A NEW SYSTEM FOR THE FIXATION OF ATMOSPHERIC NITROGEN.

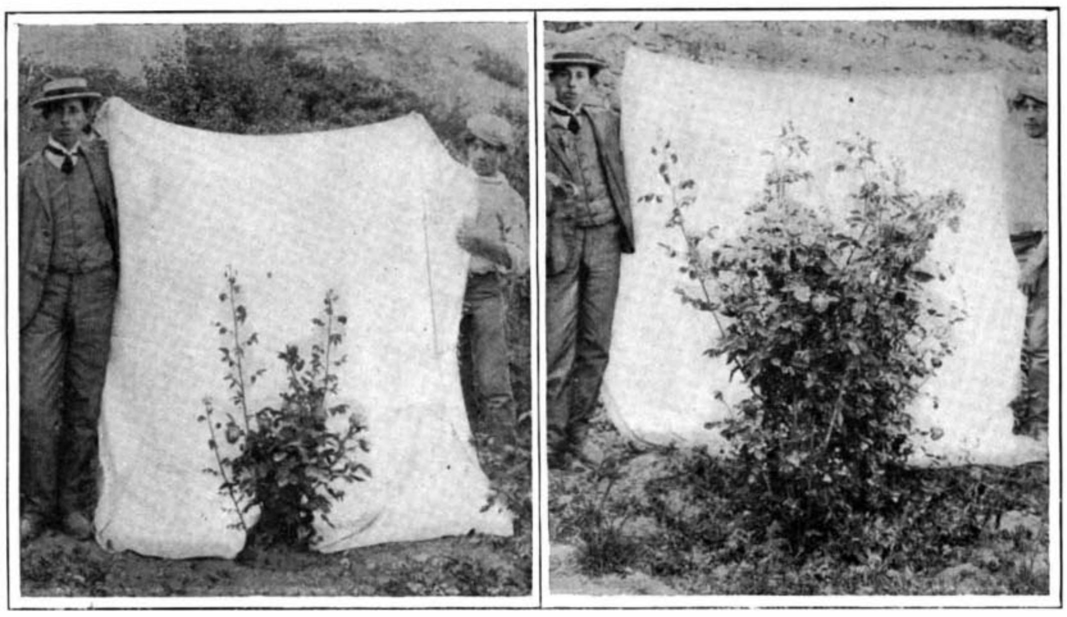
BY F. SAVORGNAN DI BRAZZA.

Nitrogen is the most important element entering into the nourishment and development of plant life. It is absorbed from the air by electrical discharges in the atmosphere, by the slow evaporation of water, and in other ways. At the same time, nitrogen plays by far the most active part in all fertilizers, whether of animal origin (in the shape of ammoniacal products) or of mineral origin, in which nitrates prevail.

