rescued, after which the firemen descend in the manner above outlined.

No other class of fire-fighting apparatus has during recent years undergone such marked improvement as the aerial ladders, which are designed, of course, primarily for use in rescuing the occupants of burning buildings. The ordinary trucks, which formerly carried only plain ladders up to 40 feet in length, are now, as a rule, equipped in addition with 50-foot and 65-foot extension ladders; and the extension ladders, operated by means of cranks, are now made in all sizes up to 90 feet, which renders them capable of reaching to the sixth story of an ordinary building. By means of 85-foot aerial trucks of this pattern, men have reached the seventh story of a building in a space of forty-two seconds. Many minor improvements have lately been made in these ladders, including the introduction of the new shoe irons, which prevent the slipping of the ladder, and permanent dowels on the inside of the shoe irons, which add to the stability of the ladder.

For life-saving purposes, however, there is nothing to compare with the new telescopic aerial ladders which are operated by means of compressed air. When it is desired to effect a rescue of a person on the roof or on one of the upper floors of a blazing building, the pneumatic ladder is shot into the air to a point just opposite where the imperiled person is standing, the endangered individual steps on to the top round, and the ladder as suddenly collapses, the tubes telescoping gradually but rapidly, and conveying the rescued person to a point near the ground.

The average telescopic aerial ladder is operated under an air pressure of 300 pounds to the square inch, the air tank being located in the center of the truck carrying the ladder. On many ladders there is provided an auxiliary tank with air under 100 pounds pressure, which is used to supply power for swinging the ladder from one side of the street to the other, so that buildings on both sides of a thoroughfare may be served without serious delay. The truck carrying the ladder weighs about two tons, the heavy construction having been introduced in order to obviate any possibility of overbalancing. Ladders of this pattern of 85 feet extension have been raised to their full height in 25 seconds. Inasmuch as the apparatus is strong enough to carry a dozen men, it is possible to conduct rescuing operations with great rapidity.

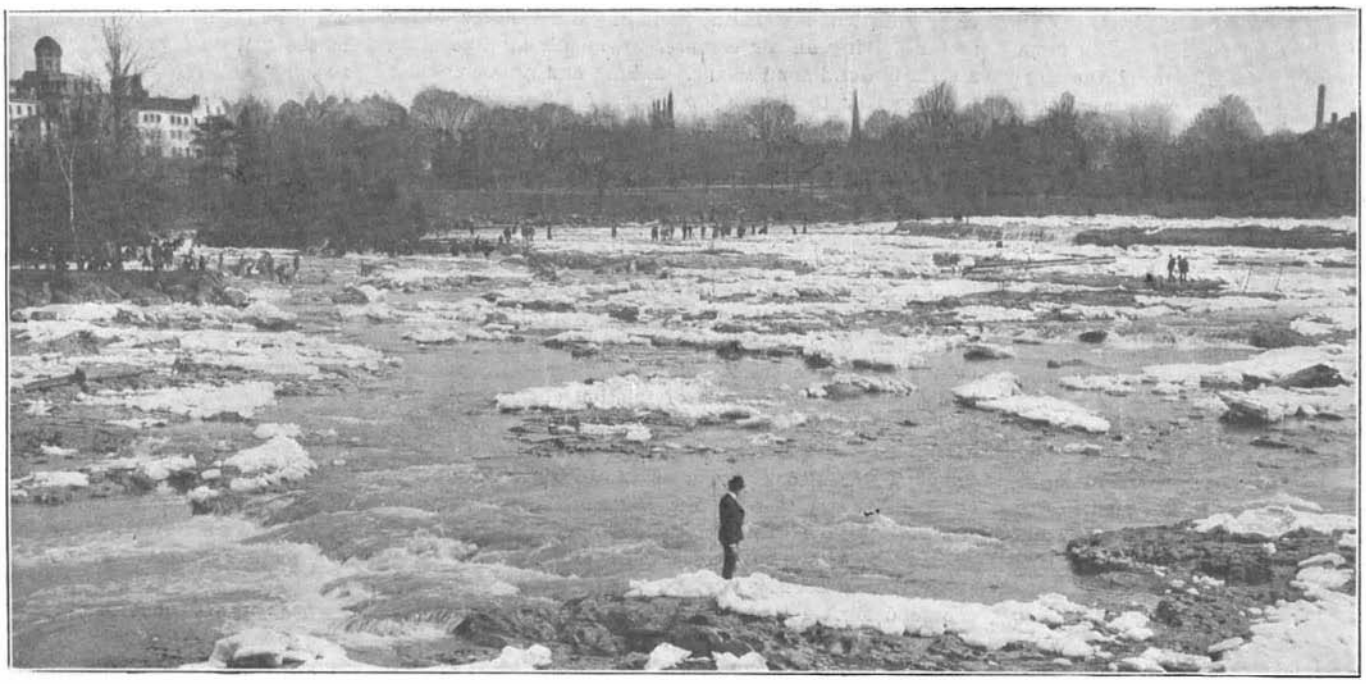
## REMARKABLE DIVERSION OF NIAGARA'S WATERS.

