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The Editor is always glad to receive for examination illustrated articles on subjects of timely interest. If the photographs are *sharp*, the articles *short*, and the facts *authentic*, the contributions will receive special attention. Accepted articles will be paid for at regular space rates.

THE RECENT HIGH-EXPLOSIVE SHELL TESTS AT SANDY HOOK.

In the presence of such a brilliant success as has just been achieved by the new army high-explosive armor-piercing shell against heavy Kruppized armor plate, there is, of course, always a danger of overestimating its value; but we shall be within conservative limits when we state that this is one of the most phenomenal and epoch-marking achievements recorded in the history of the long contest between guns and armor, the credit in this case, however, being due to the projectile rather than to the gun. From their very first appearance high explosives have appealed strongly to the artillerist; for it has been realized that if they could be detonated either against or within the structure of a warship, they would produce enormously destructive effects. Experimentalists in the matter of throwing high explosives have been divided into two schools. One of these, represented by Zalinsky with his pneumatic dynamite gun and Gathmann with his torpedo shell, have claimed that it was only necessary to explode a large amount of guncotton against the side or deck of a battleship to blow in the structure and sink the vessel. The other school has claimed that high explosives would be comparatively ineffective if detonated on the outside of the armored portions of a ship, and that the only way to secure their full effect would be to carry them in armor-piercing shot and shell through the armored sides of a vessel and burst them in her interior.

The significance of the recent tests at Sandy Hook lies largely in the fact that the two systems were tried out under exactly equal conditions, and that in one of them at least it was proved that we have a combination of an explosive, a fuse and a shell, which has given the highest possible results that could be demanded, and has placed the very best modern armor plate completely at the mercy of the gun. We refer, of course, to the high-explosive, armor-piercing shell, loaded with either dunnite or maximite, and provided with the Dunn delay-action fuse, which latter is absolutely necessary to the detonation of the high-explosive filler. The results of the test, as shown on our front page, make it certain that the best-protected armorclad afloat, if attacked at pointblank range, would be speedily put out of action, either by the disablement of her guns, the destruction of her personnel, or the ultimate sinking of the ship itself.

With regard to the Gathmann test, it is our opinion that while the results are not comparable, in their effect upon the plate itself, to those achieved by the army shell, the effects produced upon the target as a whole were so tremendous as to render the Gathmann shell anything but the absolute failure which it has generally been pronounced to be. A shell that is capable of crumpling in, in concertina fashion, the plate-steel framing of an "Iowa" and swinging the 12-inch Krupp plate with its steel and timber backing and several hundred tons of sand around, 8 feet to the rear and 8 feet to the left of its original position, is certainly entitled to be called something more than an absolute failure. At the same time it must be remembered that the target did not represent actual conditions; for had the plate been standing in its proper place on the side of a battleship, the lateral and vertical displacement which took place would have been impossible, since the plate would have been held in position by the strong armor shelf below, the 12-inch adjacent armor plates on either side of it, and by the mass of 6-inch side armor above it. Under such conditions it is quite a question whether the blast of the guncotton and the 52,000 foot-tons striking energy of the shell would have proved sufficient to crush in the plate-steel backing, representing the framing of the ship, in the way that it did in this test. The problem could only be settled by a trial under actual conditions. At the same time it is argued that it was the cushioning effect of the yielding plate frames that prevented the detonation from exerting its full effect upon the plate itself; and it is urged that had the plate been laterally and vertically supported, the energy of the detonation, which here showed itself in swinging the whole 700-ton mass of the target around to the left, would, had the plate been rigidly supported in the side of a ship, have expended its energy in smashing up the plate. It is possible, of course, that the tamping effect due to a more rigid backing would have concentrated the force of the detonation on the plate itself, and this contention is borne out by the fact that at Indian Head the detonation of 500 pounds of guncotton merely suspended against a 17-inch armor plate that was backed solidly against a cliff of wet clay, resulted in the complete demolition of the plate.

Justice to the Gathmann shell compels us to draw attention to these facts; but at the same time it must be remembered that a shell of the same size as the Gathmann filled with either maximite or dunnite, which have a greater density and far larger explosive energy, would have done more than the Gathmann shell, and would probably have smashed the plate into fragments. Moreover, the new army explosives are absolutely insensitive to shock; are perfectly safe to handle, and both the chemical composition and the delay-action fuse which is essential to their detonation are secrets which are in the safe-keeping of the United States army.

A NEW THERMO-ELECTRIC COUPLE.

In 1827 the elder Becquerel showed that copper sulphide is strongly positive to ordinary copper. He pointed out that thermo-electric couples of copper sulphide and copper yield electromotive forces greater than those obtained from any other bodies which he had tried, such as iron sulphide and manganese peroxide. These researches were continued by Edmond Becquerel in 1865 and 1866. He showed that copper sulphide can be used for the construction of thermo-electric couples in contact with copper or German silver, and remarked that in order to obtain powerful effects the copper sulphide should be in a peculiar condition. He claimed that the best means of obtaining this peculiar condition was to heat the sheets of copper in sulphur vapor, and then to melt the copper sulphide thus obtained, and to cast it in molds at a temperature as nearly as possible equal to its melting-point. Eugene Hermite and Charles F. Cooper, of Paris, France, in a patent which they have received in the United States declare that they have proved that in this last point the younger Becquerel was in error. Becquerel obtained bars of sulphide having a fibrous fracture with bubbles disseminated through the mass. If the melting is repeated several times at a high temperature and if the homogeneous mass is cast, MM. Hermite and Cooper state that its thermo-electric power is merely destroyed. In spite of all his precautions Becquerel did not always obtain bars giving the same electromotive force.

