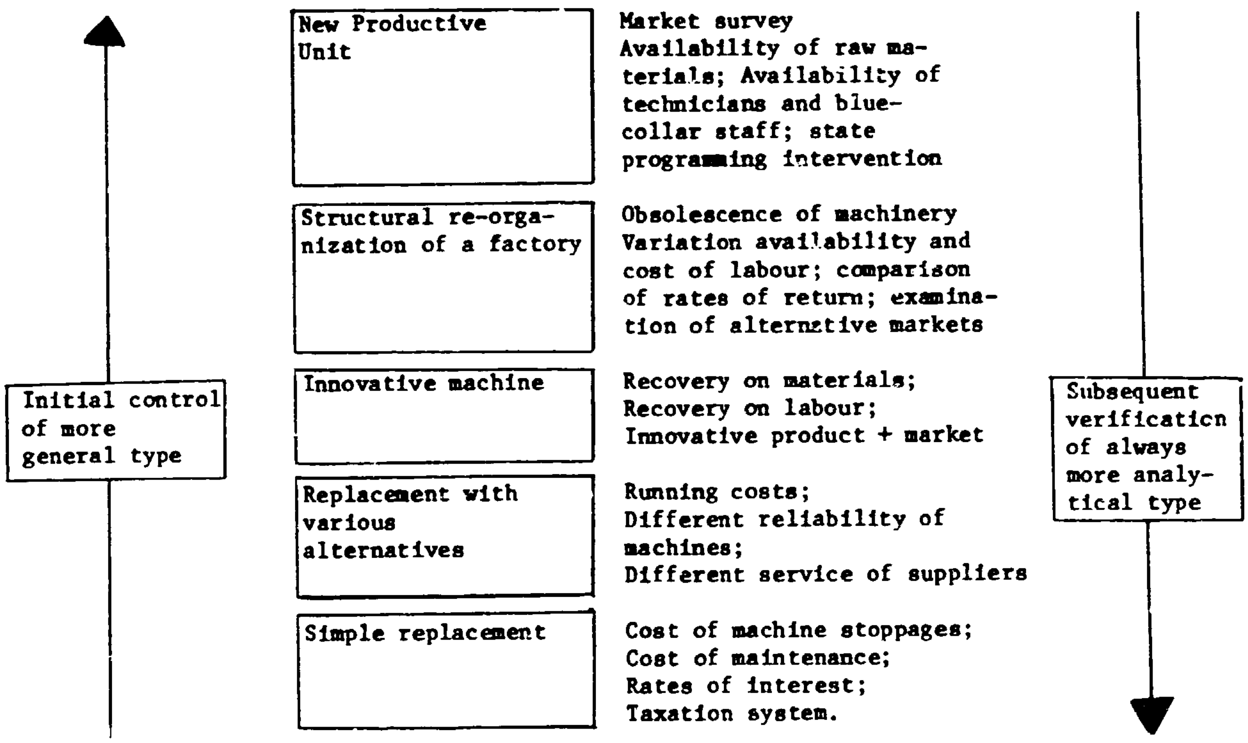
This study, prepared for those who purchase wood processing machines, is therefore also valid and very important for those who produce such machines. We are certain that this is a favourable occasion, since it enlarges the basis of whoever is interested and can appreciate our work.

WHICH ARE THE INVESTMENTS

Before starting to cover the criteria, the formulae and the examples with which an investment is evaluated, it is necessary to define it.

A fixed asset can be outlined in terms of machinery and plant, depending on the purpose thereof (see chart hereunder).

What are the investments



The opening of a new production unit, of a factory to produce planks, involves significant investments of capital, the construction of sheds, the installation of a sophisticated plant, the purchase of many machines.

At a lower level, let us consider the hypothesis of a factory being restructured, for example, in order to renew, update and considerably increase the production, and to convert the business to diversified products.

On a still lower plane we find the investment in an innovative machine, which replaces a previous type of manufacture, leads to economies on account of saving on materials and on labour. To give an example, we would mention a flanging-machine, which makes it possible to enhance less valuable materials, with excellent results in terms of appearance and quality.

A further investment which is part of a detailed economic analysis is the replacement of a worn-out or out-of-date piece of equipment, when the alternative lies between various non-homogeneous machines differing in cost, with different performances, not producing the same quantities.

The simplest case we are examining, finally, is the replacement of a worn-out machine.

Under such circumstances, it is solely a matter of deciding whether to replace the equipment part immediately, or to continue incurring high maintenance costs and postponing the investment of capital.

The classification we have just given is not a strict one and could also be modified thus including some types of fixed assets which we have perhaps neglected.

On the other hand, for all the above-mentioned, evaluating the rates of return on investment is important: the general mathematical formula is the same, although, in some cases, the application differs.

But before explaining the mathematical formula which compares an "initial investment" with a continuous flow of "revenue" and of "costs", we wish to point out that, in the various cases indicated, the types of costs and of revenue may be different. Even greater differences may exist in the matter by which we shall evaluate the extent of these monetary flows.

In the hypothesis of a new industrial unit, it is indispensible to have a good knowledge of the outlet market of the finished product, an analysis of the absorption in the regions or in the nations in which the unit is to be construction and a survey on the import and export flows. Just as important are the easy availability of raw material, the availability of local labour and their relative costs and the possibility of finding qualified technicians to run the business. And not least, the level and type of government support for the type of activity in question are decisive. On the basis of this input, cost evaluation of all the production factors (materials, manpower, capital, machines) may be made, the yield for every unit produced, and of the output which can be sold. If all the analyses are well conducted, it is possible to foresee the trends in future years of the various parameters, without falling into serious errors of evaluation.

In case of a structural reorganization of a factory, other variables must be considered: the obsolescence of the machinery, the availability and cost of labour compared with its worth at the time the factory was founded, the changed conditions of the raw material and finished product markets, the availability of innovative methods of work and machines. In this case, a comparison of the rates of return must be made between the factory still to be restructured and the modified production unit. If we wish to evaluate the advisability of investing in a machine which modifies a specific operation considerably, it is necessary to estimate a priori the economy which can be obtained on materials and labour, but it is also necessary to identify to what extent the quality of the finished product is thus improved and how this variation is reflected by the selling price and the quantities which can be sold.

If the replacement of an item of equipment, once it has reached the ultimate limit of utilization, provides for an alternative between new machines having different features, it is necessary to evaluate the different running costs for each machine; and also to consider insert into the calculation the reliability and the service rendered by the suppliers for example during the start-up, in terms of technical assistance service, in terms of availability and cost of spare parts.

The simple replacement of a worn out machine with a similar one involves an apparently simpler research into the cost of machine stoppages and of maintenance interventions, an evaluation of the rates of interest, the influence of the taxation system on the taxable business profits.

We would like to point out that the outline we have used for the various classes of investment is purely formal. In effect all the controls we have mentioned must "always" be made for all investments.

If we take the last example, the simple replacement of a machine, we must make all the verifications foreseen also for the investments of a higher class. These controls may be performed synthetically, but they must absolutely not be forgotten. We must, that is, check the reliability of the machine, any possible necessity of innovation of the product, the trend of the overall market.

All the examinations are necessary, which are normally made when a new and entire production unit is studied. Let us take the simple case of a door and window frame business which must replace one of the three installed tenoning machines; and assume that the door and window frame market is undergoing strong development or, instead, is beset by serious crisis. It is clear that the tenoning machine cannot be replaced with another of the same kind: in the first case a machine with a greater production capacity must be examined, in the second, an attempt will be made to work with the two installed machines. This example, even if banal, leads us to understand that the viewpoint cannot be restricted in a situation of detail. All the conditions in the factory must be taken into consideration when considering new investments.