BY ORRIN E. DUNLAP.

Despite any fancied or real danger that threatens the cataract of Niagara, it is certain that it will take many long years of earnest activity to bring the spectacle to the ignoble condition in which the people of Niagara Falls found it on the morning of Sunday, March 22. Late Saturday afternoon or evening the ice came down the upper river from Lake Erie in marvelous quantities. The floe was so heavy that immense fields of it lodged on the rocks and reefs above Goat Island, the result being that practically all of the water that would find its way to the lower river over the American Fall and precipice was diverted to the outer or Canadian channel. This left the riverbed of the American channel, between the mainland and Goat Island, high and dry, and on Sunday great numbers of people visited the scene and walked about the river-bed.

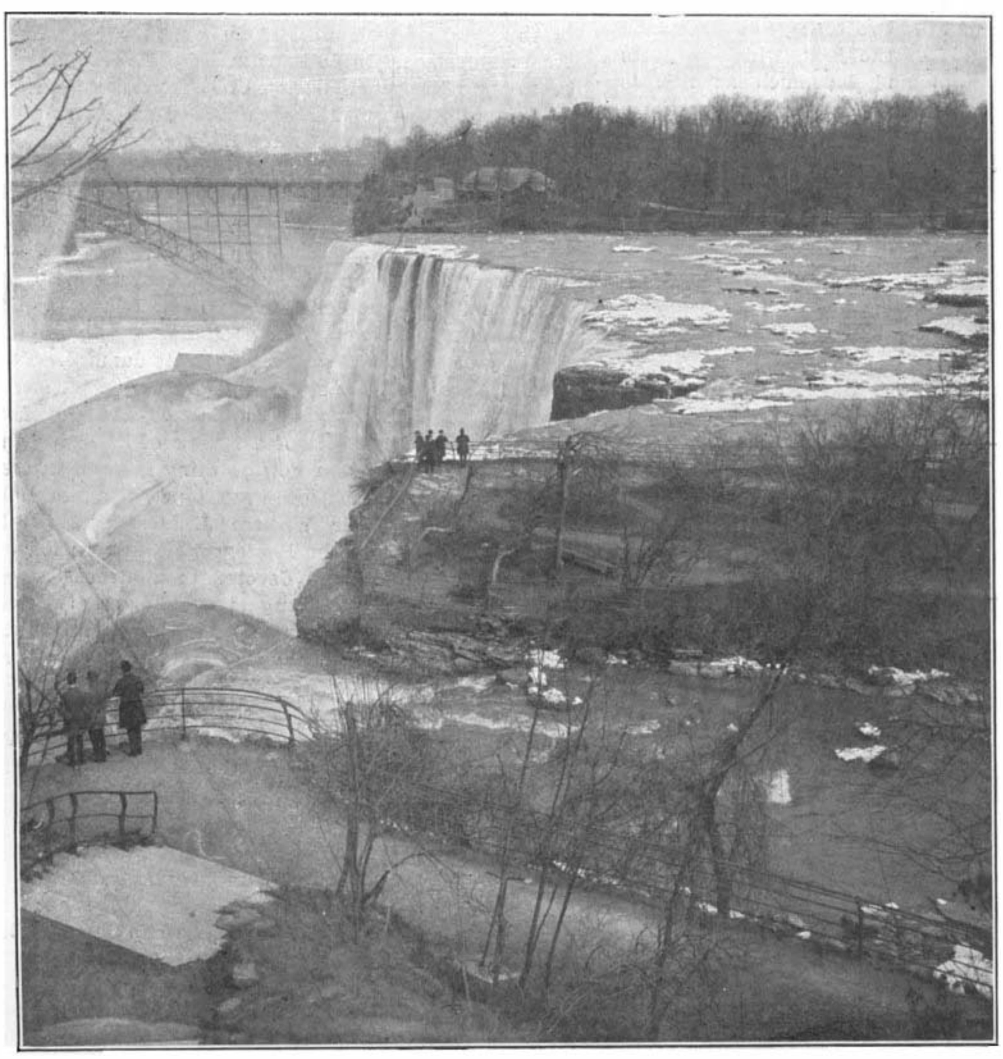
The condition was surprising. Those who have passed all their days at Niagara were amazed that such a thing was possible. Under normal conditions the channel between the mainland and Goat Island is a scene of furiously tossing water that leaps and bounds, tumbles and rolls, over reef after reef in its impetuous rush toward the awful precipice. In this channel the water speeds on at a rate of from fifteen to twenty miles an hour, and in places is twelve feet deep. But on the Sunday referred to, the rocks of the riverbed formed a glorious searching place for the relic and souvenir hunters, who marveled at the wonderful condition wrought by the gathered ice a short distance up stream. It is recorded in the historical annals of Niagara that a similar incident occurred on March 29, 1848, but people who have lived at the Falls ever since then have no recollection of such a diversion of the waters as that of March 22 last. Situated between the mainland and Goat Island nestles pretty Green Island, and it was from this island that the dry rocks were most easily reached by the crowd of pedestrians. Under normal conditions of the river, Green Island is situated in the midst of the turbulent flow, and on each side of it the water rushes in good volume at rapid speed. When the waters were diverted, however, it was possible to walk from Green Island right up the river-bed to the head of Goat Island, but in order to do this, reef after reef had to be climbed. The temporary diversion of the torrent gave fine opportunity for an inspection of the river-bed and the rock formation that causes the beautiful rapids so much admired by visitors, who stand a long time on the island bridges and watch the flood come down from the sky, as it were.

