EXPERIMENTS ON THE EFFECTS OF DETONATING GUN COTTON AT THE U. S. TORPEDO STATION, NEWPORT, R. I.

At the 1885 meeting of the American Association for the Advancement of Science and Art, much interest was excited by a paper read by Commander T. F. Jewell, U. S. N., detailing the results obtained at the U. S. torpedo station at Newport, R. I., with cylinders of compressed gun cotton. The reproduction, by the force of the explosion, of characters cut or impressed upon the face of the cylinders was described and specimens were produced. One of the old theories, to the effect that the gases produced in such a detonation preserve for an instant the shape of the original mass of solid material, was rather negatived by the peculiar fact that marks excavated in the cotton were produced, not in relief, but in corresponding depression in the iron. The subject has been further investigated by Prof. C. E. Munroe, chemist in the U. S. naval service. His high authority on the subject of explosives gives peculiar value and interest to his work. At the last meeting of the A. A. A. S., he read a paper on the subject, and exhibited the specimens which we illustrate.

The gun cotton used for the experiments was of the regular service supply. It was compressed into cylinders (Fig. 7) or cubes with truncated corners (Fig. 8). One of the cylinders is also shown in the cut below, where it is designated by A. Their size is two inches high and three and one-half in diameter. The cubes are about the same. Through the center of the blocks of each form a hole is made for the reception of a cap of mercury fulminate.

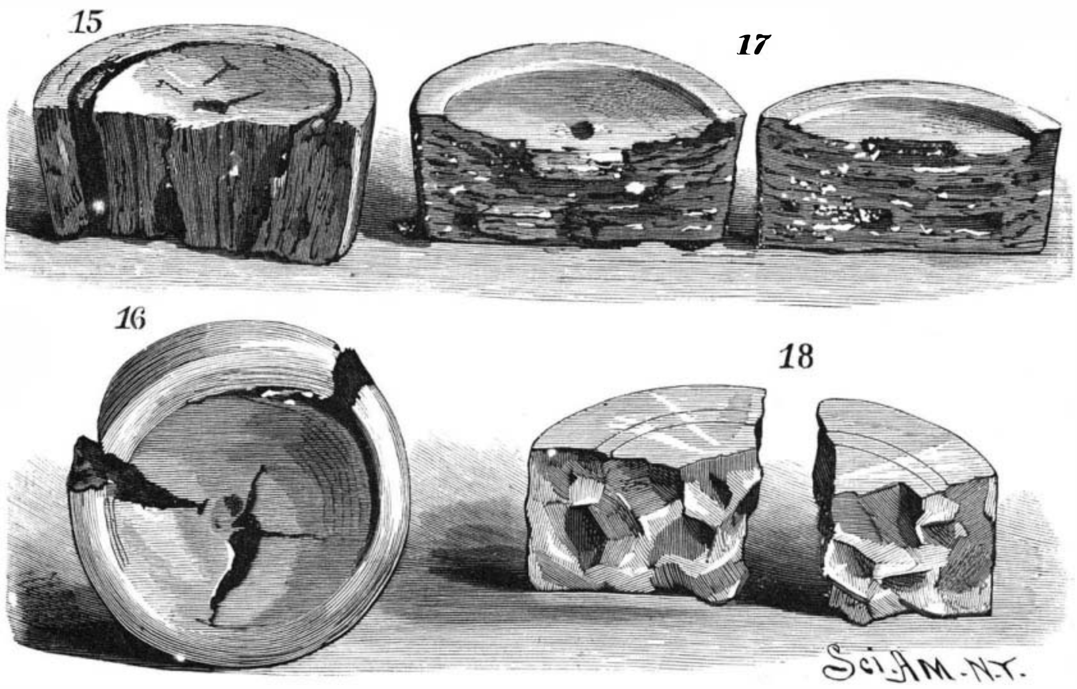
The plates of iron used are about one-half of an inch in thickness and four or five inches square. In conducting the experiments a block of the gun cotton is laid upon one of the plates, resting in its turn upon an iron beam or heavy plate. The detonator is set into the aperture in the center of the block, and a current of electricity from a hand generator is sent through it. This explodes the fulminate, which, in its turn, explodes the cylinder or cube of gun cotton.