Let us next consider that a new production unit has to be set-up. In a first general analysis a certain need for machines must be assumed and the machines would have to be chosen on the basis of general criteria. But then, once it has been decided to implement the new factory, every machine must be studied in detail. In some cases, it will be necessary to verify the advantage of an innovative machine for a certain operation, as an alternative to other traditional machines. In other cases a comparison of similar machines will have to be made on the basis of their reliability and of the services offered by the suppliers.

THE CASH FLOW TREND

Whether a new production unit has to be installed or a machine replaced the principle is always the following: an investment of capital which produces an income (or a saving on costs) for a long period of time is made on a short term basis. The fixed asset has a useful life, at the end of which it is sold at a recovery value (frequently very low). If we outline on a graph the progressive monetary outgoings and incomings, in relation to time (that is cash flow), we always find a curve like the one represented in fig.2 below. We can identify a phase A, of reduced monetary outgoings (for example the payment for the project), a phase B during which there is a rapid and concentrated outgoing for the purchase of machines and of the plant, a phase C representing the start-up of the new production with very limited incomings, a phase D in which there are constant incomings corresponding to the maximum income, a phase E during which they gradually decrease (even if they remain very high) by effect of the wear and tear of the plant and of the various external conditions (increase in cost of labour, increased competition, etc.) and finally, upon termination of the useful life of the fixed asset, an incoming for the sale of the machine and of the plant. With an initial investment equal to I, the initiative has led to the total recovery of the initial cost and has provided an income equal to G(0).

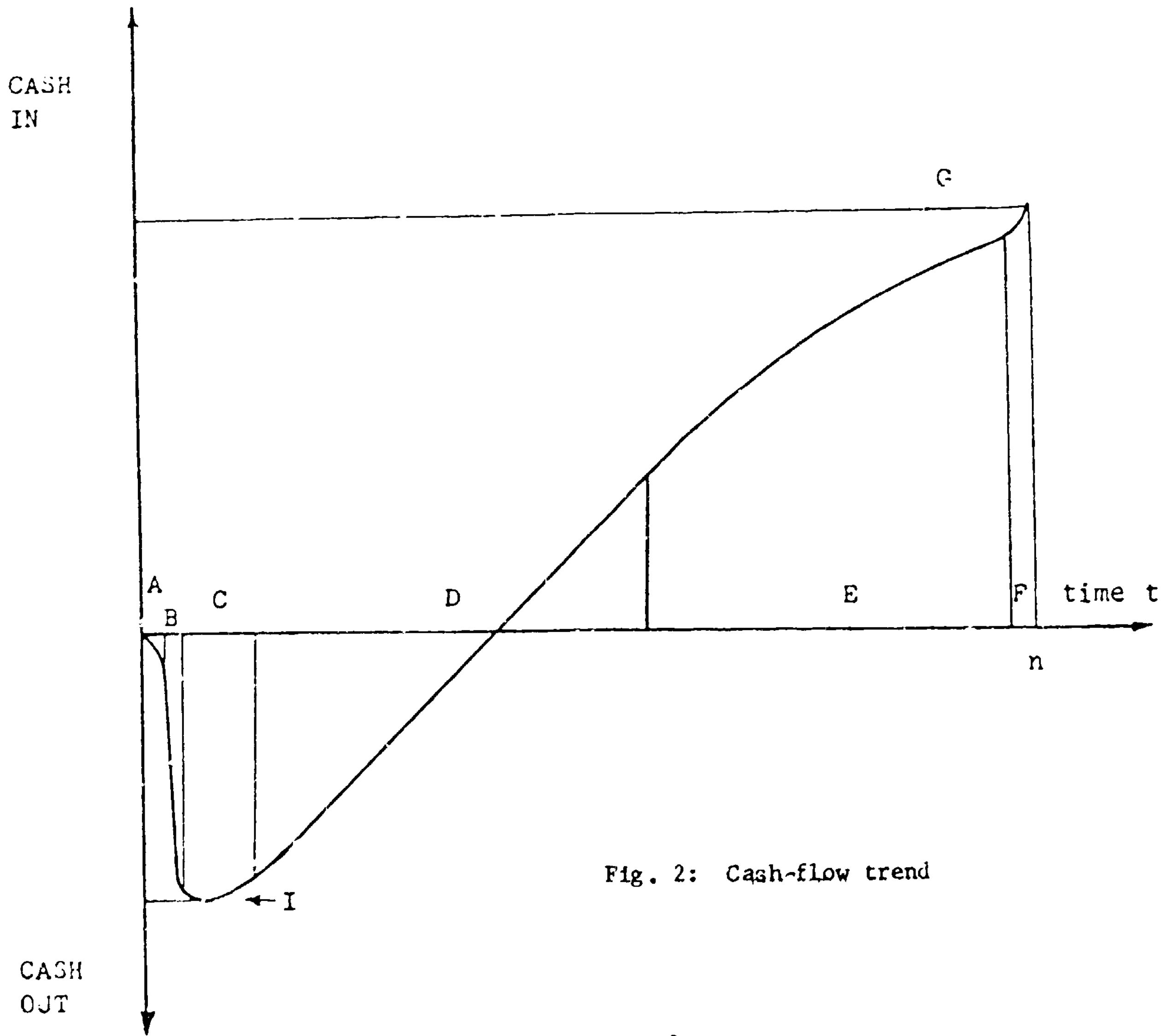


Fig. 2: Cash-flow trend

$$G(i,n) = - I - \int_0^n c(t)\,(1+i)^{-t}\,dt + \int_0^n p(t)\,(1+i)^{-t}\,dt + V_f\,(1+i)^{-n}$$

One should then evaluate the advisability of the investment in economic terms. At this point, it is necessary to insert the concepts of interest and devaluation: if today I lend someone \$ 100 and in a year he repays me \$ 110, I have apparently earned \$ 10. But, if in the course of a year, the cost of living increases by 10 percent, when I get back the \$ 110, I can purchase with this sum exactly the same goods that I would purchase today with the \$ 100 I had lent. This means that I have earned nothing.

In other words, if I bring my cash flow up-to-date with values all referred to the year in course, I will have an outgoing of \$ 100 and an incoming of \$ $\frac{110}{1+i}$. If the interest i = 10 percent, I therefore have an Updated Economic Result

$$G = - 100\$ + \frac{110}{1 + 0.10} \$ = 0$$

It is not the case to dwell now on long mathematical considerations. It is sufficient to say that the general formula of the Updated Economic Result of every investment is set forth in the lower part of diagramme no. 3 above and is based on the indices defined hereunder.

- i = annual rate of interest
- t = time function
- n = useful duration
- I = overall investment, in this formula considered instantaneous, that is with a duration of phases A and B equal to zero.
- c(t) = variable running costs in the period 0 to n
- p(t) = variable gross revenue in the period 0 to n
- V_f = value of recovery of the investment sold at moment n
- G(i,n) = updated economic result: function of the rate of interest i and of the useful life n.

If we check what takes place in our graph, we see that by outlining an instantaneous investment I, the curve changes in the AeB zone in a line descending perpendicularly, whilst with introduction of the updating coefficient $(1+i)^E$ an even more accentuated lowering of the curve takes place, since the cash incomings further forward in time are influenced more negatively by inflation.

Unfortunately, the mathematical formula, even though exact, and the graph, even if very explicit, do not permit easy calculation of the updated economic result.

In fact, the problem is to "foresee" the trend of the costs and of the gross revenue over time and this is all the more difficult and uncertain, the greater the duration n for which it is necessary to make forecasts.

The difficulty is then to express the trend of the parameters over time by means of mathematical formulae and to proceed, finally, with the calculation.

The difficult forecast of the future and the absence of general rules for the trend of costs and revenue over time would not, at this point, make it possible to go further in the solution to the problem. And in fact we must not be surprised if we encounter many engineers actively engaged in the analysis of investments: experience, instructions and knowledge of the machines and plant enable them to identify, in the various cases, the rules to be applied for evaluating the advisability of an investment.