With the water diverted, the fall of the riverbed seemed more pronounced than ever before. To stand down close by the bridges built from the mainland to Goat Island and look up stream was a remarkable sight. It was like looking up a hill of rocky shelves of stairs, and it was almost impossible to con-



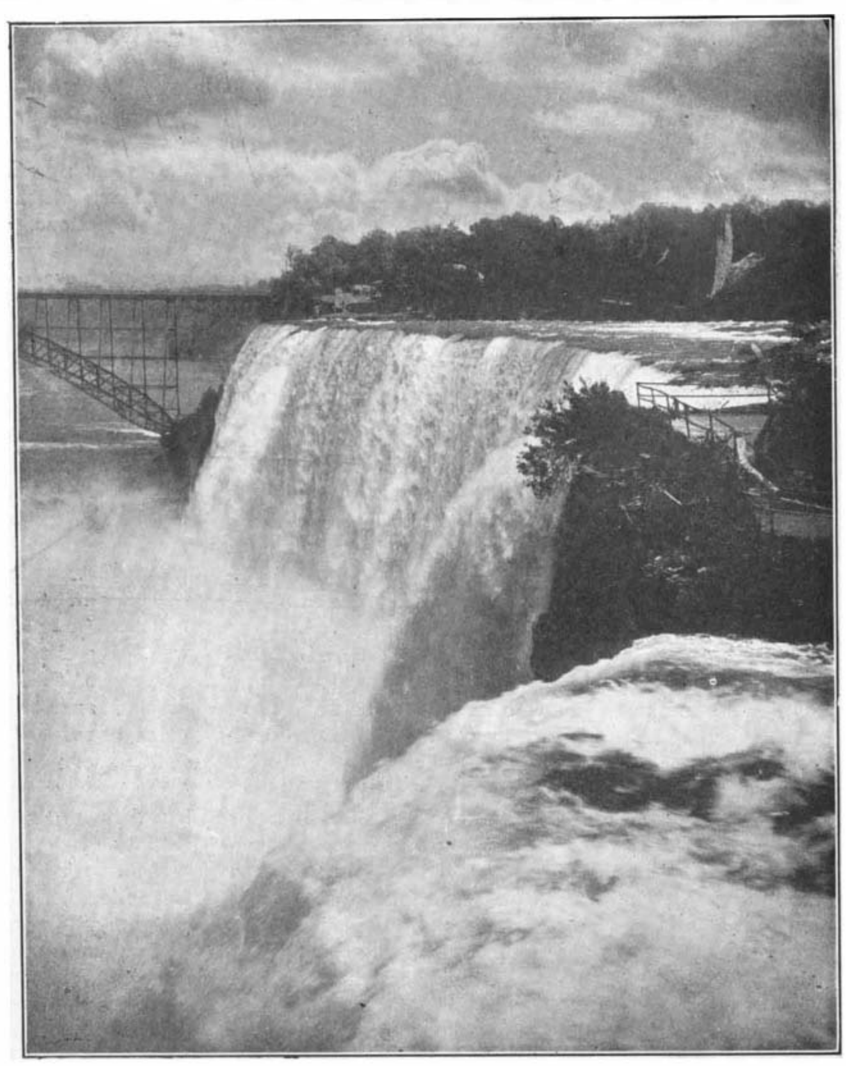


**The American Channel Looking Toward the Mainland from Goat Island. The People in the Distance are Walking up the Riverbed at Midstream, where the Rapids Usually Toss with Great Fury.**





**The American Falls on March 22, 1903, when the Waters of the River were Diverted.**



**The American Falls at the Normal Flow of the River.**

**THE REMARKABLE DIVERSION OF THE WATERS OF NIAGARA.**

ceive that only a few hours before a large portion of the waters of Lake Erie had taken this route to old Ontario and that in all likelihood they would be flowing over the same route within a few hours more. Here and there was a gravelly-like deposit that had been brought down from above by the stream at full flow, but left behind on the rocks as the vigor of the river gave out. Great patches of ice were left all about on the rocks, as the water became too low to float them. Big pieces of loose limestone rock were deposited in some places, but for the main part the river's course was over the limestone ledge that had been swept quite clean by the rushing river.

At no time in the history of Niagara were so many souvenirs taken from the river in a single day. Well-worn stones, rough rocks, small trees and canes from the little islands, Ship and Brig, all served the purpose of souvenirs, while in some cases people carried off shrubs torn up by the roots from the little islands they had never before visited. The pot holes, the crevices, all depressions were searched by the eager crowd, which was made up of men, women and children, all unmindful of the fact that the river might any moment burst through the ice jam and sweep them over the fall to eternity.

When supported by the customary downpour of water from the great reservoir above, the American Fall of Niagara is without doubt a magnificent spectacle; but when the waters cease to flow, when the plunging, reckless torrent is diverted in its volume, as on March 22, the grandeur disappears, and the world's greatest waterfall is a shame-faced spectacle that would make one of the many poets who have