Ruhmkorff stated that by adding to the copper sulphide a little antimony sulphide he obtained bars of a more uniform thermo-electric power. Finally Becquerel, continuing his researches, found that by reheating his bars of melted copper sulphide for several hours, the thermo-electric power became more regular. Becquerel constructed a thermo-electric battery in the laboratory with bars of fused copper sulphide thus obtained, covered at their ends with coils of German silver wire or copper. This battery gave an electromotive force relatively much higher than that obtained from any other thermo-electric couple studied; but the internal resistance of the battery was so great that it was of no practical use. Such was the state of affairs when Hermite and Cooper began their researches. As a result of their investigations they have reached the conclusion that copper sulphide properly prepared and coupled with certain metals is eminently fitted for the construction of industrial thermo-electric batteries.

The difficulties to be overcome are, first, to obtain copper sulphide in a form virtually quite homogeneous and offering the least possible electric resistance and at the same time yielding a constant electromotive force variable for given temperatures, and second, to make contacts between the copper sulphide and the metal employed which will be indestructible by heat, and which will at the same time suppress all accidental and useless resistance to the passage of the current. The inventors are probably the first to show an industrial method of using copper sulphide. Becquerel's battery was merely a laboratory curiosity.

The copper sulphide is melted and then cast in molds of sand to give it the form desired in the construction of the couples. The pieces obtained are placed in a crucible or furnace and heated to redness, whereupon they are subjected to the action of sulphur vapor for about half an hour. The piece absorbs the sulphur and increases in volume. If the crucible or furnace be opened, the piece will be seen surrounded by the blue flame of burning sulphur. Before the complete disappearance of this flame, the piece is withdrawn from the furnace and allowed to cool. In this condition the copper sulphide gives only a very weak electromotive force, and offers most resistance to the electric current. It is therefore replaced in a well-closed furnace and heated to bright redness for several hours under the exclusion of air, copper sheets or ingots being placed in the furnace to absorb the sulphur vapor involved.

This operation reduces the resistance considerably, and every piece gives a perfectly regular electromotive force of from two-tenths to three-tenths of a volt, depending upon the temperature to which it is heated. By adding a small amount of sulphide of iron it is found that the action of the final roasting is strongly resisted. Hermite and Cooper have found that the best metals for the contacts in the construction of thermo-electric couples are copper, German silver, silicon iron or steel, chrome iron or steel, platinum or platinum iridium, and chiefly commercial brass. Brass oxidizes much less than copper when hot; and strange to say, does not combine in a red heat with sulphur as copper does. The discovery that copper can be transformed into sulphide on the surface of brass is the key to the new method of preparing contacts on the bars or tubes of copper.

THE GROWTH AND STATUS OF NATURAL GAS.

Aside from coal, gas now forms the most important fuel, and while much has been written concerning the decadence of the natural gas supply and the substitution of artificial gas produced from coal for the natural product, the fact remains that the natural gas production is still considerable, and this form of fuel has still a wide importance in industrial operations, although the supply at this day is not up to that of a few years ago, when the natural gas production was in the heyday of its existence. For ages natural gas escaping from the ground has been known to mankind. In primeval days it was venerated by the fire worshipers, and down through the ages we have faint records of its presence at various places, but it remained for modern days to effect the utilization of the product so as to bear upon the course of human progress.

Geology gives the gaseous, liquid and solid carbon compounds and bitumens a close relationship, and tells us that rock gas, now generally recognized as natural gas, is technically known as carbureted hydrogen and that marsh gas is one of its important constituents. Concerning the genesis of natural gas various hypotheses have been put forth. Some contend that its origin is organic, while others cling to the inorganic theory. Modern science is able to transform wood into lignite, and from that substance into bituminous coal, and it is now pretty well accepted that natural gas is the product of the slow decomposition of organic matter at a low temperature. In New York, Pennsylvania and other sections of the Appalachian field the gas pockets are mostly confined to the oil sands of the Devonian period, while in other sections they occur in the carbonaceous, the cretaceous, and the tertiary geological formations. Like petroleum, the natural gas belt seems to run around the world from Canada to California and northward from Hindostan to Wallachia, but it exhibits a less continuous sign than does petroleum. For twenty or thirty years the history of natural gas was coincident with that of petroleum, with the exception that the oil was utilized and gas despised. Nearly all the oil wells produced some gas, but its value was not early recognized, and for a long time wood was used to fire the boilers in oil-well drilling, while the gas was allowed to go to waste.

Probably the first attempts toward the utilization of natural gas were made in western Pennsylvania, where the oil industry was an important one as early as the middle of the last century, and it is certain that the first discovery of natural gas in this country was made in this section. The earliest record of the product dates back to 1823, when John Klingsworth, Philip Klingsworth and Nicholas Long struck a gas pocket at a depth of 300 feet while drilling a salt well near Grapeville, thirty miles east of Pittsburg. The gas rushed to the surface with great force, and, igniting, burned fiercely for months, but it was not until about fifteen years ago that the real value of the gas deposits at Grapeville were developed, and this field proved one of the most prolific in the country. For many years the existence of gas in Washington County, Pennsylvania, was known and throughout the oil regions of western Pennsylvania the product was invariably found.

One of the first natural gas companies organized in this country was the Fuel Gas Company, organized in Pittsburg in 1874. The organization of the Philadelphia Company in July, 1884, marked the real beginning of the natural gas industry, and the capital of the natural gas companies operating in Pittsburg in 1886 aggregated $20,000,000. That year saw a decided increase in the production and consumption of the product, and it was in that year that natural gas was first applied to the manufacture of glass. As early as 1885 the new fuel was responsible for the