Ample literature has thus ensued and many parameters have been identified and defined; these are adopted in individual cases of investment in order to judge the benefits thereof.

THE FORMULAE FOR THE CALCULATION OF THE RATES OF RETURN ON INVESTMENT

Many simplified formulae arise out of the general mathematical expression illustrated above for the evaluation of advisability. It seems worthwhile to indicate hereunder the different expressions, followed for specific cases of investment. Upon completion, we shall set forth two concrete examples, applying the formulae indicated. We consider that, in this manner, we can demonstrate in practice how the calculations must be set up.

We would start by saying that the search for simplified formulae presupposes knowledge of the various parameters. In some cases, for example, and especially in the past when the value of money was relatively stable, there was a tendency to neglect the test of devaluation "i" and the values were therefore not updated. Another simplification frequently used is to calculate the difference between revenues and costs and even the sole improvement in revenue between two different solutions (for example calculations are made of the savings generated by a new machine as compared with manual processing); mathematics show that this procedure is permissible, if given rules are complied with. Again for the purpose of facilitating the calculations, a consistent trend in revenue is assumed, with constant savings for all the years of life of the investment. A notable simplification, finally, is adopted by dividing the useful life into homogeneous periods, for example into years, and by considering that the monetary incomings take place at the end of every financial year.

Having said this, let us pass on to analysing Fig.3 which shows, with a double line, the trend of the cash flow in the previous simplified hypothesis. Let us suppose that the investment is made for one of the following reasons:

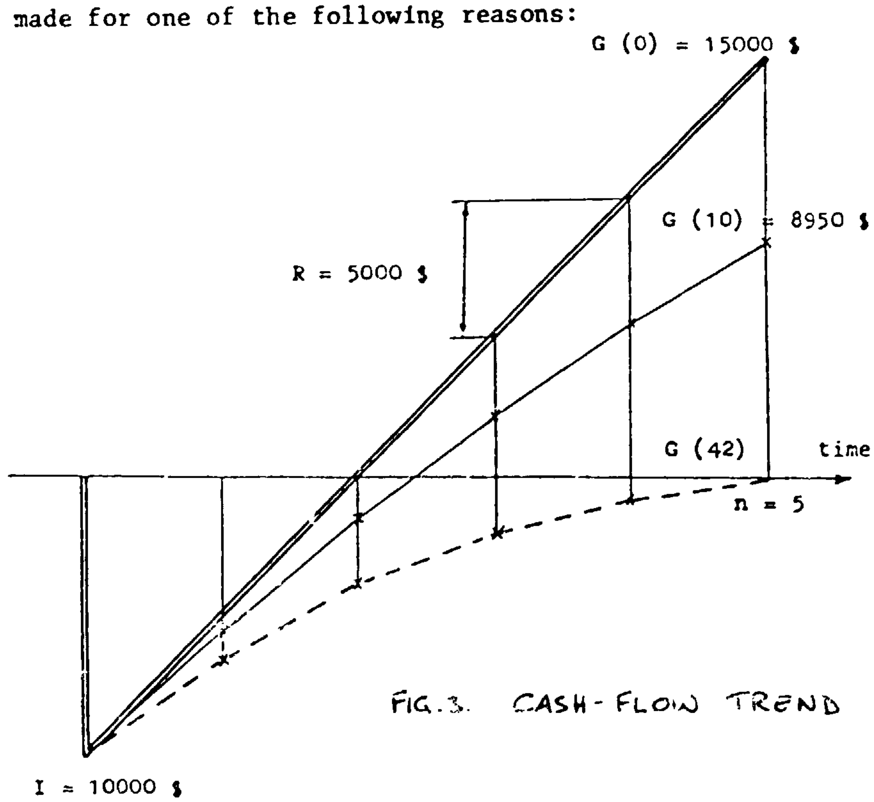


FIG.3. CASH-FLOW TREND

- purchase of a truck at the price of $ 10.000 for the transport of logs to the port, which makes it possible to save the railway tariffs for a much longer transport; let us suppose that this saving, less the cost for the use of the truck, is equal to $ 5.000 per annum; let us again suppose that the truck has a useful life of five years;

- purchase of a machine having a value of $ 10.000 for the recovery of the veneer from the rounding-off operations, with a consequent greater production of plywood for a value of $ 5.000 per annum; this example is not very precise because the plant in question has a useful life of much more than five years; it is sufficient though to change the abscissa of the timing and to repeat the calculation in the event of a longer lifetime.

At the end of the five years, the earnings, considering an interest of zero, are $ 15.000.

The main indices which are analysed in the evaluation of the investments are the following:

a) the recovery (pay-back) period;
b) the rates of return on investment, per annum and not updated;
c) the current value or updated economic result;
d) the index of benefit;
e) the discounted cash flow, per annum, not updated;
f) the equivalent cost per annum.

The Recovery Period (pay-back) is used a great deal especially for short-term investments and usually with a high rate of return and does not take the rate of interest into account. It is expressed by the formula:

$$P_r = \frac{I}{R} = \frac{10000}{5000} = 2$$

and expresses the time in which the invested capital is paid back. In our example, the recovery period is of two years and is identified on the graph with the intersection of the double line with the axis of the abscissa.

The Rates of Return on Investment, Per Annum and not Updated are calculated by the formula:

$$T = \frac{n R - I}{n I} = \frac{G(0)}{n I} = \frac{5 \times 5000 - 10000}{5 \times 10000} = 30\ \%$$

and expresses in a simple manner and without taking the interest into account, the rates of return on the investment. If, upon termination of the life of the investment, I have earned \$ 15.000, I can say that I have earned \$ 3.000 per annum having initially invested \$ 10.000. I have therefore had a rate of return of 30 percent.

The current value or Updated Economic Result takes the interest into consideration. As we have already indicated, we update the future incomings taking into account a rate which, in the example, has been set at 10 percent (logically per annum, and we are thus speaking of compound interest). In diagram no. 4 above we have indicated with a continuous dotted line the trend of the updated revenue. The formula is the following:

$$G\ (10.5) = R\ (P/A\ 10.5) - I = 5000 \times 3.79 - 10000 = 8950.$$

In this formula the coefficient

$$(P/A\ 10.5) = 3.79$$

represents the current value, at compound interest, of a temporary revenue at constant deferred instalments of the value of \$ 1 and can be found in the tables of actuarial mathematics.

We must observe that we are basing ourselves on the arbitrary presupposition that the rate is equal to 10 percent and the total earning equal to \$ 8.950 is thus determined. In the diagram the value G (10.5) is clearly indicated on the right of the graph.

The Index of Benefit is calculated starting, as in the previous case, from a pre-set value of the rate. The formula is the following:

$$\varphi = \frac{R\ (P/A\ 10.5)}{I} = \frac{5000 \times 3.79}{10.000} = 1.895$$

and expresses in updated value how many times the investment is paid back during the entire life of the plant.

Like the previous index, this one is based on a rate pre-set in an arbitrary measure and therefore gives a conditioned indication of the actual rate of return on investment. It is only worthwhile mentioning the fact that the formulae have been expressed in the case of constant incoming cash flows for the various years. Other formulae, which lead to the same result but are more complicated, are valid in the case of different incomings for the various financial years.

We have indicated the existence of two indices fixed on the basis of a pre-set rate. By analogy the indices examined previously in the case are of a rate equal to zero, others are determined in the hypothesis of a pre-set rate. It is worthwhile mentioning only the pay-back period which is identified on the graph where the continuous dotted curve intersects the axis. It should be noted, in particular, that, with a rate of 10 percent, such a period is 2.5 instead of two years.