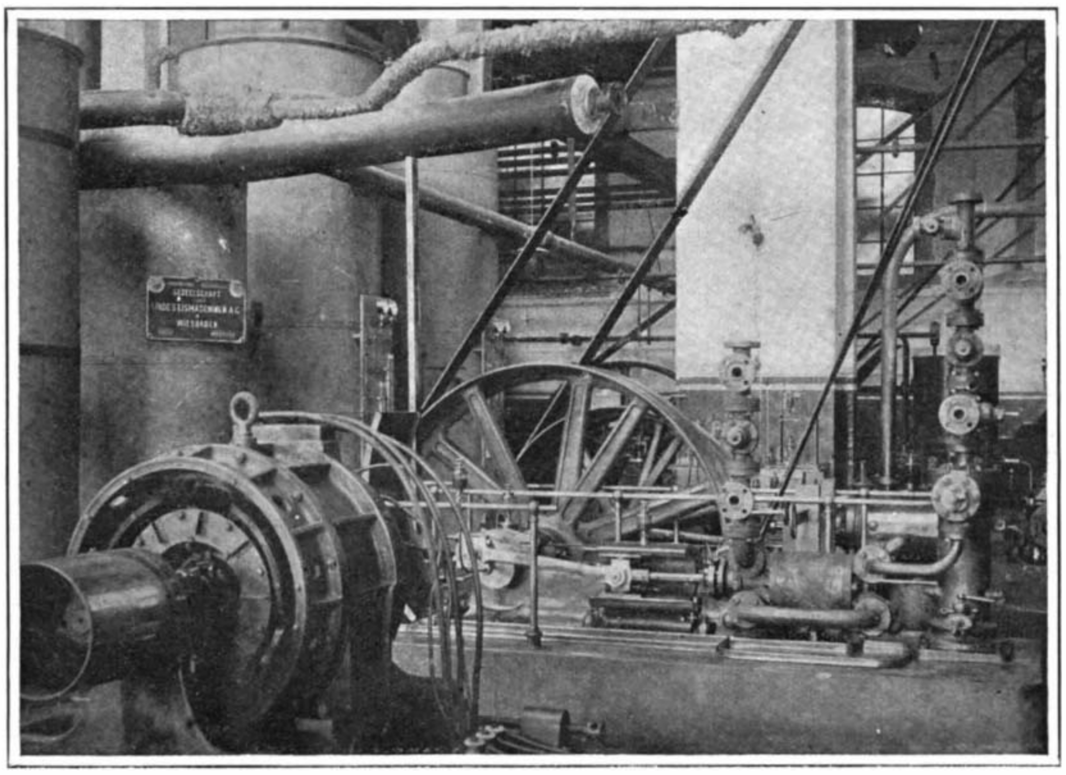
The use of nitrogenized products in agriculture is ever increasing. This serves as a proof that the time is not far distant when the production of these will be entirely insufficient. The mines of nitrates in Peru and Chili will become exhausted as a matter of course, and all attempts to discover new mines to replace these—attempts made in all countries—have thus far given negative results only. This failure has caused apprehension, and presents a very serious problem for an epoch that is by no means far removed.

The endeavor has therefore been made to discover an industrial process capable of supplying an unlimited quantity of nitrogenized products at reasonable expense. The mind immediately recurs to the nitrogen in the atmosphere, which is practically inexhaustible. And, indeed, the fixation of atmospheric nitrogen is without doubt the most difficult problem that has presented itself to chemists and scientists in recent years. The difficulties to be overcome are indeed enormous; for, on account of its chemical properties. it is most difficult to fix nitrogen in the shape of a useful compound. Two processes only have been found practicable industrially, and promise to give excellent results. The first makes use of the electric spark; the second is the fixation of nitrogen upon carbides heated to a very high temperature.

As early as 1785, Riesley had discovered that, in the presence of an electric spark, atmospheric nitrogen unites with oxygen to produce nitric acid, and that the air always contains traces of this acid after a violent storm. In 1869 Berthelot announced that a mixture of acetylene gas and nitrogen, when submitted to the electric spark, gave origin to cyanhydric acid. Just as soon as electricity began to be produced at low cost, the problem entered upon a new phase. The endeavor was now made to unite directly the two elements—oxygen and nitrogen—contained in the air by means of electrical discharges of various kinds. It was with this idea that there was established at Niagara Falls the Atmospheric Products Company, a company that utilized the patents of C. S. Bradley and S. Ross Lovejoy covering a process in which air that had been cooled and dried was submitted to an incessant rain of minute electric sparks.



Growth in Two Months of Simple Cultivation of a Plant Fertilized with Calcium Cyanamide.



