elocity. This was conclusively shown by experiments iade with a model of the above motor boat and a amus skimmer model of the same weight. The lotted records showed that the resistance curves rossed at approximately 17 knots. For lower speeds ıe boat form is much superior, but above the point here the resistances between the two models are equal, ıe skimming model possesses decidedly greater ad-antages.

Thornycroft also carried out a series of experiments ith the model of the "Gyrinus" motor boat towed ackward, in order to illustrate the clinging of the ater around the rounded form of stern, which the ow then represented; and although this gave no ouble at ordinary speed, the effect at extreme speeds as found to be surprising. The real stern lifted, hile the bow was depressed until the model made a ırge angle with the line of motion, as was found to e the case by Mr. Froude with his Ramus model.

Sir John Thornycroft also studied the passage of ir underneath skimmers. It is generally supposed hat air does pass beneath them when traveling at igh speed, but he contends that this is only likely to ccur when the water surface is broken, as it is well nown that a jet of water impinging on a surface ven at an acute angle does not all pass under in the irection of the jet. A small part near the surface as its motion reversed, and renders the passage of ny air between the jet and the surface impossible. f, however, the surface of the moving water is broken or churned into foam, then that mixture of air and water will pass along the surface. What will be the effect of this seems uncertain, but the late Lord Kelvin was thoroughly of the opinion that the friction of this mixture would be greater than that of solid water. The form used by M. Fauber is adapted to eject any air from under his vessel, and Sir John Thornycroft thinks it possible that he obtains from this advantages which balance what would appear to be a loss due to the many short skimming surfaces.

In the opinion of Sir John Thornycroft, hydroplanes are closely related to aeroplanes. Although smooth water would seem to form a definite plane on which to travel, a boat of this kind when moving at high speed is not content to be limited to motion in two dimensions, but tends to oscillate vertically and to jump from the water surface, and under some conditions to dive.

* * *

ARTIFICIAL RUBIES.

BY VICTOR BARTON.

Diamonds are composed of pure carbon, but most other precious stones consist of alumina, colored by various oxides. Hydrated silicates of alumina are known as clays and are found in vast quantities everywhere, but all varieties of crystallized alumina, or corundum, are comparatively rare. Some corundums are colorless, while others derive various tints from the presence of metallic oxides. Red, blue, green, and yellow corundums are used as gems and are known, respectively, as rubies, sapphires, oriental emeralds, and oriental topazes. Rubies and sapphires are by far the rarest and most valuable of these gems.

Many attempts have been made to produce rubies and sapphires synthetically by fusing alumina with coloring oxides and crystallizing the mass by cooling. The first partial success in the synthesis of colored corundum was obtained in 1837 by Gaudin.

In 1852 Ebelmen, director of the national porcelain works at Sèvres, produced rubies of microscopic size by heating a mixture of alumina, borax, and oxide of chromium in a porcelain kiln. St. Claire Deville and Caron succeeded in producing rubies, in the form of very thin crystalline laminæ, by means of the reaction between vaporized anhydrous boric acid and aluminium fluoride. In the course of their experiments they occasionally obtained crystals of sapphire, the formation of which they could not explain, but which were doubtless due to the presence of particles of oxide of iron.

In 1865 Debray and Hautefeuille attacked the problem, but it was reserved for Frémy and his assistants, Feil and Verneuil, to solve it in a series of remarkable researches distributed over the period 1877-1890.

In the method first employed by Frémy and Feil, an aluminate of lead was formed, and this salt was then decomposed by the action of silica, the result being to set free the alumina and to cause it to crystallize. The crystals of corundum thus produced were colorless, but rubies were obtained by adding 2 or 3 per cent of potassium bichromate, while the

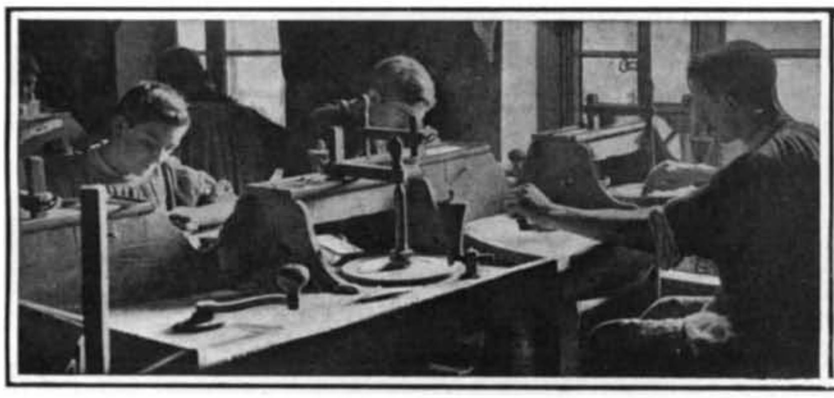

Fig. 3.—Cutting "scientific" rubies.