The discounted Cash Flow, per Annum, Updated (discounted cash flow method) involves us in rather more complicated consideration. We have seen that, when we consider the interest equal to zero, the earning on the investment is equal to \$ 15.000. With the rate of 10 percent, the earning is reduced to \$ 8.950, because the curve of diagram no. 4 has gone down. If we now suppose that we have a rate of 15 percent, the curve will go even further down; this is clear. There will therefore be a rate for which my earning is nil: that is at the end of the five years I simply recover the capital invested. This curve is indicated in the diagram already mentioned with a dotted line.

The index normally known as IRR (Internal Rate of Return) is expressed by i^^ and is calculated with the following formula:

$$G\ (i^{**}5) = 0$$

$$R\ (P/A\ i^{**}5) - I = 0$$

$$(P/A\ i^{**}5) = \frac{I}{R} = 2$$

On the already mentioned tables of interest I can easily find that this interest is equal to: $i^{**} = 42$ percent. We must dwell on this criteria of calculation, because it is widely used in the evaluation of investments and represents, in our opinion, the most appropriate methodology.

The IRR cannot be likened to the indices examined previously.

According to a mathematical demonstration which is too long to present, the incoming cash flow of each year can be divided into two quotas, a part for the reimbursement of the capital and the remainder to pay the interest i^{**} for one year on the capital "which is still to be repaid". For this reason the index IRR = 42 percent is higher than the non-updated rate T = 30 percent illustrated above. It is important now to understand how the in terest i^{**} must be evaluated. A new index is introduced, MARR (Minimum Attractive Rate of Return).

The MARR can be defined as the rate at which an enterprise is interested in investing, since it has other possibilities of producing this return.

The MARR must not be confused, as often happens, with the cost of the capital which the enterprise receives from the share-holders and from banks. the MARR must be substantially higher than the average weighted rate from the sources of business financing, because it is not advisable to invest in projects which result in an earning equal to the cost of the capital by reason of the risk elements present in many projects and on account of the uncertainty of the future.

If, therefore, a business sets a MARR equal, for example, to 20 percent, it thus expresses its availability to invest in all initiatives which have an IRR > MARR. The capitals invested in the various initiatives will have a return cash flow as we have seen previously and can gradually again be invested in other activities, always with IRR > MARR.

At this point the validity of the system is evident. The investment is examined and calculated completely on the basis of the foreseeable cash flows without inserting external hypotheses on the rates; it is the IRR index which, in the end, is compared directly with the minimum attractive rate of return set by the business.

There remains only to set forth some specifications regarding the MARR. If, in a nation, inflation is low, for example at the level of 5 percent, the average rates payable by a business may be of the order of 8 percent and the MARR will be fixed at around 10 to 15 percent, but if, in another nation, inflation is for example of 20 percent, the business cannot but fix the MARR a. a level of 25 to 30 percent.

To give another example, if a business has average rates payable of 10 percent, it can fix the MARR at 15 percent; but if another business of the same country has mainly short-term financing and therefore pays rates of 15 percent, it cannot but fix the MARR at 20 percent.

We have taken a lot of trouble to illustrate the discounted cash flow system since we consider that it is undoubtedly better than others in the evaluation of a new investment. Some supplementary measures must be adopted when more than one alternative of investment exists, like for example the purchase of two similar machines, with different initial costs and annual returns.

In this long illustration of examples of formulae, we have not yet dealt with the Equivalent Cost per Annum system. The formula applied is the following:

$$CE = R - \frac{I}{(P/A\ 10.5)} = 5.000 - \frac{10000}{3.79} = \$\ 2.361$$

This is used in particular when various alternative solutions exist, with different useful lives of the fixed asset.

FIRST EXAMPLE: INNOVATIVE MACHINE: LIPPING MACHINE FOR DOORS:

Although we have sought to limit detailed study of the formulae and have done our best to render the illustration simple and interesting, the reader is certainly feeling bewildered and perhaps bored as well. On the other hand the hypotheses set forth up to now are too schematic and do not represent actual cases. We thus feel that it is advisable to give some more concrete examples which may better illustrate what we have described up to now. The reader can use the same methodology in order to make an independent calculation in the specific conditions of his business and for any other investment of interest to him.

Let us, therefore, examine a business which produces internal doors for housing in a quantity of 500 pieces/day; we imagine that these doors are of the veneered type, with the frame made of high-quality wood and the leaf of plywood veneered with the same kind of wood. The technical manager of the business, visiting INTERBIMALL has examined with interest the lipping machine of a certain manufacturer and has seen the possibility of adopting for the leaf frame a much more economical type of wood. The solution is made possible by the machine examined, which glues a wooden band along the whole of the rabbet of the door.

We refer to the chart on page 5. We are faced by the case of the "innovative machine". First of all a verification of the more general type is necessary, of which here is given only some results, in order to illustrate how to operate.

Knowing the market of his own industry, the technician estimates that the production of 500 doors per day is an advisable qantity and that it is not reasonable to expect increases in the sales or to examine machines with higher capacities. The most economical kind of wood is widely available and will undoubtedly remain at a competitive price for more than ten years. The functioning of the new machine can be ensured by the personnel of the business and the limited extra labour can easily be found by hiring more staff. Similar results are obtained with all the other checks, so that the technician is sure that there are no contra-indications to the purchase of the chosen machine.

The machine is of the type illustrated in figure 4 with the sole difference that it operated on only one side and this is amply sufficient for the production of 500 pieces per day. The operations performed by the lipping machine are illustrated in figure 5 very clearly.