The arrangement of the respective parts and the construction of the primer is shown partly in section in Fig. 14. The general arrangement is also shown in perspective in the cut on this page. The fulminate is contained in a copper case. Through its top two wires are introduced, and across the space between their ends a fine platinum wire extends, being secured by soldering. The wire is surrounded by fine gunpowder. Below this is the fulminate. The effect of the electric current is to heat the wire to incandescence. This explodes the gunpowder, which, in its turn, causes the fulminate to explode, and the latter acts upon the gun cotton, effecting its detonation.

The blocks of gun cotton in their manufacture have impressed upon their face the letters U. S. N. and the year of manufacture. These letters are sunk into the face. On placing the cylinder on the iron plate, so as to rest upon this face, and exploding it, a saucer-like depression is produced in the plate. In the center, where the priming aperture of the cylinder was located, an excavation is made where naturally an elevation would be looked for. The letters are reproduced with great exactness, but in the same peculiar way. The sunken letters on the gun cotton appear as sunken characters in the solid iron. In other words, exactly the reverse effect is produced of that which would be anticipated.

This initial experiment was the one first described by Commander Jewell. Starting with this as a basis, quite a series of experiments have been performed.

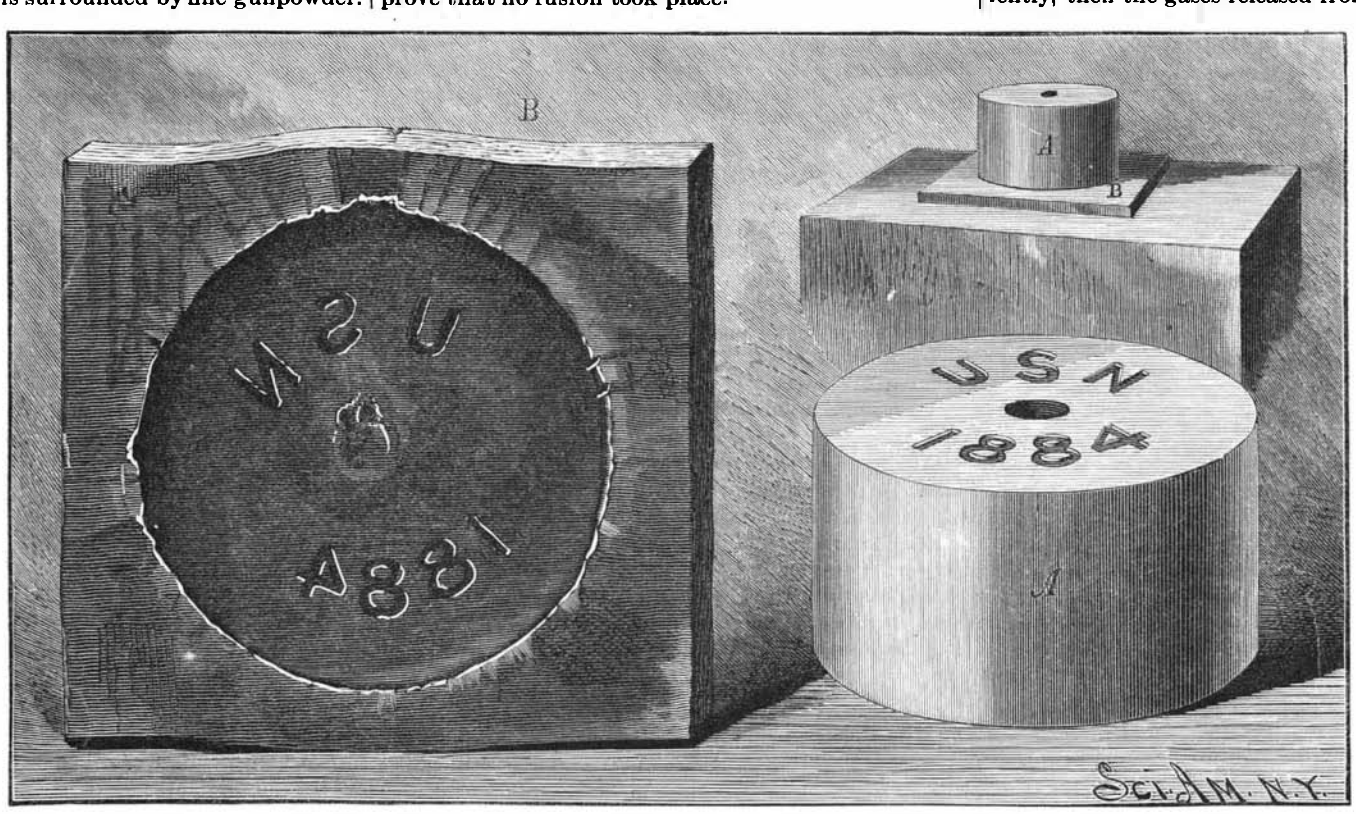
Across the face of a cylinder of gun cotton some grooves were cut by a pen knife. Gun cotton is somewhat fibrous and soft. The grooves, therefore, were not smooth and well defined as if they had been cut in harder material. On exploding the cotton with the face thus prepared in contact with the iron, the grooves are reproduced in *intaglio* with wonderful accuracy.