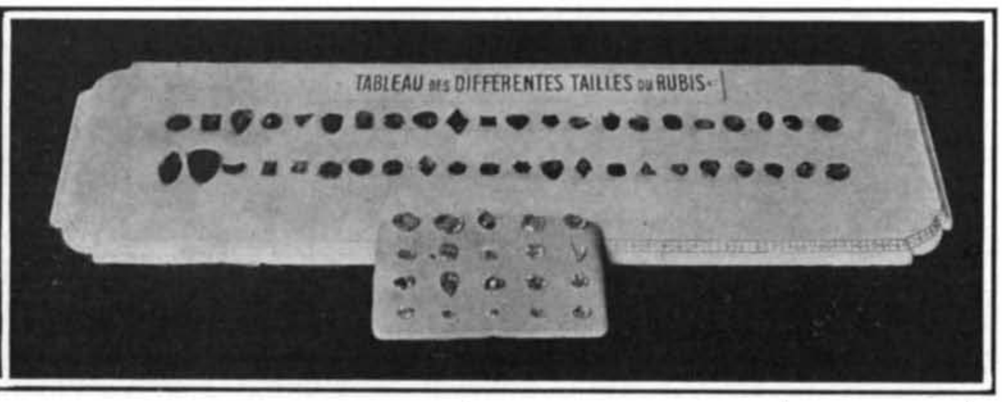

Fig. 5.—Rubies of various shapes.