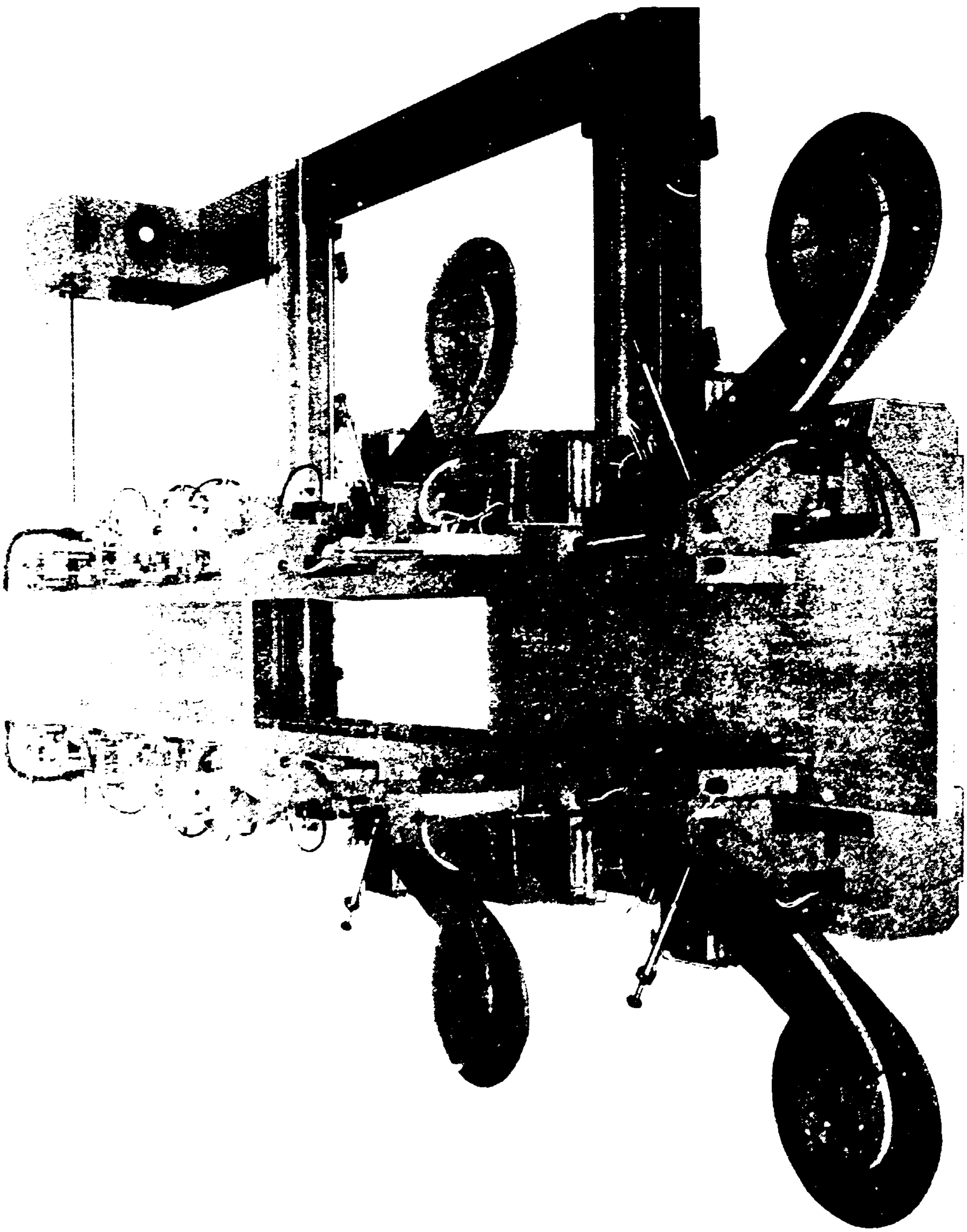
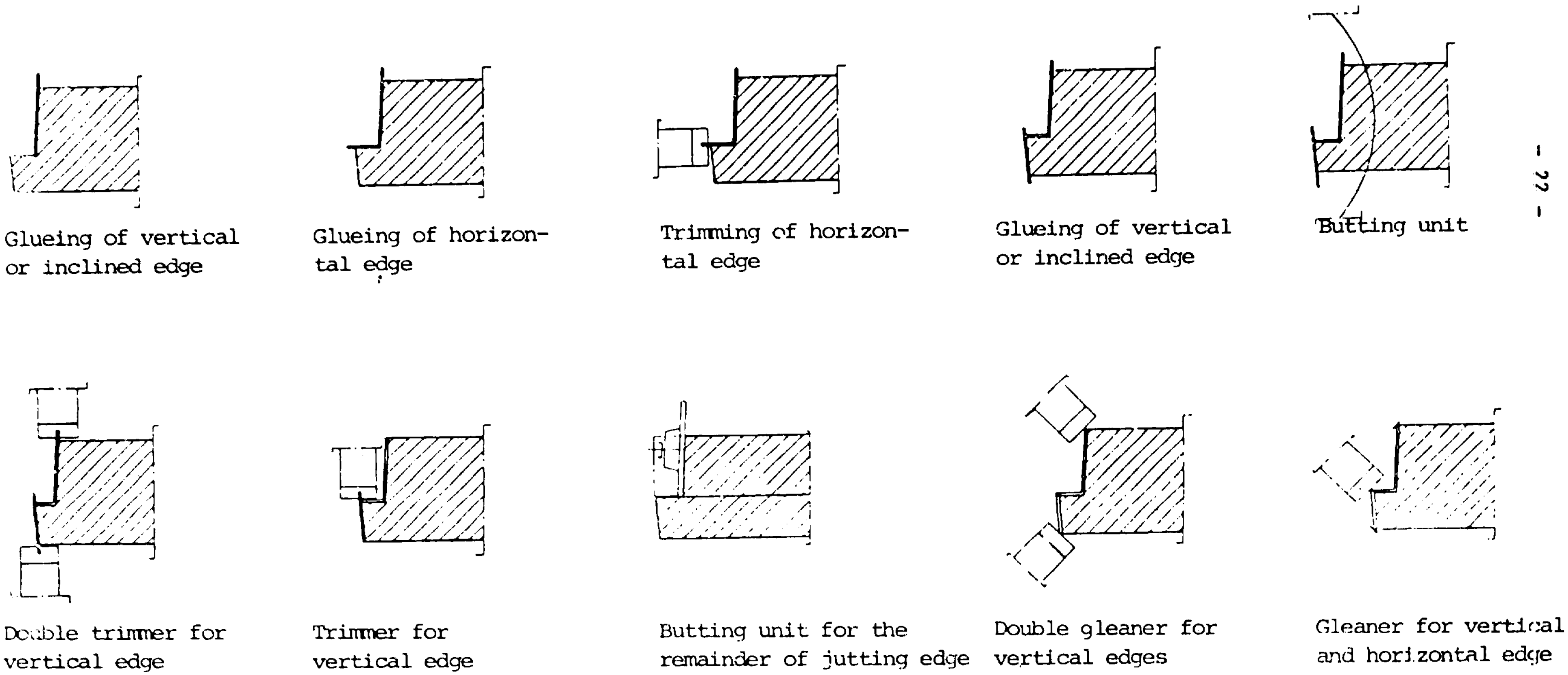


Fig.4: LIPPING MACHINE FOR DOORS

FIG.5: MANUFACTURING CYCLE



It is now necessary to evaluate the economic benefits of the investment and, for this purpose, the technician must select all the cost elements which are necessary. Here we have renewed the examination of the "economic components" already illustrated by Ing. della Torre in his paper (ID/WG.369/ 3) and we are adapting them to this particular concrete case.

In table 1, we find the values and the information necessary for the evaluation of the fixed asset. The table is very detailed and does not require further explanations. Thevalues refer to 1982 and it is presumed that the machine enters into operation on 1 January 1983.

Table 1:

CALCULATION OF CAPITAL INVESTED AND OF RELATED VALUES

Machine		Lipping machine (one side only)
Theoretical production of machine		800 doors/day
Production assured by the machine to the business		500 doors/day
Purchase value FOB (value indicated)		$ 40,000
Transport-Insurance-Taxes	27%	$ 10,800
Complementary equipment	not relevant	--
Base, link-up, power, etc.	not relevant	--
Start-up and testing Staff training	8%	$ 3,200
Commercial value of area occupied for new manufacture	12.5 m² x $80/m²	$ 1,000
		$ 55,000
Useful life of machine		8 years
Remaining value at end of life		$ 8,000
Fiscal depreciations		8 years
Accelerated fiscal depreciations		5 years
Depreciations desired by business		5 years
Initial purchase of tools and spare parts for two years		$ 7,000

Note: the values are chosen in such a manner as to permit a typical example. They do not, therefore, necessarily represent reality and are not to be considered binding.

Indication is given of the economic values for all the years of expected utilization of the lipping machine in table 2.
It is useful to comment briefly on the hypotheses adopted in the simulation we have made:

The nation where the business under examination has its headquarters is an exporter of timber: for this reason the difference in value between a high-quality wood and an economical one is limited to $ 65 per cubic meter; in Europe such differences are much higher and always justify the purchase of the lipping machine since the rate of return is much greater;

All the values have been assumed for the total duration of the investment, simulating what the technician of the user business must do; the values increase over the years according to the medium-term plan set-up by the business; we see that on the basis of these calculations, it is foreseen that the cost of timber rises on average by 6 percent per annum, the cost of labour by 9 percent, motive power by 9 percent; these values give an idea of the inflation in force in the country examined;

The additional cost for labour is calculated as for three workers, thinking in terms of manual loading and unloading of the machine;

The cost of the non-recoverable scrap has been indicated for a general case; with the machine under examination, the scrap can always be reconditioned; the time for recovery is amply absorbed by the hypotheses already set forth;

The cost for maintenance includes the spare parts purchased at the start for approximately two years and which, correctly, have not been inserted into depreciation; in the subsequent years a progressive increase is foreseen for the costs of the spare parts, taking the ageing of the machine into account.