TESTS OF QUALITY OF IRON AND STEEL.

The little projecting fibers and irregularities are all to be found in the solid iron. Some of the results of this experiment are shown in Figs. 1 and 2. On the same principle, an irregular excavation was made with a gouge in a cylinder, which was exploded upon a plate, with the result shown in Fig. 3.

The next step was to use a plain surfaced cylinder and substitute extraneous markings. This was done by laying a piece of wire gauze over the iron plate. Upon this the cylinder was placed and exploded. The result is shown in Fig. 4. The wire gauze was driven down and so destroyed as regards its structure that it was impossible to say whether it was melted or not. The bright yellow metal, however, was plainly to be seen. Around the edge of the depression radiating marks of the color of brass, and due to fine brass "plating," were formed. The reticulations of the gauze were reproduced with accuracy, the openings forming depressions, while the contour of the interwoven wires remained in relief. In this plate there was no trace or indication of oxidation visible. The brass was all of bright color and of a true brass color. This tended to prove that no fusion took place.



THE INITIAL EXPERIMENT WITH CYLINDER OF GUN COTTON AND PLAIN IRON PLATE.

In Fig. 5 a plate is represented upon which a cylinder was exploded, whose characters were filled with vaseline.

No impression of the letters was produced, the vaseline preventing the action. In some experiments a number of cylinders were piled up on each other. In one instance four were thus arranged and exploded, when a very large and deep depression, corresponding to the central aperture, was produced.

The cylinders of gun cotton were marked differently from the cubes. The latter had letters in relief upon a sunken ground. On exploding one of these, the characters were reproduced in relief upon a sunken ground. The plate is shown in Fig. 6, while directly below it one of the cubes is shown.

The next experiment went to prove that this peculiar effect is only produced by the surface of the gun cotton. Upon a plate of iron some characters were cut. It was laid upon another one with its engraved face downward, and the two were placed upon a bed plate, and a cylinder was exploded upon them. The result was striking only as an illustration of the power of the explosion. The letters were reproduced in relief upon the lower plate. The action was that of a die and blank in a coin press. The two plates are represented in Figs. 9 and 10. One plate was driven down into the other, forming a saucer-like depression and corresponding elevation.

Characters were cut into a plate, and upon the engraved face a cylinder was exploded. Here little effect was produced, except that a secondary impression of one of the letters was discernible. This experiment is about the most unexplainable of all. The plate, after the explosion, is shown in Fig. 11.

