three is no doubt due in some measure to the strands after the first breaks becoming more nearly straight, thus enabling the stress to act along the direction of the length of the fibers. The three strands were broken where rupture took place near the centre of the specimen, so that we got the absolute strength. In the ropes which contained the greatest number of twists to the foot, the irregularity between the comparative strength of three strands, two strands, and one strand was the most noted. This would appear to bear out the deduction just referred to, namely, that the proportionately less strength of three strands as compared with two, and one, is due to some extent to the less twist per foot in the two strands, and one strand, after the first and second strands break.

REMARKS ON EXTENSION CURVES.

The extensions shown on the curves are (for diagrams of these curves, see CANADIAN ENGINEER for February) the amounts the ropes stretched under the different loads in a distance of eighteen inches. In the same diagram each of the three curves gives the average results of the untarred or tarred rope, as the case may be, in three different conditions, viz.: dry, wet and soaked. Diagram for untarred manilla and hemp rope: Here it will be noticed that the ratio of stretch to load is least for the dry rope, while those for the wet and soaked do not differ widely. The two curves are, however, quite different in shape. The soaked rope stretched less at first, but its curve soon crossed that of the wet rope by its stretch becoming greater. Then the stretch of the soaked specimen became less than the wet, as is shown by the two curves again crossing. At the upper limit of the load the two curves run nearly parallel. It would appear as if the great shrinkage in the soaked specimen at first resisted the load up to a certain point and then suddenly yielded somewhat more rapidly than the wet specimen and nearly finished stretching at the same time. This latter truth can be seen at once from the curve of the soaked rope by noticing how nearly vertical the curve is at its upper limit.

TABLE SHOWING COMPARATIVE STRENGTH OF ROPE BEFORE FIRST STRAND BREAKS, AND AFTER THE FIRST AND SECOND STRANDS BREAK.

Description of Rope.	1st Strand Break. Load.	2nd Strand Break. Load.	3rd Strand Break. Load.
Manilla	3,200	2,750	1,150
"	6,000	4,425	1,800
"	750	650	425
"	1,170	950	575
"	1,525	1,100	800
"	1,825	1,425	1,000
"	2,300	1,775	1,025
"	2,175	2,000	650
Tarred manilla	1,275	950	455
" hemp ratline	750	640	475
" "	1,120	890	380
" " boltrope	740	600	600
" " "	800	650	425
" manilla "	5,425	3,400	2,000
" " boltyarn	6,535	4,475	2,600

In the diagram for tarred rope there is not such a difference between the stretches in the three conditions. What seems surprising is that the ratio of stretch to load is least not for the rope when dry, as in the untarred specimen, but for the rope when wet; while it is the curves for the soaked and the dry specimens which intersect. Moreover, it is the curve for the soaked tarred specimen which most nearly resembles the curve for the wet specimen in the untarred rope. It is also to be noted that the ratio of stretch to load decreases at an increasing rate, which decreases as we reach maximum load.

DEDUCTIONS FROM THE TABULATED RESULTS.

The most noticeable fact is that a wet rope is stronger than the same specimen dry. This was no doubt owing to the fact that the rope was more pliable so that it adjusted itself in such a way that the stress was more uniformly distributed; and none of the fibers were strained to rupture almost, before others had any considerable stress; for we found that when any of the outside fibers on a bend, which of course are strained most severely, gave way, the rope was practically at its maximum load. The above was an important factor in determining the position of fracture. A larger proportion of the failures took place at the upper pin or thimble than in any other position. This was particularly so with the larger ropes, where the outside fibers were affected not only by the direct stress, but by this stress acting at a leverage of the diameter of the rope, minus the crushed depth, in the same manner as the outside fibers of a beam in a transverse test are affected by the skin stress and the depth of the beam We endeavored to place a sleeve on the pin, but the short distance between it and the head of the machine left barely room enough for the rope. This pin had no feather in it and turned round in its eyes, so that a greater portion of the stress developed in the specimen was transmitted down to the toggle end of the rope than would have been if the pin had had a feather to keep it from turning.

It will be noticed that a large number of breakages occurred at the upper thimble. We believe this to be due to the injury the rope may have sustained by the pin turning in its eyes, and not due to any defect in the method of fastening. The smaller number of breakages occurring at the bottom thimble, where the pin had a feather in it to keep it from turning, and where the fastening was similar to that at the top, would tend to confirm this.

Considering the bending moment referred to above it would be natural to conclude that a small rope would be less affected by it than a large one, and would be more likely to break at the centre. This was proved to be so by our tests. It may also be noted that the melting or soaking did not increase the strength of a tarred rope as much as that of an untarred. This would be expected, as tar allows motion of the fibers so that the stress is more uniformly distributed throughout the whole specimen. The increase in strength was greater in tarred manilla than in tarred hemp. Immersion always increased the strength of an untarred rope, but a continued immersion had no marked effect. It might be thought that the additional stretch of a wet or soaked specimen above that of a dry would be due entirely to the shrinkage. A comparison of results will show that this additional stretch is greater than the shrinkage.

CORROBORATION OF EXISTING FORMULÆ.

Most of the existing formulæ giving the strength of rope are very complicated and hard of application, but in "Jones and Laughlin's" hand book is the following formula: "To get strength of manilla rope, multiply the square of the circumference in inches by eight, and the result will be the number of hundred pounds required to break the rope." This agrees remarkably closely with the results of our tests; e.g., In the first rope of the tabulated results the formula giving the number of hundred pounds required to break the rope gives the following:

Load $= 2 \times 2 \times 8 = 32$; breaking load $= 3200$. Exactly what we obtained. Again, take No. 3:

Load $= 2.5 \times 2.5 \times 8 = 52$; breaking load $= 5200$, while we obtained 5150. Many others are equally near.

In submitting this thesis, we sincerely hope that the data tabulated, and the explanation given thereof, may be sufficiently lucid to all readers; and that the benefits obtainable therefrom may, in some degree, be commensurate with the labor entailed by its preparation.