Table 2: VARIATION OF BUSINESS REVENUES AND OF COSTS RESULTANT UPON INVESTMENT

FINANCIAL YEAR		1983	1984	1985	1986	1987	1988	1989	1990	1991
Saving on price of timber	$/m^3	65	65	75	75	75	85	85	95	-
Timber consumed for framework	m^3/year	1700	=	=	=	=	=	=	=	-
SAVING	$	110500	110500	127500	127500	127500	144500	144500	161500	-
Cost of labour	$/h	3.0	3.4	3.8	4.0	4.4	4.8	5.1	5.7	-
Labour necessary for loading and unloading	h/year	5400	=	=	=	=	=	=	=	-
Cost of suppl. labour	$	16200	18400	20500	21600	23800	25900	27500	30800	-
Suppl.cost of spec.technician	$	900	1000	1100	1200	1300	1400	1500	1700	-
Cost of wood edging	$	54000	54000	60000	60000	65000	65000	73000	73000	-
Cost of glue and other materials consumed	$	4000	4200	4400	4800	5100	5300	5600	5900	-
Cost of residue not recovered					IRRELEVANT					
Cost of maintenance	$	7000	500	4400	4900	5500	6200	7000	8000	-
Cost of motive power	$	2300	2500	2700	3000	3300	3600	4000	4400	-
SUPPLEMENTARY COSTS	$	84400	80600	93100	95500	104000	107400	118600	123800	-

Note: the values are chosen in such a manner as to permit a typical example. They do not, therefore, necessarily represent reality and are not to be considered binding.

Table 3 indicates the incoming capital for all the years from 1983 up to the end of the useful life of the machine. It should be noted that the calculation of the taxes foresees that the greater earning determined by the machine is normally subject to taxation and that the relative tax is paid the subsequent year. It should also be noted that, although having assumed a limited saving on the cost of the timber, in the subsequent financial years the business has incoming capital which vary between $ 11.000 and 32.000. As we can see, it is very important to make a correct forecast of the revenue and costs and it is not possible, therefore, solely in order to simplify the calculations to consider that the incoming capital is constant.

Table 3: TREND OF INCOMING CAPITAL

	1983	1984	1985	1986	1987	1988	1989	1990	1991
Savings	110500	110500	127500	127500	127500	144500	144500	161500	-
Supplementary costs	(84400)	(80600)	(93100)	(95500)	(104000)	(107400)	(118600)	(123800)	-
Margins	26100	29900	34400	32000	23500	37100	25900	37700	-
Payment of taxes	-	(6050)	(7550)	(9350)	(8400)	(5000)	(14850)	(10350)	(15050)
Realization value	-	-	-	-	-	-	-	-	8000
INCOMING CAPITAL	26100	23850	26850	22650	15100	32100	11050	27350	(7050)
Margins	26100	29900	34400	32000	23500	37100	25900	37700	
Fiscal depreciations	(11000)	(11000)	(11000)	(11000)	(11000)	-	-	-	
Taxable profit	15100	18900	23400	21000	12500	37100	25900	37700	
Calculation of taxes (40%)	6050	7550	9350	8400	5000	14850	10350	15050	

We now pass to table 4. We realize that all the formulae indicated previously have little true relation to reality.

Table 4: Calculation of discounted cash-flow

YEARS	Flows of incoming capital	Pro-sess. incom-ings	Rate of 40%		Rate of 45%	
			Table	Updated value	Table	Updated value
1983	26100	26100	0.714	18635	0.690	18009
1984	23850	49950	0.510	12164	0.476	11353
1985	26850	76800	0.364	9773	0.328	8807
1986	22650		0.260	5889	0.226	5119
1987	15100		0.186	2809	0.156	2356
1988	32100		0.133	4269	0.108	3457
1989	11050		0.095	1050	0.074	818
1990	27350		0.068	1860	0.051	1395
1991	(7050)		0.048	(338)	0.035	(247)
TOTAL	178000			56111		51077

Calculation of rate by interpolation

$$\left.\begin{array}{l} 56111 - 55000 = 1111 \\ 55000 - 51077 = 3923 \end{array}\right\} IRR = i^* = 40 + \frac{1111}{1111+3923} \times 5 = 40 + 1.10 = 41,$$

$$\text{Pay-back period} = 2 \text{ years} + \frac{55000 - 49950}{26850} \times 12 = 2 \text{ years} + 2,3 \text{ months}$$

Table of coefficients $(1 + i)^{-n}$

The search for the internal rate of return IRR = $i^{\wedge\wedge}$, of such a nature as to reduce to zero the earning indicated in the following formula, is performed easily by attempts and by interpolations. The formula, taking non-constant annual quotas of recovery into account, is the following:

$$G\ (i^{\wedge\wedge}n) = 0$$

$$I = R_t\ (1 + i) - t + V_f\ (1 + i) - (n + 1)$$

According to the methodology illustrated, we obtain the following two parameters necessary for evaluation of the investment:

rate IRR = $i^{\wedge\wedge}$ = 41.1 percent

pay-back period = 2 years 3 months

Let us illustrate the significance of these values. If the business which is studying the investment has headquarters in a country with a rate of inflation of 6 to 9 percent and therefore established a MARR (Minimum Attractive Rate of Return) equal to 17 percent, it easily verifies the benefits of the purchase of the lipping machine, since 41.1 percent is very attractive. From the financial point of view, the pay-back period indicates that the monetary savings permit the return of the capital into the corporate coffers in the very reduced period of time of two years and three months. The investment is, therefore, undoubtedly extremely advisable.

SECOND EXAMPLE: NEW PRODUCTION UNIT: PLYWOOD FACTORY

Let us now examine another case. A business wishes to construct, in a timber-producing nation, a factory for the manufacture of plywood. (see fig. 6).

The project, on the basis of a detailed study by the purchaser which has surveyed all the local features, has been performed by an Italian engineering firm.

The factory illustrated in fig. 7 has been designed

Fig. 6: Plywood factory (reeling system and reel stores)