It was of interest to determine if a soft body could produce an impression upon iron. Between two plates a couple of green leaves were placed, and gun cotton was detonated upon the pair of plates. Impressions of the leaves were produced, very faint, but exact. One of the plates is shown in Fig. 12. The direct action of gun cotton was next to be determined. Accordingly, a leaf was placed directly under a cylinder of gun cotton, lying between it and a plate of iron. On explosion the leaf was, of course, annihilated, but its impression was left, marked out exactly upon the metal, the ribs and outline all being sharply defined. This plate is represented in Fig. 13.

This interesting series of exhibits illustrates the phenomenon in its various phases very clearly. One of the early attempts at explaining it referred it to the indisposition of air to suddenly change its form when exposed to compression. This explanation was, however, a theory based only upon the first experiment, and fails to account for the action in the case of wire gauze. A more probable one is derived from the projectile force of the gases of explosion. If we assume this kinetic energy to be capable of acting upon the iron so violently, then the gases released from excavations have a longer range of action, and consequently a higher force of impact. Or the force of the gases may be in ratio with the surfaces of emission. In this case an excavation furnishes a larger surface per area of action than does a flat surface. It would seem possible that both of these causes had a part in the reaction.

In Figs. 15, 16, 17, and 18 some interesting experiments are shown illustrating the use of gun cotton as a means of testing the quality of metal. By its use soft iron and steel are distinguished. The steel is broken into angular fragments, as shown in Fig. 18, while iron resists the sudden shock much better, and if it does break, shows a different fracture, one which is far more fibrous. The same test affords a clew to the treatment to which metal has been subjected in the manufacturing process. In Figs. 15 and 16 the section of a bar fractured by it is shown. From the appearance of the metal, it is clear that it was not of even quality. In all probability it was rolled, and the ac-

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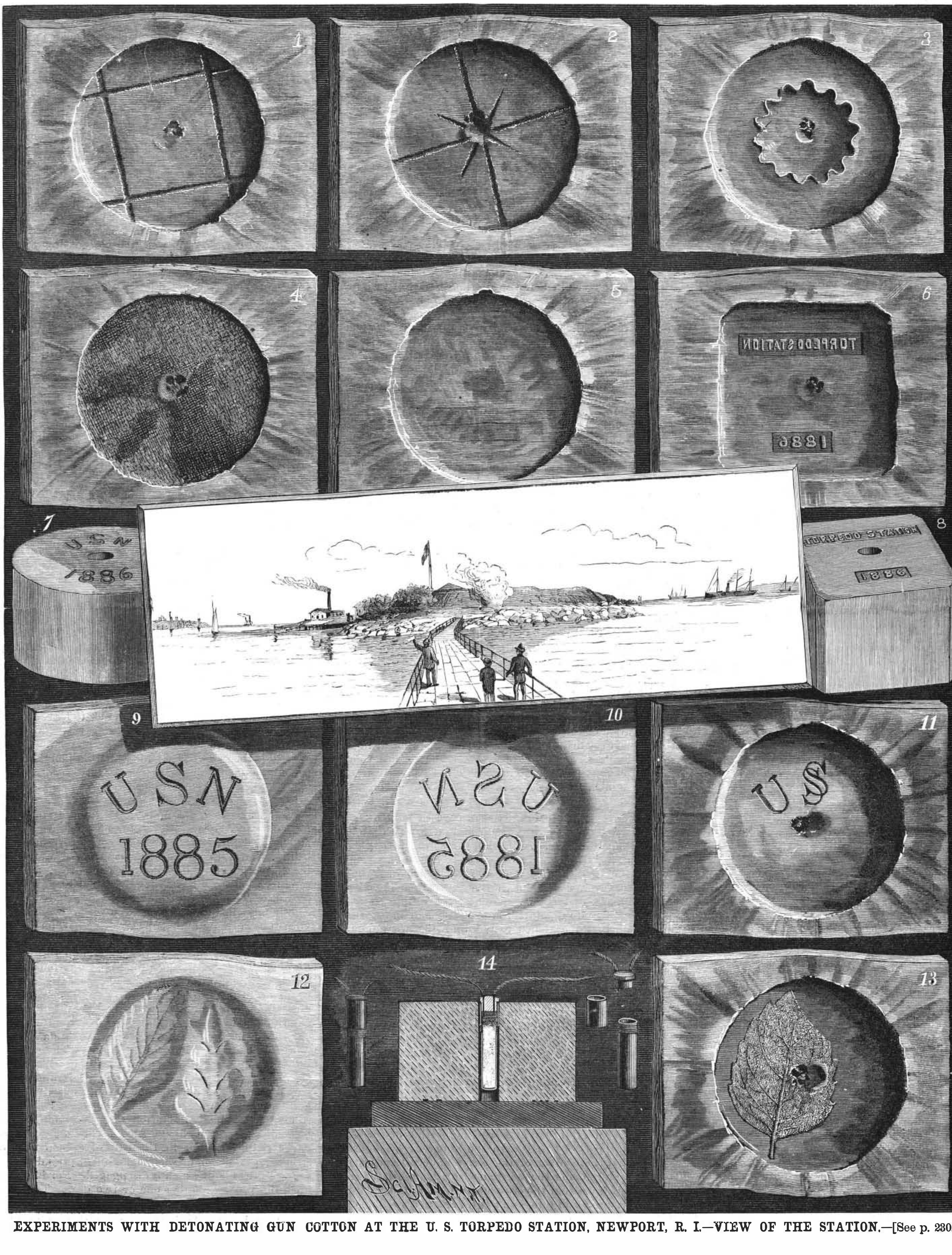