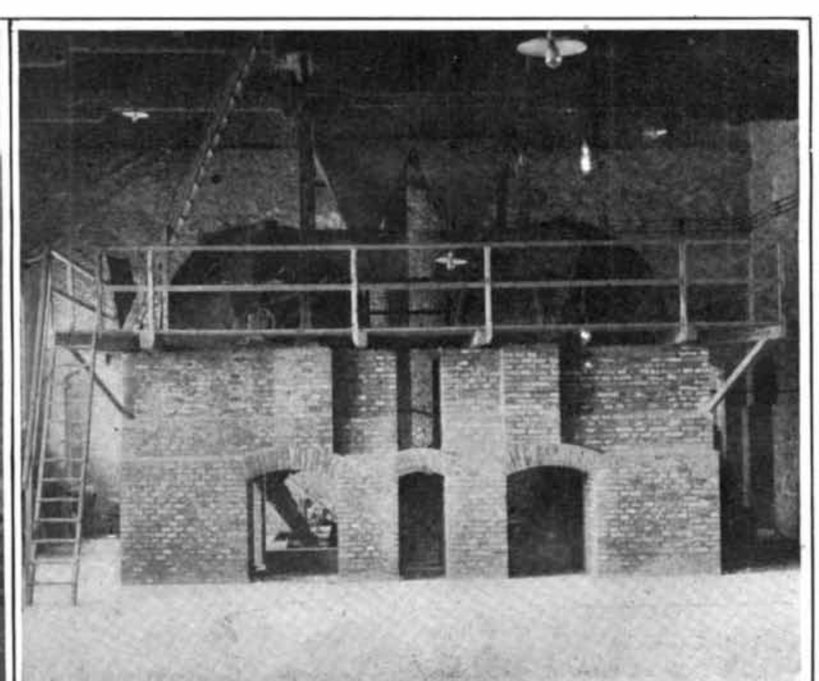
The Apparatus for the Production of Liquid Air and for the Fractional Distillation Necessary to Separate the Nitrogen and the Oxygen.

Lately two Norwegians, Birkeland and Eyde, have continued the investigations of Siemens & Halske. They have succeeded in obtaining an industrial process that has given excellent results in fixing atmospheric nitrogen through the agency of electrical discharges. A factory is now being constructed for production on a large scale. We do not yet know the economic results of this process, which, theoretically at least, is excellent, but the proposed commercial production on a large scale would seem to indicate that the promoters of the process have confidence in its practical success.

In Italy a large factory, the first in the world, has been established recently for the production on a large scale of nitrogenized products obtained by the fixation of atmospheric nitrogen. It makes use of a new process discovered by Prof. Frank, of Charlottenburg, and Dr. Caro. The factory is situated at Piano d'Orte, in the province of Chieti. It employs hydro-electric power of 15,000 horse-power, drawn from the Pescara River, and it is estimated that in time it will have a daily output of over 13,000 pounds of the new product, which its inventors have called calcium cyanamide.

The process is based upon the property of calcium carbide to fix nitrogen at high temperatures. The inventors drew their inspiration from the experiments of Bunsen and Playfair, who obtained cyanides by passing nitrogen over a hot mass of carbon and alkalis. Drs. Frank and Caro suspected that the production of cyanides and nitrogenized products by this process were, perhaps, preceded by the formation of carbides. Experiments proved their conjectures to be true. Dr. Frank now endeavored to make use of barium carbide mingled with alkalis. He submitted the product, when heated, to a current of nitrogen, and at once obtained alkaline cyanides. Barium carbide, however, has one great drawback—it is entirely too costly to permit of its use in an industrial process. Calcium carbide, on the contrary, can be produced economically, and in great quantities. The substitution of this material for barium carbide constitutes, therefore, a noteworthy step in advance. It was then learned that calcium carbide, when raised to a temperature of 1,000 deg. C., fixes nitrogen directly, without the intervention of alkalis. The result is calcium cyanamide, $CaCN_2$. It was further proved that all the nitrogen in this new product, when united with water under high pressure, changes into ammonia, $CaCN_2 + H_2O =$

The New Italian Plant for the Fixation of Atmospheric Nitrogen at Piano d'Orte.



The Apparatus for Pulverizing the Calcium Carbide.

A NEW SYSTEM FOR THE FIXATION OF ATMOSPHERIC NITROGEN.

$CaCO_3 + 2NH_3$. This was the long-sought-for solution of the production of ammonia and ammoniacal salts by means of atmospheric nitrogen.

This production suggested the thought that calcium cyanamide might, under certain conditions, be used as a fertilizer, and might furthermore be directly applied to the nourishment of plants. Numerous experiments made in different countries gave favorable results, and it would seem, therefore, that the solution of the problem of the fixation of nitrogen for the production of useful compounds had at last been found.

