

usually fall, is to overrate the funds on hand or in view, and on the other hand, to underrate the cost of the completed enterprise. Roads are seldom built within their first estimated cost, and therefore, this is a danger against which the chief engineer must guard; he must be sure and firm in his figures, because it is difficult to foresee all contingencies, and still more so to impress the directors with the reality or necessity of each item.

The finances at the command of the company should always be fully known to the chief engineer; he has the right to know it, and should have the courage to insist on the fullest confidence of the directors. These means should be carefully studied, allowances made for changes in the money market affecting the value of bonds, the amount of money which can be raised easily, and the difficulty in getting the *last* part of the required amount should also be considered. Usually the bonds of new roads, just being built, sell below par, and, as the amount issued increases, the selling price may get less and less, until they may become unsaleable.

Many roads become bankrupt before or just after construction is finished, and a promising project ends in a receivership, the wiping out of past debts, or issue of prior-*lien* bonds on the part of the bondholders themselves. Receiverships, instituted originally to protect bondholders, are often made the instruments of defrauding them. The history of the railways of the United States, particularly, is full of examples of unnecessary roads built on faith and hope, and ending in disaster or fraud. Over 25 per cent. of United States railways are now in receivers' hands, and nearly all have passed through that stage in some period of their history.

The most casual observation teaches that in a country like Canada, where traffic is still unfortunately very light, we must build roads with the utmost economy. This has been practised in several justifiable directions.

(a) The introduction of curves where necessary, with a sharpness of as high as  $4^\circ$  to  $6^\circ$  on main lines, and  $8^\circ$  to  $10^\circ$  on branches, with a frequency only limited by a piece of tangent of 200 to 400 feet long between curves; in this way, by a slight addition to the cost of hauling trains and length of line, the cost of road-beds has been kept at a minimum.

(b) The use of fluctuating grades, by which the local "sags" or depressions do not increase the cost of hauling trains, but cheapen the cost of construction materially, and which have no objectionable feature except a change in train speeds, as they store up or yield a part of their "velocity head."

(c) Timber structures over all important streams, and even timber box culverts under light banks; in this way a railway company is enabled to get its road in operation quickly at a minimum cost, is able often to tide over the first few years of meagre traffic, replacing them, gradually, as means will permit, with permanent structures. On the other hand, there are certain directions in which economy cannot be practiced.

(a) Narrow gauge roads, except in isolated cases, have now been abandoned, because the demands for interchange of traffic put them at a disadvantage; because the cost of construction is higher in proportion to carrying capacity of cars, etc., and chiefly because it is found that American engines of standard gauge can pass around any ordinary curve quite freely.

(b) Light rails. This will be dealt with more fully in future chapters, but it may be well to say here that

with rails quoted at \$20 to \$25 per ton, there is no greater blunder than to buy light rails. In stiffness, strength and wear the increase varies nearly as the square of the weight per yard, thereby decreasing maintenance charges enormously as the weight increases. The present weights are roughly 60 lbs. per yard for branches and 80 lbs. for our main lines, with a strong tendency upwards.

(c) Excessive ruling gradients. Almost any other mistake can be corrected in time, curves can be flattened, short grades lifted, temporary structures replaced, but the ruling grade is the life or death of a road that has or expects to have any traffic beyond a meagre minimum. This question will be fully dealt with in Chapter II.

(d) Locating roads adjacent to but not through towns. Many instances might be given of this fact, where railway companies, in order to save money on right of way, to shorten the line slightly, or out of pique at not receiving bonuses, have built the road a mile or more away from the centre of population. Experience proves, however, that it is usually profitable to pass as near as possible through the *very heart* of all towns or cities, even at considerable extra expense.

The engineer must, therefore, when entrusted with a study of proposed routes, have several leading ideas constantly in his mind:

(1) How to obtain the most traffic, including the idea of shutting out, avoiding or fighting competitors.

(2) How to get a road built with as small fixed charges as possible consistent with small operating expenses, and clause (1).

(3) How to build a road that will be operated and maintained at as small a charge as is consistent with clauses (1) and (2). *These three things are intimately intertwined*, but may be affected by such considerations as obtaining heavy local aid, having heavier grades in direction of lesser traffic, and a complete change of train loads at the end of each engine division (100 to 130 miles), excepting always that the whole road will allow the passage of moderately heavy passenger trains intact.

Unfortunately these matters are often, erroneously enough, may be, settled quite apart from engineering ideas, politics and local aid being the controlling factors; but facts remain, and while politicians perish and local aid, once given, looks for a *quid pro quo*, the railway burdened with too heavy grades, too much debt, or distant from its customers, will gradually, but surely, fail in the race. The problem which has to be solved, in each case, is to create a paying property without satisfying, often, the dangerous desire on the part of the engineer to build solidly and erect monuments to himself, or satisfy his innate desire for excellence of construction considered from too narrow a standpoint. This is a difficult matter in a thinly settled country like Canada, as statistics to be given will show, but our roads are being more economically constructed and operated day by day and traffic is slowly increasing, so that we may confidently look forward to a time when there will be a change and some small returns for the stockholders and promoters.

(To be continued.)