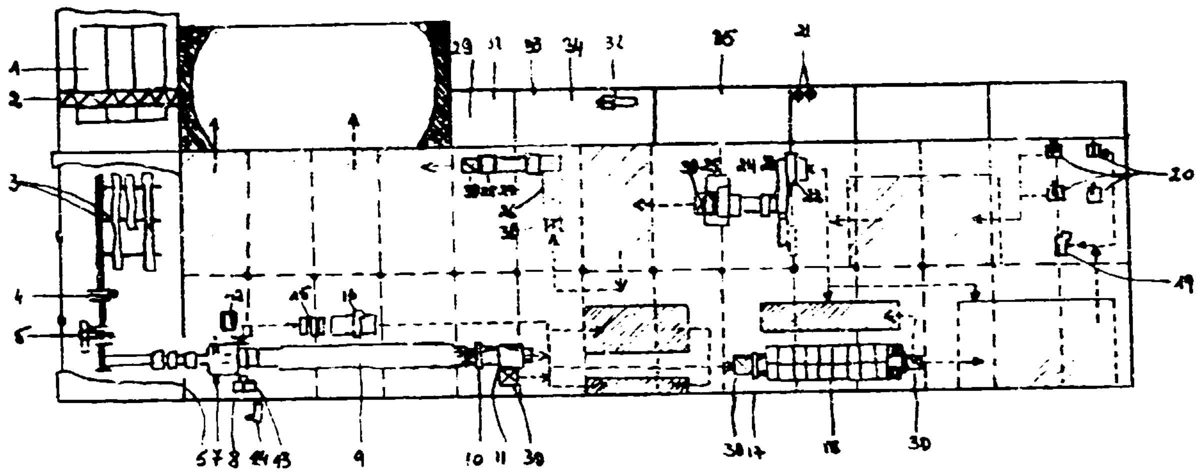


Fig. 7

1. Steaming bins
2. Electrical crane, 10 tons
3. Chain conveyor carpets for logs
4. Chain saw
5. Log debarker
6. Chain conveyors for charger
7. Automatic lathe charger
8. High efficiency telescopic veneer lathe
9. Tray deck system or reeling system and reel stores
10. High speed pneumatic clipper
11. Fully automatic veneer stacker
12. Core chain conveyor with pneumatic ejector
13. Waste belt conveyor
14. Waste veneer chipping machine
15. Device for recovery of roundings
16. Automatic clipper for recovery of roundings (option: Zig-zag tray is best)
17. Automatic veneer loader for dryer
18. Jet veneer dryer with cooler
19. Veneer jointer assembly
20. Veneer splicers - other systems possible
21. Glue mixers
22. Four cylinder glue spreader
23. Pre-press
24. Press loading and unloading devices
25. Hot press
26. Four side panel squaring unit with automatic transfer
27. Transfer conveyor
28. Wide belt sander
29. Suction plant for sizing and sander
30. Hydraulic hoisting platforms
31. Air compressor unit
32. Automatic precision knife grinder
33. Grinder for circular blade of squaring unit
34. Grinder for chain saw
35. Generating heating plant

//// Veneer and plywood storage

The characteristics of the production and the investments necessary, as indicated in table 5, are sufficiently explanatory.

TABLE 5; FACTORY FOR THE PRODUCTION OF PLYWOOD

GENERAL FEATURES

Kind of wood used	**Okoumé**
Covered surface	7,500 m^2
Timber processed	15,200 m^3 per annum
Plywood produced	8,000 m^3 per annum
Blue-collar staff employed	67 people
Team bosses and technical and administrative staff	8 people
Days worked	300 days per annum
Shifts	2 shifts
Year of reference	1982

INVESTMENTS NECESSARY

Plant and machinery FOB value 1/		$ 1,000,000
Transport, insurance and taxes	27%	$ 270,000
Base, link-up, etc.	5%	$ 50,000
Start-up and staff training	10%	$ 100,000
TOTAL VALUE OF PLANT		$ 1,420,000
Buildings	$80/$m^2$	$ 600,000
Operating capital	estimate	$ 500,000
TOTAL FINANCIAL REQUIREMENT		$ 2,520,000

1/ The value is actually higher and has only been rounded to $ 1.000.000 for ease of calculation.

Without dwelling on an illustration of the plant, a task to be performed by other technicians, and considering that the project is exact, let us see how the calculation of the rate of return is made. Against the investments indicated in the previous table, the business has a series of revenues and of costs, all identified on the basis of the market conditions, of the experience of the technicians, of the verification of a similar plant.

In particular, we observe that the plywood is of the high quality type for export and therefore has a high sellingprice; the cost of the personnel is very low, as occurs in some countries (in this example we have set a cost of $ 3.600 per annum, different from the case examined previously); the thermal power is mostly self produced form residues whilst a quota equal to 15 to 20 percent is obtained with other fuels; no calculation is made on taxes because we assume government exemption in order to facilitate investments.

As we can see from table 6, against annual sales for $ 3.400.000, we have costs for $ 2.032.000 and a gross margin of $ 1.368.000. By deducting the depreciations and the necessary interest on capital,we obtain the net profit.

TABLE 6: REVENUES AND COSTS

ITEM	Consumption (per m^3 of plywood)	Unit.prices ($)	Unit.values ($/m^3 plywood)	Amounts ($/annum)
Plywood sold 800 m^3/annum	1	$425/m^3	425	3,400,00
Timber	1.9 m^3/m^3 (yield 53%)	$ 75/m^3	142.5	1,140,00
Glue	100kg/m^3	$0.4/Kg	40.0	320,00
Electric power	150 KWh/m^3	$0.05/KWh	7.5	60,00
Fuel (estimate)	100Kg/m^3 x 15%		3.8	30,00
Tools	3% on imp.value		3.8	30,00
Maintenance	4% on imp.value		5.0	40,00
Total variable costs			202.6	1,620,00
Wages	20h/m^3	$ 12/dav		240,00
Technical and administrative staff	8 people	$4500/annum		36,00
Overheads and selling expenses				136,00
FIXED COSTS				412,00
TOTAL PRODUCTION COSTS				2,032,00
GROSS MARGIN				1,368,00
Depreciation				172,00
Interest only on loan				126,00
Net profit				1,070,00
Sales variable costs			222.4	
Fixed costs				710,00
Break-even point			3,192 m^3/annu	
% of capacity			40%	

The application of the classical formulae to evaluate the rate of return on investment does not, in this case, have much significance. In fact, by again taking the indices set forth previously, we arrive at the following values:

I = Initial investment	$ 2,520,000
R = Gross annual margin	$ 1,368,000
(P/A 10.15) = coefficient obtainable from the tables in the case of interest on capital at 10 percent and useful duration of the factory of 15 years	$ 7,606
$P_r = \frac{I}{R}$ = recovery period (payback)	1 year, 10 months
$T = \frac{n R - I}{nI}$ = rates of return on investment, per annum and not updated	51 %
G (10.15) = updated economic result considering i = 10 % and n = 15 years	$ 7,885,000
= index of advantageousness	4.13
IRR = i ^^= rate of return, updated and per annum	54 %
CE = equivalent annual recovery	$ 1,037,000

Apparently, the investment has an extremely high rate of return. It is necessary to recall that, at the start of our analysis, we said that the formulae used alter reality by introducing simplifying hypotheses. Diagramme no. 15 indicates, with a dotted line the simplified cash flow, on the basis of which the formulae are fixed. Especially for an investment in a very complex factory, the simplifications adopted previously are no longer acceptable. We refer, in particular, to the start-up period: the installation of the production units has a duration which, in reality, is of almost a year; upon completion of the factory, the maximum production is not reached at once, it being necessary to train the personnel, to set up the machines, to start up sales. We have assumed that this period lasts for approximately 1.5 years; finally after about eight years of activity of the factory, a lower rate of return must be expected on account of wear and tear and obsolescence of the plant; the curve of the cash flow which emerges from this hypothesis is indicated in fig. 8 by a continuous line.