EXPERIMENTS WITH DETONATING GUN COTTON AT THE U. S. TORPEDO STATION, NEWPORT, R. I.—VIEW OF THE STATION.—[See p. 230.]

tion of the rolls did not reach its center. Thus a different quality of metal in the circumference was produced. At any rate, want of homogeneousness is shown, and it is evident that it is not a hammer-forged bar. The appearance of homogeneous iron when fractured is shown in Fig. 17. This purported to be hammer-forged, and from the test there is every reason to believe that it was. Thus a simple and effective method of testing metals is at the service of the mechanical engineer.

GEORGE FREDERIC BARKER.

The proudest boast of an American citizen is that he is a self-made man. To overcome difficulties and acquire a high reputation by persistent effort is indeed well worthy of the highest ambition. Those who have made science a profession have, for the most part, been thoroughly educated and carefully trained in the leading universities and schools of the world. A notable exception is the subject of this sketch, whom we may fairly claim is a self-made scientist.

George Frederic Barker was born in Charlestown, Mass., under the shadow of Bunker Hill, on July 14, 1835. He was the son of a sea captain, who commanded one of the packet ships then sailing between Boston and Liverpool. His early education was received in the public schools of his native town, but in 1849 his parents moved to South Berwick, Me., where he continued his studies in the classical academy of that town, and later at similar institutions in Groton, Mass., and Yarmouth, Me. While a student he showed great fondness for the physical sciences, and even at that time was given charge of the chemical and physical apparatus.

The knowledge thus acquired he applied practically, for he celebrated the Fourth of Julys with fireworks of his own manufacture, and accompanied the performance with electrical displays from Leyden jars, galvanic batteries, and friction machines, which he himself had constructed.

In 1851 his father took him to Europe, and he visited the great world's fair held at the Crystal Palace in London—the first of the international exhibitions, on the juries of which, in later years, he has served.

On his return, the boy, then sixteen years of age, with a fair education, was apprenticed to J. M. Wightman, of Boston, a well known maker of philosophical apparatus. For five years he was employed in this manner, acquiring not only a knowledge of the principles of mechanical construction with the use of tools, but also learning the scientific principles which the apparatus embodied and illustrated.