It remained, however, to make this process economic, practical, and industrial. The necessary materials—calcium, carbon, and atmospheric nitrogen—were to be had everywhere, but the production of pure nitrogen in great quantities presented new difficulties. To obtain it directly from the atmosphere, it was necessary to separate it from the oxygen with which it is combined. The first attempt consisted in passing a current of air over copper filings very highly heated. The oxygen united with the copper, forming an oxide, and the nitrogen remained pure. But a process of this character was still too costly. It was therefore abandoned, and was replaced by a duly modified form of the Linde method. In this, the separation of the two gases is obtained by means of the liquefaction of air and fractional distillation, the boiling points of liquid nitrogen and of liquid oxygen being different. This constituted an economic process that could be very easily employed on a large scale.

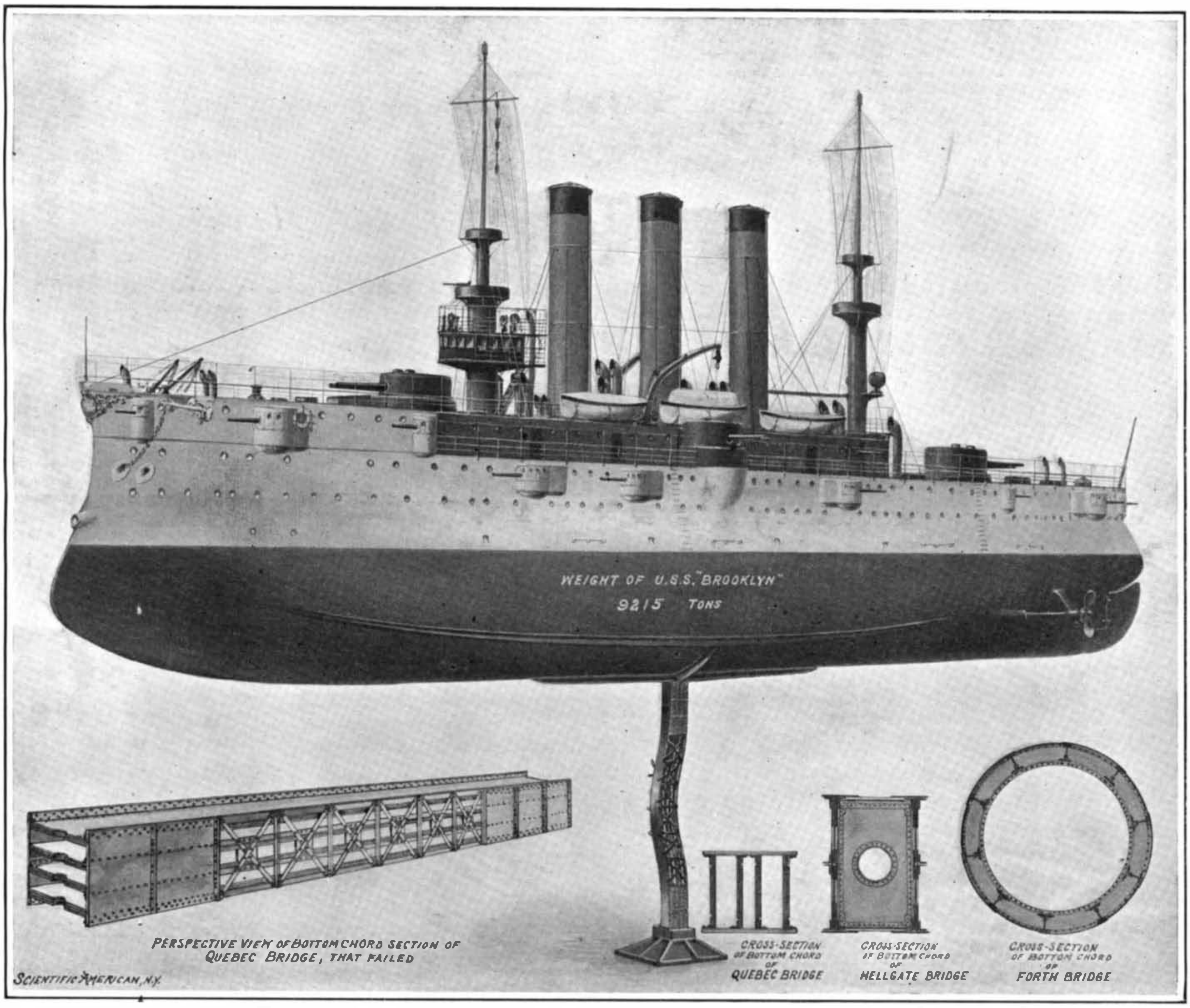
For reasons of economy, and owing to the immense power at the disposal of the plant at Piano d'Orte, the calcium carbide is here produced on the spot by means of a complete equipment of electric furnaces. The carbide is then ground to a very fine powder by special machinery, and is placed in special iron retorts. It is then heated until it fuses at a temperature of from 800 to 1,000 deg. C. At the same time, very powerful pumps blow over it a continuous current of nitrogen that has been separated from liquefied air by the fractional distillation mentioned above. After a couple of hours, the carbide is transformed into calcium cyanamide ready for use.