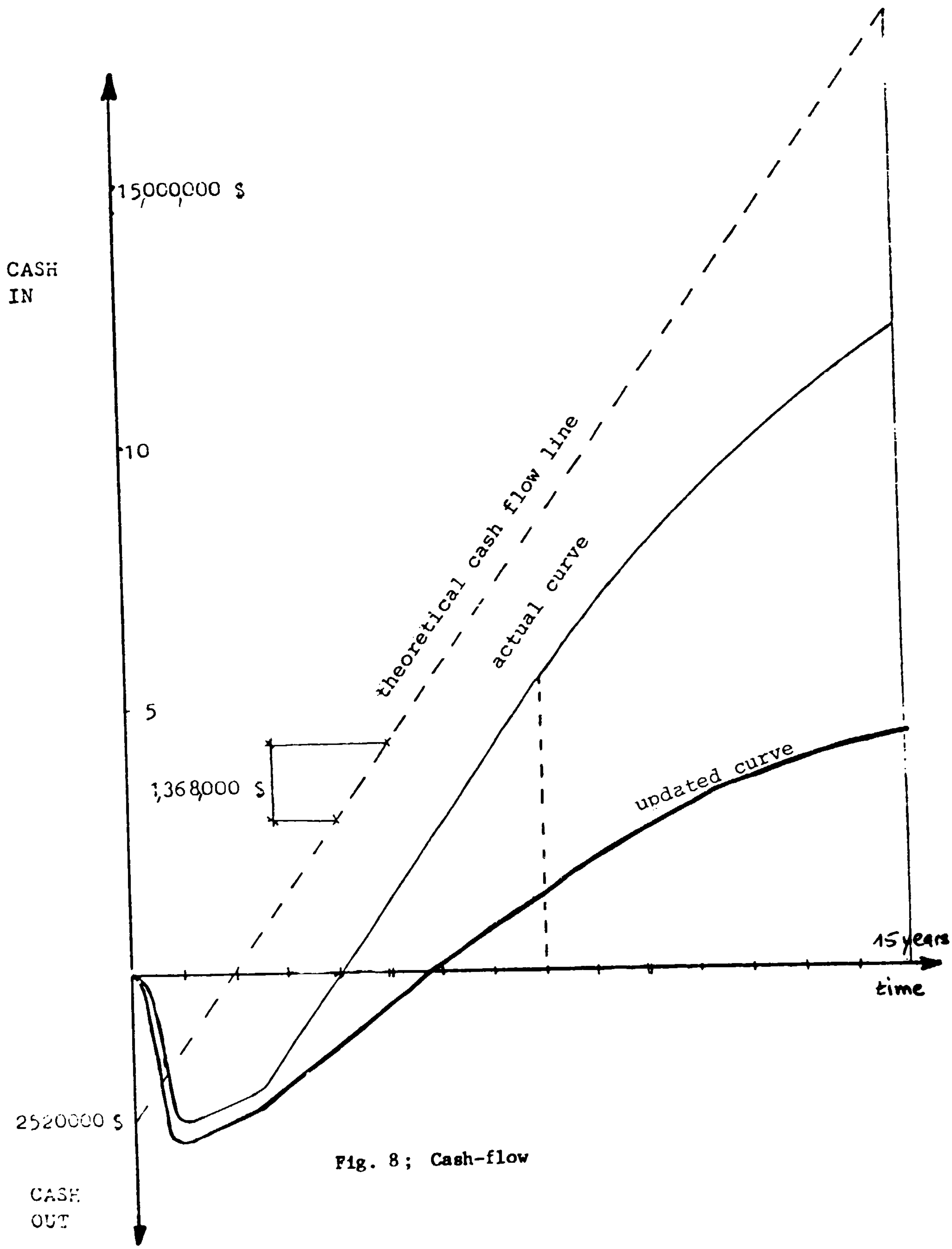


Fig. 8 ; Cash-flow

The major uncertainty in our example is due to inflation: for a new activity it is difficult to foresee the trend of all the prices and costs over the 15 or more subsequent years. We may as well, therefore, consider the values without inflation and calculate solely the interest at 10 percent. The curve goes further down, as indicated in the graph.

Graphically, we have seen the initial curve diminish considerably. Given these conditions is the investment still economical? Yes certainly. Even upon paying an interest of 15 percent of the capital, at the end of 15 years the updated earning is of more than $ 4,000,000. Moreover, at the end of the 15 years the business is still efficient and valid and, with a suitable programme for renewal of the machines, can still provide a notable profit.

It is necessary to pay attention to the pay-back period of the capital, which actually is about six years. If we assume that resort is made to a loan, it is necessary to foresee quite a long time for the repayment.

What we have outlined here with a curve can be calculated with a cash flow table which takes into account, in the most exact manner possible, the forecasts we have made. We shall not linger here on all the calculations necessary, which can be made as in the case previously indicated.

The one thing we do wish to emphasize is the importance of a further index commonly used by project engineers, the break-even point. The factory we have examined has a break-even point corresponding to 40 % of the maximum production as is illustrated by the calculation in diagramme no. 14. If, therefore, and especially in the start-up phase, the production reaches only the level of 50 percent (for example with one shift), a positive cash flow still exists, as we have assumed in this example. But if the break-even point were much higher, the factory would have a lower coefficient of certainty and in the initial phase would produce outgoings, as opposed to cash recoveries.

It is now necessary to go back a little. When we indicated in the chart on page 5 the various types of investment, we said that, after a first general examination, it is necessary to analyse in greater detail all the machines and all the alternatives. Let us suppose, in fact that the purchaser, on the basis of the calculation we have verified, decides definitely to construct a production unit which assures him a good return on the capital invested.

As in the case of the structural reorganization of the factory it is now necessary to evaluate the alternative and complementary markets. It may emerge as being advisable to modify the initial project partly as a result of the following hypotheses:

- possibility of sale of dried rotary-cut veneer to local industries which produce tables with particle board cores (in this case it is necessary to increase the flaking and drying capacity);
- possibility to produce enhanced plywood with planks purchased from other businesses;
- possibility to expand the factory with the production of planks as well, partly used internally and partly sold;
- possibility to install the factory in a different location where the waste can be sold at a higher price.

If these verifications do not lead to modifications to the project, it is necessary to pass on to other controls. It may be advisable to examine some innovative machines or machines which can, in any event, permit greater productivity.

This is the case of the plant for the recovery of the rounded-off veneer pieces which we see illustrated in fig. 7. This plant permits much better utilization of raw material around 3 - 4 %; The calculation of the rate of return of this supplementary investment is made correctly with examination of the capital required and of the revenues and marginal costs. If the investment is advantageous, the final project will also include this plant.

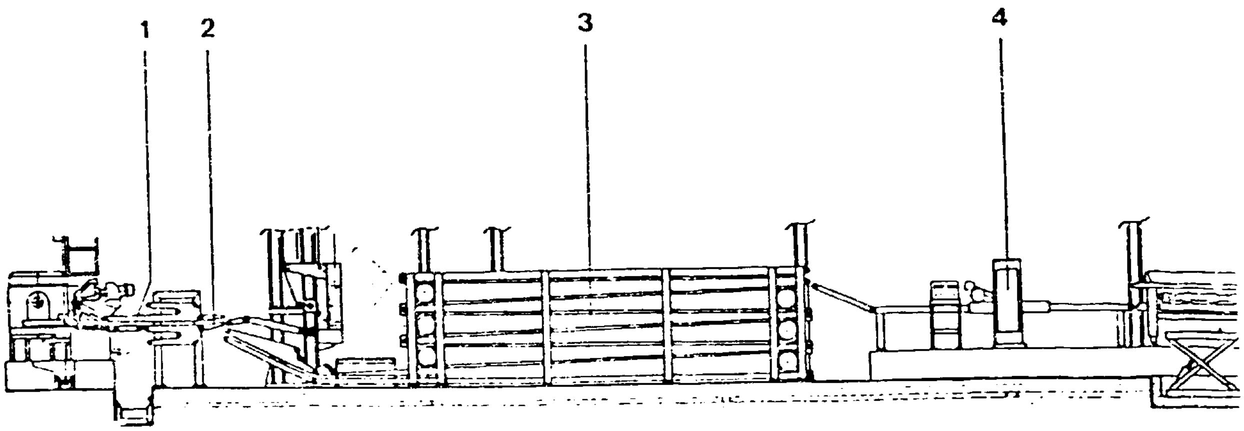


Fig. 9: Plywood factory, recovery and roundings.

CONCLUSIONS

Our long examination has without a doubt clarified some concepts:

- no sole and perfect criteria exists for the evaluation of the rate of return on investment;
- it is quite easy to know and to use some formulae, but it is indispensable, every time, to make forecasts on the quantities and on the prices with a great deal of precision in order to anticipate effectively the future reality;
- capital cannot be invested thoughtlessly without having made all the controls necessary in the most careful and most certain manner.

I conclude this document with this last concept which I recommend to the purchasers, so that they firmly require a valid calculation of rates of return, and to the manufacturers of machines, so that they always complete their offers with precise indication of the evaluations, of the coefficients, of the indices. It does not take a great deal to calculate a discount cash flow, an updated rate of return, a break-even point.