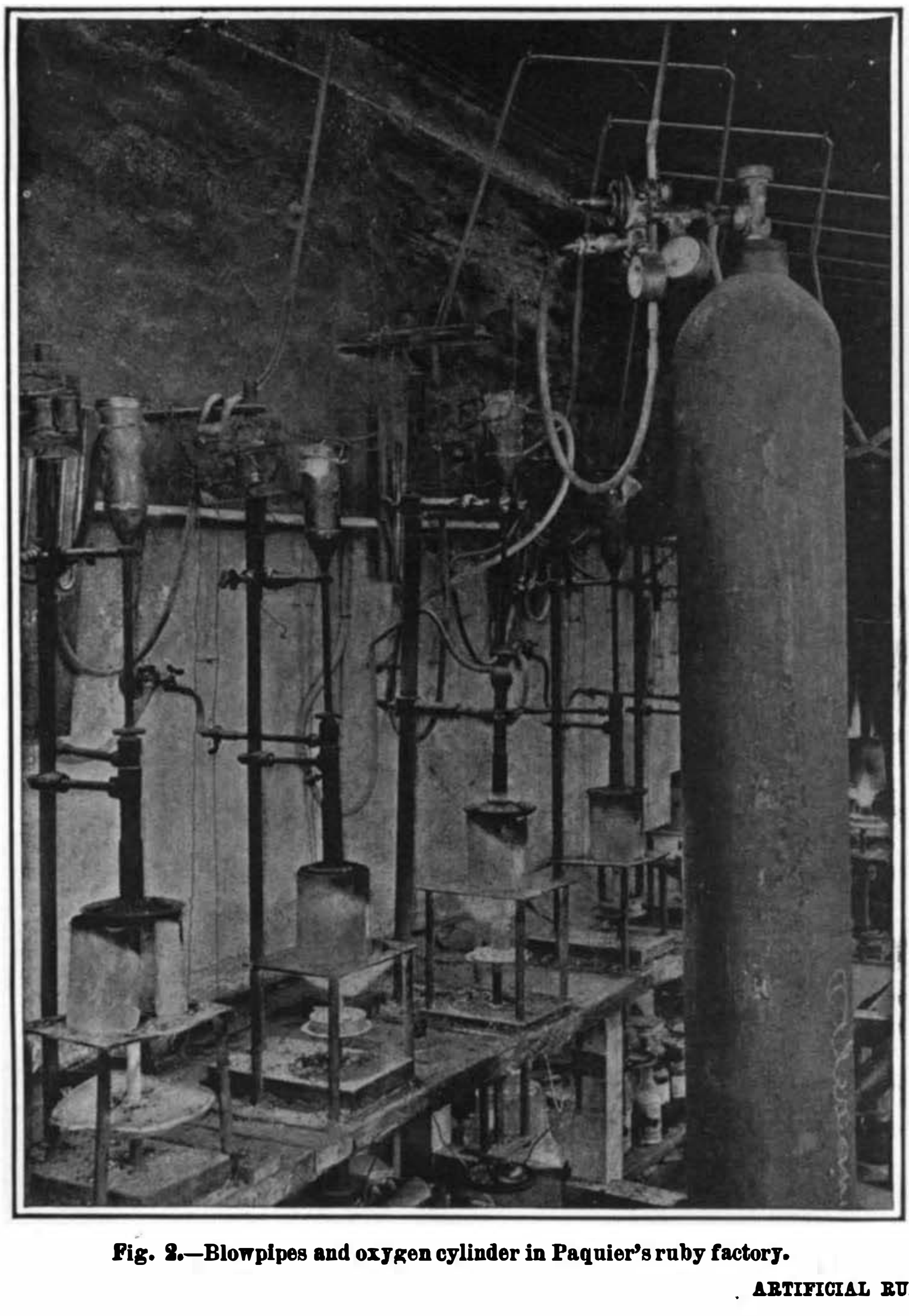

Fig. 2.—Blowpipes and oxygen cylinder in Paquier's ruby factory.

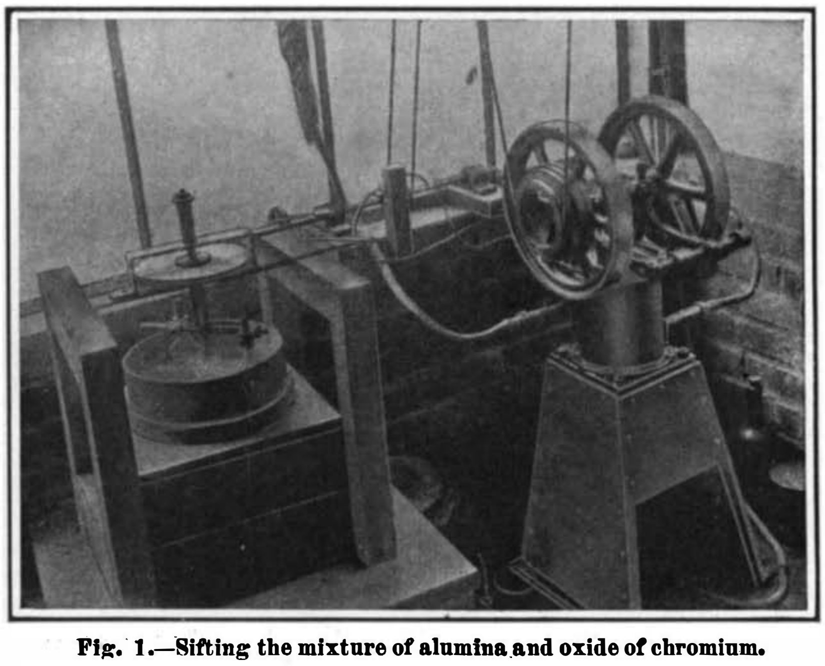

Fig. 1.—Sifting the mixture of alumina and oxide of chromium.

Fig. 4.—Examining artificial rubies, and mounting them on rods for cutting.

ARTIFICIAL RUBIES.

further addition of a little oxide of cobalt produced the blue color of the sapphire. These artificial gems, however, were laminated, friable, and of little value as jewels.

In a second series of researches Frémy and Verneuil crystallized alumina at a very high temperature by a process in which potash and barium fluoride were employed. By skillful manipulation and by maintaining a circulation of air in the crucible, they succeeded in producing magnificent rhombohedral crystals, as transparent and brilliant as natural rubies and thick enough to be cut in the rose form. But these crystals were still too small to be employed to advantage in jewelry.