Calcium cyanamide as obtained from the retort has the appearance of a very dark mass, composed of extremely fine crystals and of free carbon. Furthermore, it always contains a small quantity of calcium carbide that has not become transformed. Therefore, after grinding the product very finely, it is necessary to expose it for some days to the air, in order that the small quantity of water vapor in the air may remove the portion of calcium carbide still remaining.

Calcium cyanamide, the *Kalkstickstoff* of the Germans, contains from 14 to 24 per cent of nitrogen, 40 to 42 per cent of calcium, and 17 to 18 per cent of carbon. If calcium cyanamide be again placed in a retort, it changes to a cyanide.

In the results when applied to agriculture, the new product has proved itself equal, if not superior, to various other mineral fertilizers, among others the nitrates of Chili. This process demands, however, very great electric power, and its application will prove useful only where great electric power can be provided at a small expense.

The dangers of European ballooning were emphasized during a long-distance race from Paris on September 29, for the grand prize of the Aero Club. Rain or fog circled the aeronauts throughout the race, and a southerly wind drifted them seaward. M. De Lobel, one of the competitors, finding the sea ahead, determined with his two companions to risk reaching England; but a change in the wind carried them back over the North Sea, which they struck twenty-five miles from Ostend. They were thrown into the water, but grasped the cordage and regained the balloon. De Lobel tied himself to the car and his companions to the rigging. They passed several hours thus, looking out for a ship, and were finally picked up by a German boat and landed at Dover.



The vertical post, which is shown in the act of breaking down under the load of the cruiser "Brooklyn," is drawn to scale and represents the lower chord member of the Quebec bridge which failed by buckling through the rupture of the latticing. Theoretically this member should have carried 11,320 tons; actually it failed under 8,000 tons.

GRAPHIC REPRESENTATION OF THE ENORMOUS LOAD WHICH THE COLLAPSED QUEBEC BRIDGE BOTTOM CHORD WAS SUPPOSED TO CARRY WITH A MARGIN OF SAFETY.

WHY THE QUEBEC BRIDGE FAILED.

The Quebec Bridge fell because of the buckling of the bottom chords, and the bottom chords buckled because the four ribs or webs of which each was built up were not sufficiently braced together to enable them to act as a whole.

In a previous issue we stated that the first failure occurred in the left-hand bottom chord of the anchor arm in the second panel out from the main pier. Subsequent detailed examinations of the wreck show that, simultaneously with the failure of the left-hand chord, the corresponding right-hand chord collapsed in a similar manner, being buckled into the form of the letter S. Furthermore, the later investigations have revealed the fact that the whole of the bottom chord members had shown signs of weakness which were sufficiently disconcerting to cause comment and considerable anxiety among the workmen on the bridge. Of this there seems now to be no doubt whatever. Evidently, at the time of the disaster, the various struts, posts, and chords throughout the whole bridge, but particularly the chords, were suffering from overstrain and were trembling on the verge of collapse. It was merely some local action that caused the break to happen just where it did. Probably there were a score of other compressive members which might have failed as readily as this one.

At the same time, we are confronted with the significant fact that, regarding the tension members, that is the eye-bars, there had never been any anxiety whatever on the part of the erecting gangs; everybody connected with the bridge, from riveters up to chief engineer, being perfectly satisfied that these members were standing well up to their work. Furthermore, the tension members passed through the terrific ordeal of the final collapse of the bridge with a really mar-