The system of fire alarm telegraph which William F. Channing and Moses G. Farmer were at that time introducing in Boston attracted his attention, and he formed a warm personal friendship with Mr. Farmer, that has since continued.

His apprenticeship ceased when he became of age, and he determined to supplement his practical knowledge with two years' study. Accordingly, he entered the Yale, now Sheffield, Scientific School, and was graduated in 1858 with the degree of bachelor of philosophy.

His entire university career was limited to a two years' course at Yale, the last half of which was spent as private assistant to Benjamin Silliman, Jr. Compared with those who have supplemented the usual college course with years of study in foreign universities, Professor Barker stands out as a scientist whose early training was practical.

In 1858–59 and in 1860–61, he assisted Professor John Bacon in his lectures on chemistry at the Harvard Medical School, and in 1861 was called to the chair of physical sciences in Wheaton College, Ill.

He was invited, in the autumn of 1862, to fill, temporarily, the professorship of chemistry in the Albany Medical College, where he remained until 1864, having meanwhile pursued a course in medicine, and in 1863 he received the degree of M.D. from that institution.

After delivering his third course of lectures, he was, in 1864, chosen professor of natural sciences in the Western University of Pennsylvania, in Pittsburg, where he remained a year. It was at this institution that the apparatus placed at his disposal for demonstrations proved to be that which he had constructed years before when an apprentice in Boston.

In 1865 the younger Silliman urged his return to New Haven as demonstrator of chemistry in the Yale Medical School. This appointment he accepted, and in 1867 he became the professor of physiological chemistry and toxicology in that department, also having charge of the entire instruction in the academical department of Yale during the absence of Professor Silliman in California, during the college year 1866–67; and he likewise delivered the lectures on chemistry at Williams College in the years 1868 and 1869. In 1873, when the University of Pennsylvania remodeled its scientific department and erected new buildings at West Philadelphia, Professor Barker was invited to fill the chair of physics, an appointment which he accepted and has since filled.

The collection of physical apparatus selected by him, now in the possession of that university, is probably unsurpassed in the United States, and in some branches it is absolutely unique in the world.

Of his original work it is difficult to write, for his career has been so largely a public one that his investigations have either been of a special character, called forth by government or private request.

He was invited by the late Henry Draper to become a member of the expedition which observed the solar eclipse of July 19, 1878, from Rawlings, Wyoming. Professor Barker was specially assigned to the observation of the spectrum of the corona.

For this purpose he used a Merz spectroscope of high dispersion, and during the totality he saw distinctly several of the dark lines characteristic of the spectrum of the sun's disk, thus confirming the observation made by Janssen in 1869. In 1886 the latter again obtained like results, in his observations made at the Caroline Islands.

It was at this time that Mr. Edison, who was one of the party, established the fact of the existence of heat in the solar corona. Indeed, all of the results obtained on the Draper expedition tended to prove that a part of the light of the corona is reflected from the sun.

NATIONAL ACADEMY OF SCIENCES.

During the years since Professor Henry Draper's death, many of his unfinished researches, that were placed by Mrs. Draper in Professor Barker's charge, have been gradually approaching completion, and already some of them have been published.

As an expert in court, Professor Barker has very ably distinguished himself. In the line of chemistry and physics, his reputation is unequaled in the United States, and his great knowledge of these subjects is universally conceded. The power of explaining complicated forms of apparatus in simple language, and of demonstrating to conviction a scientific problem, is the secret of his power.

During his connection with the Yale Medical School, important toxicological cases were submitted to him for examination. Of these the Lydia Sherman case in 1872 is the most celebrated, owing to the interest which it created at the time.

On account of the inefficient testimony offered in the Wharton trial, a doubt had been raised in the public mind as to the possibility of detecting by means of chemical analysis the presence of poison in a dead body.

Mrs. Sherman was accused of having poisoned three husbands and four children within the space of three years, and the bodies of four persons were given to Professor Barker for examination. He established the presence of arsenic in each, and nearly two hundred specimens of this poison in various forms, obtained by him from his analyses, were placed on exhibition in court during the trial.