Several chemists conceived the idea of increasing the size of Frémy's rubies by a process of "feeding" analogous to Leblanc's process of increasing the size of soluble crystals by keeping them in the mother liquor, from which additional matter is slowly deposited on them. With rubies the process was conducted, necessarily, in the dry way, the matter being in the fused state and the temperature between 2,700 and 3,300 deg. F. But the operation proved less simple in practice than in theory.

The first "reconstructed" rubies appeared on the market in the early eighties. They were made by fusing ruby chips together, and their artificial character was easily detected by experts. Yet they had a brilliant appearance and sold for $20 or $30 per carat, although they crumbled when they were cut. Large rubies of a cloudy and unsalable character were obtained soon afterward by the chemist Maiche. Meanwhile the inventor of the "reconstructed" rubies, a Swiss engineer named Michaud,[*] had been compelled by lack of money to sell his secret to a foreign resident of Paris, who sold it in turn to a number of other persons, several of whom formed a company which soon failed. Then some men who had been employed in the work undertook to carry on the manufacture of rubies by the process, which had become public property and which was conducted substantially as follows:

The first small ruby, or nucleus, was placed in a platinum crucible, which was fixed at the center of a rotating disk and exposed to the flame of an oxyhydrogen blowpipe, producing a temperature of 3,300 deg. F. Minute ruby chips were then brought, one by one, with pincers, into contact with the incandescent nucleus, and the process was continued until the mass had attained the desired size. The chips became welded together and formed a mass sufficiently compact and homogeneous to allow of cutting. The work required great skill and the partially amalgamated crystals often cracked in cooling. At first the reconstituted rubies, uncut, sold for $2.40 per carat. About a thousand carats daily were manufactured in Paris and exported to Germany and America, and even to India, whence they sometimes returned, mixed with natural rubies. Competition gradually lowered the price to 6 cents per carat.

Fig. 1.—Electrically operated trolley-repairing automobile in service.

Fig 2.—The trolley-repairing truck ready to start.

Fig. 3.—A special form of tower for repairing trolley wires.

AN AUTOMOBILE TROLLEY-REPAIR TRUCK.

The "scientific" rubies have suffered a similar depreciation. These gems first appeared in commerce in 1901. They were made, and are still made by Paquier, Disclyn, and others, by the improved Verneuil process described below.

In the first place, calcined alum is mixed with a small quantity of a salt of chromium, the function of which is to produce the red color of the ruby. The mixture is rubbed through a very fine sieve by means of two stirrer blades driven by a small motor (Fig. 1). The sifted powder is then melted by blowpipes consuming illuminating gas (Fig. 2).

Verneuil found that three conditions must be satisfied in order to produce transparent rubies; the mixture must be exposed to that part of the flame which is richest in hydrogen and in carbon, in which it not only melts but boils and becomes purified; the ruby must be built up gradually from the bottom, and the operations of fusion and solidification must be so conducted that the area of contact between the first layer and the support is extremely small, in order to reduce the danger of fracture to a minimum. These conditions are satisfied in the construction and operation of Paquier's apparatus, which is shown in the accompanying diagram (Fig. 6). The calcined powder, consisting of alumina with a little oxide of chromium, is placed in a little sheet-brass hopper (*A*), the bottom of which is made of wire gauze of sufficiently fine mesh to retain all particles large enough to obstruct the orifice of the blowpipe beneath. This hopper is suspended by a rod in a chamber (*B*), which is really an enlargement of the oxygen tube. The lower part of the chamber is drawn out into a slender tube, which ends in a fine jet. Oxygen is admitted at *C*. The oxygen tube is surrounded by the coal gas tube, to which gas is admitted at *E*. The flow of gas is regulated to produce a temperature of from 3,300 to 3,600 deg. F. A little hammer, operated by an electromagnet, falls at regular intervals on the top of the rod which supports the hopper, and each blow causes a little of the powder to sift through the gauze bottom.

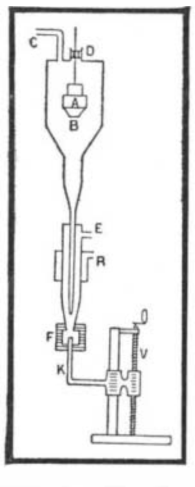

Fig. 6.—Diagram of apparatus for making rubies.

