THE SUPERHARDENING OF HARD STEEL.

IN a paper entitled "The Work Hardening of Steel by Abrasion," presented by Mr. E. G. Herbert, of Levenshulme, Manchester, at the recent Glasgow meeting of the Iron and Steel Institute, it was contended that articles of hard steel, such as gears and cams of motor-cars, were superhardened by the surface action which occurred in service. The paper, and the subsequent discussion thereon, will be published, in due course, in future issues of ENGINEERING. When presenting his contribution to the meeting at Glasgow, the author stated that the investigation of superhardening, caused by wear, had suggested the inquiry whether articles of hard steel could be superhardened, beforehand, as a means of resisting wear. The result of that inquiry, continued the author, had been the invention, by him, of the "Cloudburst" process. Physicists told us, went on Mr. Herbert, that we were immersed in an atmosphere consisting of molecules travelling about with high velocity and constantly colliding with each other and with us. He would ask the meeting to imagine an atmosphere, the molecules of which consisted of small, hard, steel balls travelling about with high velocity and colliding with each other, and with any object immersed in it. An article placed in such an atmosphere would be subjected to a rapid succession of blows, and if a certain relationship existed between its hardness and the atmospheric pressure, *i.e.*, the momentum of the balls, its surface would be compressed without being sensibly indented. The article, if of hard steel, would become encased in a thin superhardened layer. If the velocity of the balls were now slightly increased, the hard layer would resist indentation, but would be increased in hardness, and in thickness. By gradually increasing the velocity of the balls, a superhardened layer could be produced, intensely hard on the surface and gradually decreasing in hardness throughout its thickness, which might be about 2 mm. As there was no abrupt change of hardness, there was no tendency for the layer to flake or scale off.

The actual hardness that could be produced depended on the superhardening capacity of the steel, which property was easily measured by means of the Pendulum hardness tester. The ball velocity required to produce this hardness could be determined by experience. Just as there was a relationship between the original hardness of the steel and the initial ball velocity, which compressed the surface without indenting it, so there was a relationship between the "maximum induced hardness" of the steel, as measured with the Pendulum, and the final ball velocity, which was sufficient to produce maximum hardness, but was insufficient to indent the superhardened surface. Any further increase of velocity would merely roughen the surface without increasing its hardness, and the whole superhardening process must, therefore, take place between these two limiting velocities. The process could, of course, be applied to produce a work-hardened layer on any metal, by adjusting the initial and final ball velocities to its original hardness, and to its "maximum induced hardness."

Hereupon, Mr. Herbert showed a number of slides to illustrate his process; these are reproduced in Figs. 1 to 5 on the present page. Continuing, Mr. Herbert said that Fig. 1 showed the superhardened layer in the fractured surface of a 1·25 per cent. carbon steel, hardened and superhardened. A micrograph of the same specimen, under a magnification of 20 diameters, was shown in Fig. 2. This specimen had been polished, etched, and tested for hardness in five places with the Pendulum and diamond. It depicted the hardness gradient of the superhardened layer, extending to a depth of 1·5 mm. The original hardness, namely, 57·2, was equivalent to 770 Brinell. The final surface hardness, namely, 75·7, was equivalent to 1,020 Brinell. On certain case-hardened steels, a maximum diamond time-hardness of 94·6, equivalent to 1,275 Brinell, had been produced by superhardening. Fig. 3 was a micrograph of a nickel-chromium steel, heat-treated and super-hardened, under a magnification of 20 diameters. Eleven Pendulum test impressions were shown over a depth of 1·7 mm., and the average surface hardness, namely 53, was obtained. The diamond time-hardness value of 53 was equivalent to 715 Brinell, and the original surface hardness, which was 38·8, was equivalent to 525 Brinell.

FIG. 1.

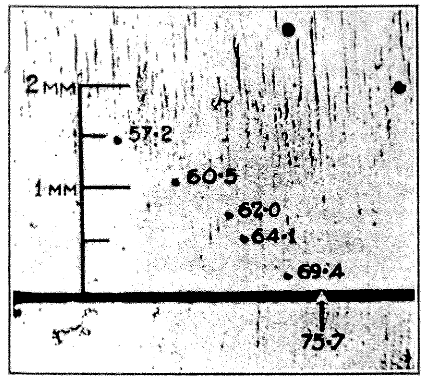

FIG. 2.

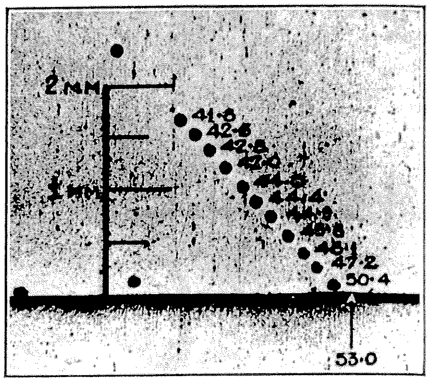

FIG. 3.