told of its sublimity sorry he had ever looked upon it and become enthused over its magnificence. Usually, a powerful stream of water rushes through between Goat and Luna Islands, for it is under this Center Fall that the Cave of the Winds has its glory; but on the occasion of the ice jam the stream at this point was unworthy of the name creek, so weak was its flow. For centuries the water has burst over the edge of the precipice of the American Fall in a gleeful way, shooting far out with a bound and a jump, forced on by the pressure of the flood behind. The picture reproduced shows barely enough water coming down to the brink to curtain the rocky cliffs from the view of the curious thousands who came to see Niagara and its force conquered. The huge ice mounds in front of the fall stood out naked, while the rocky talus at the base of the fall was also partly in full view, telling only too plainly why it is the bodies of so few persons who go over this fall are recovered.

As wonderful as it was, it is certain that if the time ever comes when the flow of the Niagara River is diverted for any purpose to such an extent as to make such a spectacle as that of March 22 continuous, there will be sorrow at Niagara. And yet Lord Kelvin, the eminent English scientist, personally stated to the writer:

"I look forward to the time when the whole water from Lake Erie will find its way to the lower level of Lake Ontario through machinery, doing more good for the world than that great benefit which we now possess in the contemplation of the splendid scene which we have presented before us at the present time by the waterfall of Niagara."

## ELECTRIC TRACK WELDING.

BY WALDON FAWCETT.

Marked improvements have been made during the past two years in the process of electrically welding rail joints. Although by the process which has been used since 1897 the breakage on all welding did not exceed one per cent, the new system has reduced the percentage of breakage to less than one-tenth of one per cent. In the city of Rochester, N. Y., where the new process was rarely employed, more than 5,300 joints were welded during the latter part of 1901. An examination in the spring of 1902 disclosed only six broken rails. None of the damaged rails had a joint broken through the bars or a weld pulled off; practically all of the breaks occurred through the existence of old bolt or bond holes beyond the bars.