This overwhelming evidence resulted in a full confession by Mrs. Sherman, thus substantiating the analytical results obtained by Professor Barker, and the confidence of the community was largely restored to a belief in the value of such testimony. The chemical evidence was subsequently inserted as a typical case in the later editions of Wharton and Stillé's "Medical Jurisprudence."

He has also served as expert in many chemical patent cases, of which the phosphate baking powder suit is perhaps the best known, and he was one of the scientific witnesses on behalf of the people in the suit in New York City where the use of the lactometer by the health authorities was opposed.

His attention since his residence in Philadelphia has naturally been more in the direction of physics. With the advent of the electric light, and in its subsequent development, Professor Barker has taken a leading part. His relations with Thomas A. Edison have been exceedingly confidential, and he is the retained adviser on scientific matters to the great inventor.

His intimate knowledge of this subject led to his being requested by the department of justice to act as one of the government experts in the suit against the American Bell Telephone Company. He has appeared in other important telephone suits, and testified in behalf of the American Union Telegraph Company in their suit against the Western Union Telegraph Company on the Page patents.

In 1881 he was appointed one of the U. S. Commissioners to the International Electrical Exhibition, held during that year in Paris, and also was a delegate to the International Congress of Electricians convening at the same time. He was made one of the vice-presidents of the jury of award, and was decorated by the French government with the cross of commander of the Legion of Honor, of which organization he is the ranking officer in the United States.

He was appointed, in 1884, by President Arthur, a member of the United States Electrical Commission, which was formed for the purpose of determining the standard of the electric light.

Among the municipal appointments which Professor Barker has held in Philadelphia, several are noteworthy. These include studies of the local water supply, the quality of illuminating gas, and means for protecting the public buildings from lightning.

As a lecturer, Professor Barker is fluent and forcible, with a perfect command of his subject. For the elucidation of his topic, he finds no experiment too troublesome, and prosaic formulas acquire under his influence new and vivid significance.

During the winter of 1859–60, he gave a series of lectures on scientific subjects in Pittsburg, under the auspices of the Western University of Pennsylvania, and in 1864 he was invited to address the Chemical Society of Union College, on which occasion he spoke on the "Forces of Nature."

In 1871 he delivered a lecture before the American Institute in New York City, on the "Correlation of Vital and Physical Forces," in which he advanced the idea that the word "mind" possessed a certain physiological significance, and could represent the energy phenomena of brain tissue in the same way as mechanical work represents that of muscular tissue. From experiments performed in his own laboratory, he had proved that mental action did not increase the destructive assimilation of brain tissue any more than muscular work increased that of muscular tissue.

His lectures on "Spectrum Analysis" and "Electricity and its Applications" have been given before crowded audiences in the Academies of Music in New York and Philadelphia. In 1876 he was elected to membership in the National Academy of Sciences, and has served on many of its important committees that have furnished reports to the government, notably those "On the Measurement of the Velocity of Light," in 1878; "On the Co-operation with the National Board of Health," in 1879–80; "On the Separation of Methyl from Alcohol," in 1883; and he was chairman of those "On Glucose," in 1883, and "On Opium," in 1886. Professor Barker is also chairman of the standing committee on the Henry Draper medal, which honor was in 1885 conferred on Samuel P. Langley, and in 1887 on Edward C. Pickering.

In 1859 he joined the American Association for the Advancement of Science, and in 1876 presided over the section of chemistry, delivering an address on "The Molecule and the Atom" which is a valuable contribution to theoretical chemistry. At the St. Louis meeting, in 1878, he was elected president of the Association, and after presiding over the Saratoga meeting, delivered his retiring address at Boston, in 1880, on "Some Aspects of the Life Question," a masterly discussion of the oft-repeated query "What is life?" that attracted very general interest, not only from the scientific world, but also from the cultured public.

Professor Barker is one of the secretaries of the American Philosophical Society, life member of the Chemical Society of Berlin and of the Society of Tele-