Thus the powder is thrown, a little at a time, into the current of oxygen which comes into the flame, where it is transformed into liquid drops. Some of these drops fall on a little platinum dish attached to the top of a rod (*K*) and inclosed in a box of fire-clay (*F*) to prevent too rapid loss of heat. The box is provided with an opening through which the formation of the ruby on the platinum dish can be observed. The dish can be moved in any direction by three screws, at right angles to each other, of which only the vertical screw (*V*) is shown in the diagram.

Each drop, as it falls on the dish, unites with the solid mass formed by preceding drops, and thus the ruby increases in size and assumes the form of a pear resting on its stem.

Each blowpipe produces about 10 carats per hour, and one operator can attend to ten or twelve blowpipes. Pear-shaped rubies weighing 80 carats can be obtained.

After the rubies have cooled they are split lengthwise, so that each furnishes two cut rubies. The loss in cutting amounts to three-quarters of the original weight, or three times the weight of the cut stones. The crude pear-shaped rubies are worth about 2½ cents per carat, the cut gems about 40 cents per carat.

The cutting, so called, and the polishing are performed by cementing the stone to a rod and pressing it on a revolving wheel of copper or bronze covered with abrasive powder of various degrees of fineness, the final polishing being done with tripoli and water.

Paquier's "scientific rubies" are physically, chemically, and optically identical with natural rubies. Both frequently contain microscopic air bubbles, which are called "frogs" by jewelers and "inclusions" by mineralogists, and which are spherical in the artificial rubies, but of various shapes in the natural gems. Moreover, the planes of crystallization characteristic of the natural ruby are not always discernible in the "scientific" ruby. But these slight differences are sometimes lacking. The eminent geologist Lacroix has expressed the opinion that it is impossible to decide with absolute certainty whether a ruby of fine color and free from inclusions is of natural or of artificial origin. On the other hand, Pinier, one of the leading gem experts of Paris, asserts that an artificial ruby can always be distinguished from a natural ruby.

Artificial sapphires are made by M. Louis Paris, by a process which was described in the Scientific American of December 17th, 1908, and which differs from the ruby process chiefly in the substitution of cobalt for chromium and the addition of lime in order to prevent the separation of the cobalt. These sapphires are not as perfect copies of nature as the rubies here described. Even in chemical composition, density, and hardness they are not quite identical with natural sapphires, and in physical and optical characters they differ unmistakably from the latter. In short, they consist of colored alumina, melted and solidified, but not crystallized, and their artificial origin can be detected very easily.

AN AUTOMOBILE TROLLEY-REPAIR TRUCK.

BY DR. ALFRED GRADENWITZ.

The ability of the automobile to travel quickly naturally led to its use by the fire departments of the more prominent cities of the world. Its success in this field has further led to its adoption by some street railway companies as a repair vehicle. Inasmuch as most of the street railways of the world are now operated by electricity, it was but natural that the electric automobile should have been selected. The cost of charging the batteries involves no great outlay on the part of the company with an elaborate power plant at its disposal, and the vehicles themselves are so simple in construction that they can be operated by any of the mechanically trained employees of a railway company.

The conditions which require immediate repair of a live wire are not unlike those which demand speed on the part of the fire automobile. Until the damage is repaired the cars are often stalled.

In the accompanying illustrations we present views of the electric trucks designed by the Siemens-Schuckert Company for street railway repair. In Fig. 1 an electrically propelled power car is illustrated which consists of a substantial frame which can be moved up and down by a crank. The frame is mounted on a base so stable that even when rounding curves there is no tendency to side swaying. On the frame a platform is mounted on a turntable of considerable radius. The lowermost level of the platform is eleven feet and the uppermost fifteen feet from the ground. The platform is reached by means of a ladder. Within the frame, spare parts and wrecking tools can be carried. The seating capacity is two men besides the driver.

The electrically propelled truck pictured in Figs. 2 and 3 differs from that just described. Instead of a tower, a large collapsible ladder is carried, which, when extended, rises sixteen feet above the ground. This ladder is readily set up and folded.

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[*] The best reconstructed rubies were made by fusing minute rubies of inferior quality together with quartz crystal. The secret of the process was lost on the death of the inventor, a Swiss priest, who delivered the uncut rubies to a lapidary of Geneva. These rubies reached America in 1886. Some were very inferior, but others sold as high as $100 per carat and were—and are—as brilliant as the finest Burmese rubies. A few of them are still to be found in the possession of dealers and connoisseurs.