The new plan of welding has been still further improved to meet such exigencies, and now all welding bars are made long enough to reach over bolt and bond holes, so that in the future even this source of breakage will be practically eliminated. The remarkable state of perfection to which electric track welding has lately been brought appears all the more marvelous in view of the fact that in the latest approved method employed, each weld depends on the judgment of the man making it, and must necessarily remain in the track and await the strain of winter to disclose defects, if any exist. Even under these circumstances, however, not one weld in a thousand fails to successfully stand the actual test.

The machinery employed in electric track welding—and it is of a very ingenious character—is mounted on trolley cars of special design, the running gear of which is provided with threaded axles, so that the machines can be used to weld track of almost any gage. The welding of newly-laid rails is done either before or after the paving is in place, space being left at the joints to permit the entrance of the welder. When welding is to be done on rails which have been in place for some time, the paving is torn up around each joint, and the old plates and bond wires removed. It is necessary, of course, in such instances, to bring the rail ends up to the proper grade.

The new method of electrical welding comprises three distinct operations. The first step is that of sand-blasting, whereby all the dirt, rust, and foreign matter is removed from the rails, at points where welds are to be made, and also from the bars used in making the joint. Sand-blasting necessitates the employment of apparatus, including a ten horse power motor driving an air compressor, an air storage tank, a sand bin and sand mixer. A hose and nozzle enables the operator to direct the blast of air, carrying the sand against the rails, so that all foreign matter is quickly removed.

Two cars are required to carry the apparatus for welding, which constitutes the second step in the work. The welder itself is hung from a bail on a crane, extending out beyond the end of one car. This crane is so arranged that the jaws of the welder can engage the sides of the rail, and also shift from one side to the other, thus enabling work to be carried out on both rails of the track. The operation of this crane is accomplished by means of friction clutches, from a shaft in the car, which shaft is kept running continuously by a five horse power motor.

The motor also drives a small rotary pump, which circulates water through the welding transformer and the faces of the contacts, thereby keeping them cool. The water, after it has passed through the welder, is elevated to a cooling tank on top of the car. It is of course desirable that this water shall be cooled just as rapidly as possible, for which purpose a novel plan is employed. Starting from the middle of the tank, and passing around and around until the outer circumference of the tank is reached, is a serpentine partition. A perforated false bottom is provided, through which air is forced from a powerful blower. The hot water from the welder passes into the outer portion of the serpentine partition, and is subjected constantly to the modifying influences of the forced air. After reaching the center of the serpentine partition, the cooled water is conducted to one of the tanks in the car.

The welding apparatus proper consists of an alternating current transformer, the primary winding of which is made up of two coils in parallel, each of forty-four turns. A single loop of copper of large cross section forms the secondary coil; and the terminals constitute the contacts or jaws, which engage each side of the rail, and between which the weld is made. Supporting the transformer on either side, although insulated from it, are large levers hinged together at about two-thirds of the distance from the top, which levers are used to transmit the necessary pressure to the weld. A hydraulic jack connects these levers at the top. A pressure of over two tons per square inch is obtained on the rams of the jack, which are less than four-inch diameter; and inasmuch as this is increased by the leverage of the arms, the pressure developed at the weld is in excess of thirty-seven tons.

For making a joint there are employed flat-rolled steel bars which have on one side, at either end, bosses or projections, serving as contact points between the bars and the web of the rail, and confining the welded area of these sections. About the middle of the bars on the same side with the projections is placed a flat strip of steel, perhaps one-eighth of an inch in thickness and one inch wide. The bars are supported on small blocks, and so placed across the joint that the middle strip engages the web of both rails. The end welds are horizontal, while the middle weld is vertical and the full width of the bar.

The whole operation of welding is conducted very expeditiously. When the welding train of two cars is moved up to a joint, the welder is swung into place and the jaws made to press against the bars on each side of the rail. The current is then turned on and flows from contact to contact through the bars and the rail web. By altering the pressure on the jaws, the resistance of the several junctures is increased, and the whole is soon brought up to a welding heat. When this point is reached the current is cut off, and simultaneously the pressure is brought up to the full amount. After the pressure is loosened, the welder car is moved back, in order to bring the jaws opposite the extremity of the bars, and here the same process is repeated, with the addition that when the final pressure is applied, it is held there and the weld permitted to cool under pressure, until no glow is apparent. Then the welder is moved forward to the other end of the bar, and the process is repeated, after which the welder is swung to the opposite side of the car and the joint on the other side is welded.

