FINANCIAL ENGINEERING

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> Engineers usually find that they know very little or nothing about financial matters when they get out into industry. They also seem to underestimate the importance of the financial aspect of their work. It is obvious that the final decision on any engineering question is based largely on the financial practicability of the project, since no one will build a bridge, or any other engineering project, if they do not think that it will yield more revenue than could be obtained from any other investment.
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> Feeling that there is a definite need in this respect among student engineers we are offering this article, which will be followed by others along similar lines, if you think that they are desirable. Let us know how you like this, our first attempt at giving a glimpse of the outside world.
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> —Editor.

THE economic aspect of any electrical or mechanical appliance or plant layout is always of importance, since any problem in power generation, distribution, or utilization may have several solutions, any one of which would be acceptable from an engineering standpoint.

Engineers, as a rule, are inclined to stop with the correct technical solution of their particular problem. Too many of them do not give due consideration to the fact that a machine or plant is only a means to an end, a tool of production, and a possible source of profit; that the board of directors is more interested in dollars and cents than a possible error in theoretical design.

From an economic standpoint, then, the engineer is faced with a choice between several equipment layouts—each different in first cost, in length of life, and in cost of operation.

Prof. Goldman* has developed formulas which give us a basis for such comparisons. His comparator is "vestance," the cost of permanent service; and the scheme is one of "funding" the operating costs and the depreciation costs.

Suppose a motor which cost C dollars will last N years. At the end of N years a similar sum C is needed to replace the old motor. The present worth of C dollars in N years is $\frac{C}{(1+R)^N}$ where R is the interest rate.

At the end of N more years C more dollars are needed to replace that motor. The vestance, then, which covers continuous depreciation, becomes the sum of an infinite series of present worth or

$$V_D = C + \frac{C}{(1+R)^n} + \frac{C}{(1+R)^{2n}} \dots \dots \frac{C}{(1+R)^{xn}}$$

This sum becomes

$$VD = C \frac{(1+R)^n}{(1+R)^n-1}$$

Interpreted, this means that the cost of the motor maintained by the term $\frac{(1+R)^n}{(1+R)^n-1}$ gives a sum, which if invested at the rate of interest R, will yield enough to buy a new motor every N years. There is nothing particularly new about this, as it is only an application of compound interest.

If the operating cost is A dollars per year, the amount of money invested to bring in A dollars is $\frac{A}{R}$. Taxes, or other fixed yearly expenses can be treated in the same way. Thus $\frac{A}{R}$ is the operating vestance and the total vestance, or cost of permanent service becomes,—

$$= C \frac{(1+R)^n}{(1+R)^n-1} + \frac{A}{R}$$

Now by comparing the vestance of one machine with that of another we have a means of selecting the more economical.

Many possibilities are presented by these equations, but it is our purpose to take up the application of them to some well known problems. Besides being of interest they serve as good illustrations of the principle involved.

The last five years have seen a great deal of high pressure salesmanship applied to two household conveniences—electric refrigerators and electric washing machines. The chief selling points have been economy and convenience. Granting the convenience to the housewife, let us apply the vestance formula to each, comparing them, respectively, to the cost of buying ice and of hiring washing done.

An electric refrigerator unit for small family, (including refrigerator) costs about \$200. The operating cost is six cents a day, assuming continuous use. The life of the equipment would be about 12 years. Interest rate 6%.

$$V_t = \$200 \frac{(1.06)^{12}}{(1.06)^{12}-1} + \frac{\$ .06 \times 365}{.06} = \$761.00$$

The cost of a refrigerator alone (life about 20 years) is about \$35.00. The refrigerator would require about 100 lbs. of ice every three days, costing \$ .60 per hundred pounds (assuming continual use, as above)

$$V_t = \$35 \frac{(1.06)^{20}}{(1.06)^{20}-1} + \frac{.60 \times 365}{3 \times .06} = \$1267.$$

Just what do the figures \$761 and \$1267 mean? The \$761 would buy an electric refrigerator, the balance invested at 6% would yield enough to buy a new one every 12 years and cover the operating cost besides. \$1267 will buy a \$35 refrigerator every 20 years and yield enough to buy 100 lbs. of ice every 3 days.

Thus we see that the electrical refrigerator is the more economical of the two.

The cost of ice varies in different localities. There exists some minimum price for ice, above which it is more economical to have an electric refrigerator. Let us equate the two vestances volving for ice cost.

$$\$761 = 35 \frac{(1.06^{20})}{(1.06^{20}-1)} + \frac{(\text{cost of ice per lb. }100) \times 365}{.06 \quad\quad 3} \qquad \text{Cost } \$.35$$

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* "Financial Engineering," John Wiley & Sons.

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Thus, if ice sells cheaper than \$ .35 per hundred pounds it is more economical to buy it. If it sells for more than \$ .35, it is more economical to buy an electric refrigerator.

The washer problem:

An electric washing machine costs \$150. It should last 15 years. The cost of one washing—soap and electricity—would average about \$ .10. Assume the washing is done once per week.

$$= \$150 \frac{(1.06^{15})}{(1.06^{15}-1)} + \frac{52 \times .10}{.06} = \$344.$$

Assume that it costs \$1.00 per week to hire the washing done.

$$V_t = 0 + \frac{1.00 \times 42}{.06} = \$870$$

Thus it is over twice as economical to own a washer than it is to pay for laundry work done.

The general solutions are in favor of the modern methods.

Results figured from these equations are correct inasmuch as the compound interest law is true. Altho we figure the cost of permanent service, the actual time involved between the periodic removals of part of the principle, to invest in new equipment, is short is the life of the equipment.

Over short periods infinitesimal compounding is more accurate than periodic compounding, although both become "impossible" when applied to hundreds of years. This is recognized by governments in their statutes on interest limitations.

The method precludes any basic change or improvement in equipment which will lengthen its life or increase its economy, and it neglects obsolescence, which may be taken care of by the unit cost rule.