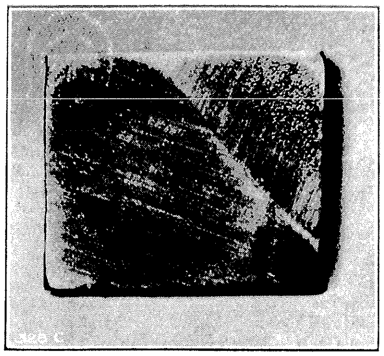

FIG. 4.

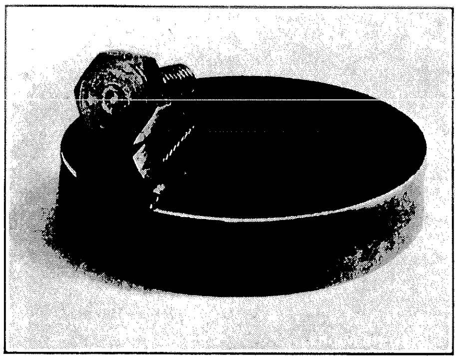

FIG. 5.

The atmosphere of steel balls was invented and investigated as a means of superhardening. The investigation had, however, revealed another effect of equal importance. The initial ball velocity was so adjusted to the hardness of the work that it was just insufficient to indent the surface. It followed that if any part of the work was soft, its surface would be indented and roughened. If, for example, a quantity of hardened-steel articles were placed in a ball atmosphere of correct pressure, it would be found, on removing them, that any soft articles, or soft spots, could be easily distinguished by their indented appearance. By means of this new process, which might become known as "Cloudburst Hardness Testing," large quantities of hardened articles could be tested for hardness without marking them, except on the soft spots.

The existing Cloudburst testing machine was capable of delivering 200,000 blows per minute. This, however, was only a small machine, and the number could be increased indefinitely. By choosing a suitable velocity, all surfaces, hard and soft, might be indented, and the hardness, at any part, measured by the size of the indentations. In Fig. 4 was shown a piece of mild steel, case-hardened. The case had been ground away at one corner and the specimen polished. The Cloudburst hardness test showed the soft core, and also revealed irregular soft patches at the other end of the specimen, but left the hard surface unmarked. A piece of steel, which had been case-hardened and superhardened, was shown in Fig. 5. The letter H had been painted on it with protective compound before carburising, and was decidedly softer than the surrounding surface. The Cloudburst had roughened the softer surface and had rendered it easily visible. The reflection of the steel screw showed the mirror-like superhardened surface.

For producing the steel-ball atmosphere, two methods had been employed. In one, the balls were allowed to fall into the chamber from a height which could be adjusted. Continuous circulation of balls was maintained by means of a conveyor. In the second method, the balls rolled down an incline and were struck in an upward direction by the vanes of a rotor, the speed of which could be varied. After entering the rubber-lined chamber in which the work was placed, the spent balls again rolled down the incline, thus maintaining a continuous circulation.

The whole process had been the subject of much investigation, but the possibilities of it had not been fully explored. In the development of the invention, as in the original research, the Pendulum hardness tester had been indispensable. Without it, the measurement of superhardening capacity, of surface hardness, and of the hardness gradient below the surface, would have been impossible.

NEW PUMPING STATION, HAVANT.

THE source from which the town of Portsmouth and the surrounding district derive their water supply distinguishes them from most of the other large communities in the country. Neither river water nor wells are used, but springs emanating from the chalk, from which the flow is collected in surface basins. These springs not only break out within a restricted area, having a length is about half a mile in an east and west direction, but are copious enough to meet the needs of about 280,000 people. In developing these resources, the Borough of Portsmouth Waterworks Company, Limited, have organised the springs in two groups, which are dealt with at pumping stations at Havant and Bedhampton respectively, these stations being interconnected by conduits, so that water from either group of springs can be pumped at both places. Without going into the history of the undertaking in too great detail, it may be said that operations were first begun with a pumping station at Havant in 1860, and that this was supplemented and finally replaced by a second station at Bedhampton, which was opened in 1889. The latter station has in turn been practically superseded by a new station at Havant. This is built alongside the original works, and was formally opened by the Mayor of Portsmouth (Councillor Frank J. Privett, J.P.), on Wednesday, September 21.

The water pumped from the springs by this plant is delivered to the Farlington reservoirs on the southern slope of Portsdown, about 150 ft. above sea level. Here it is filtered through eight open sand-filter beds, each nearly half an acre in extent, and thence flows into