The present plan of holding the pressure after the completion of the weld increases the strength of the weld very materially. Only the ends are so treated, the center weld being subjected to so slight a strain that such a precaution is unnecessary. One of the improved processes of the new plan of welding grows out of the discovery that it is advantageous to weld the ends of the bars while the bars are in an expanded state. By making the center weld first, and not stopping to cool it under pressure, the greatest elongation of the bars is, of course, secured. As the bars cool off, after the ends are welded, they shrink and exert a powerful pull to bring together the abutting rail ends, thus closing the slightest opening and leaving practically no joint whatever.

The advance in this direction is of greater significance than might at first be imagined, for in the manufacture of a continuous rail, the abutting rail ends, if not brought firmly together, give the metal in the head of the rail an opportunity to flow into the opening between the rails. This will in time cause a low spot in the head of the rail. The bars being always in a state of tension, the rail inclosed between the bars is necessarily in a state of compression; and inasmuch as any contraction of the rail between the joints will be transmitted to the end welds, it is obviously necessary that these latter be as tough as possible, that they may withstand the strain. The center weld merely contributes to vertical stiffness, and tends to prevent any movement of the rail ends.

The current actually used in welding operations by this new plan approximates from 25,000 to 30,000 amperes at 7 volts. The car accompanying the welder carries a rotary converter for changing the direct current from the trolley to an alternating current. The current in the primary coils of the welder is a 40-cycle alternating, at 300 volts; and the direct-current side of the rotary converter is capable of taking from the trolley, current at from 325 to 600 volts. By means of the regulating apparatus, a constant supply to the welder of 300 volts is maintained, regardless of fluctuations on the line. At a voltage of 500, about 225 amperes is required on a line, or, in other words, about 125 kilowatts is required to make a weld, the time consumed, or rather the interval during which the current is on, being two and a half minutes.

The final operation of welding consists in grinding the head of the rail to a true surface. There is comparatively little need for this finishing process where new rails are being welded, but in old track it is very essential, inasmuch as the receiving rail is purposely welded higher than the other. The grinder, which is used to grind out the inequalities in the rail head and bring it back to a true surface, consists of an emery wheel mounted on a carriage having two rollers which are about four feet apart. The carriage is let down on the rail, so that the rollers roll along the head of the rail, and the emery wheel is thus over the uneven portion at the joint. A swing frame connects this carriage with a motor on the car, and the operator is thus enabled to move the emery wheel back and forth over the joint while the car remains stationary. A hand wheel enables the emery wheel to be gradually fed down, and as it is moved forward and back the high places are ground off until the whole joint is brought to a true surface. In many respects the operation corresponds to the manipulation of the ordinary carpenter's plane. When carried on as a continuous process, only about fifteen minutes are required to complete a joint; and when operations are conducted day and night, at least eighty joints are completed in 24 hours.

### The Current Supplement.

The current SUPPLEMENT, No. 1422, opens with an article on the recent collision on Long Island Sound, in which the two great Sound steamers, "Plymouth" and "City of Taunton," suffered no little damage. Two splendid pictures of the steamers after the accident are presented. The industry of compressed and liquefied gases is made the subject of a review of some length. Jacob Backes describes a new printing system, whereby it is possible to use ordinary typewriting in lieu of printing types. Sir William J. Herschel's presidential address before the Photographic Convention of the United Kingdom was devoted to a discussion of color photography. Among the shorter articles are those on the osmium electric lamp, monorail lines, steam trucks for heavy hauling, and radio-activity of ordinary metals. Prof. Thurston of Cornell University discusses steam turbines to date. Fred. T. Jane concludes his naval war game articles. Otis T. Mason has studied the traps of the American Indians.

### The Scientific American Automobile and Yachting Number.

Next week's issue of the SCIENTIFIC AMERICAN will be another enlarged special number, this time devoted to automobiles and yachts. The cup defender is accurately described and illustrated; the new racing ratings of the New York Yacht Club are explained; and the New York Yacht Club itself and its handsome club house are described and pictured. Automobiles in warfare and the leading types of American and French vehicles form the subject of some interesting articles in the automobile section.