them unbroken lines from the bottom chord of the trussed arch to the top chord of the superstructure trusses. The whole effect is harmonious and extremely pleasing.

A study of our illustrations, of one-half of the great central arch, shows that there is a line of wind bracing running through the lower chord of the arch and that sway bracing is introduced between each pair of vertical members throughout the whole arch. There is no lateral bracing, however, between the upper chords of the arch, the whole duty of resisting the wind strains being thrown upon the lower lateral system.

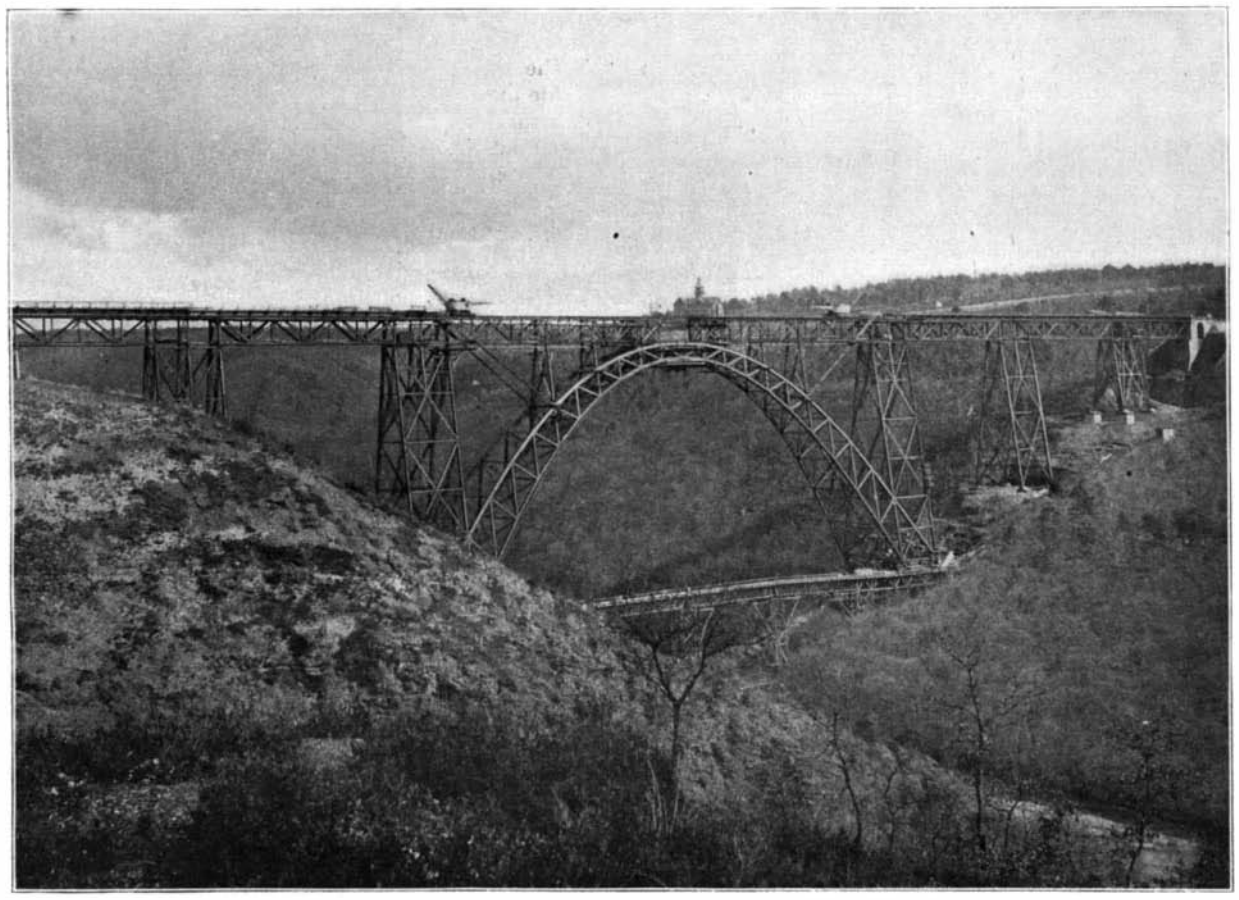
The superstructure trusses do not call for any special description. They are of the standard Warren type, with alternate struts and ties at each panel point. To provide for expansion and contraction, the superstructure trussing is divided at two points, which are located at the towers above the springing of the main arch.

The construction of this bridge, which was carried out under Mr. A. Rieppel as chief engineer, presented, on account of the great depth of the valley, considerable difficulty. A special plant operated by electric power was laid down at the site of the bridge, and extensive buildings, including residences for the workmen, were constructed. To begin with, a temporary inclined railway was built parallel to the line of the bridge down each slope of the valley, while a trestle bridge of timber was constructed to carry the railway over the river Wupper, the inclines being worked by separate electric winches. The portions of the bridge extending from the abutments to the springing piers at the main arch were erected first, the piers being built by the assistance of interior staging to their full height and the superstructure trusses erected on falsework and temporary trusses. After this portion of the bridge had been completed, temporary anchorage bolts were attached, which extended diagonally back from the first pier to an anchorage chamber which had been excavated from the solid rock of the hillside. These anchorages were put in to resist the horizontal pull due to the erection of the main arch by the overhang or cantilever principle. One of our illustrations shows this portion of the work completed prior to the building out of the main arch.

The great arched trusses and the superstructure trusses were built out, a panel at a time, without the use of any temporary falsework beneath, and as the overhang increased, the bending strain on the arch was relieved by tying the structure back to the piers. Two of these temporary ties are shown in our illustration, Fig. 2.

Unlike other great arch bridges, such as those at Niagara, Garabit, and Grunenthal, the Mungsten bridge is not provided with hinges at the skewbacks. While the absence of these hinges produces more complexity in the calculation of the stresses of the bridge, due to the reversal of strains, it provides a structure having greater rigidity and offering less difficulty in erection.

We are indebted for our illustrations and particulars to Fritz Müller von der Werra, civil engineer, of this city.



4.—THE MUNGSTEN BRIDGE.

Total length, 1,590 feet; span of arch, 557·6 feet; depth from floor to river, 354 feet.

PROPOSED ARMAMENT FOR OUR THREE LATEST BATTLESHIPS.

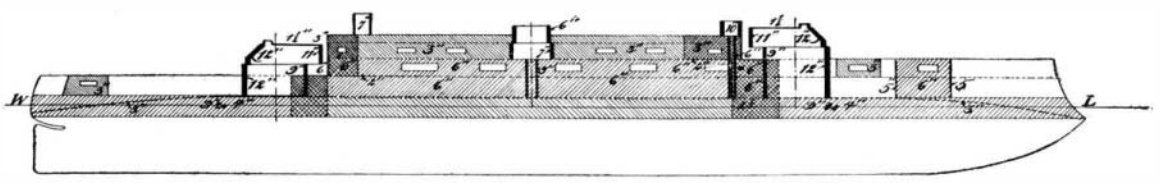
By the courtesy of Rear-Admiral O'Neil, Chief of the Naval Ordnance Bureau, we are enabled to reproduce the accompanying plans, which were submitted to the Bureau of Construction as suggestions in regard to the armament and armor of our three latest battleships, "New Jersey," "Georgia,' and "Pennsylvania," authorized by the last Congress. They show the many improvements which are possible on a given displacement as the result of the greatly increased resisting power of the latest type of armor and also as the result of the increased energy due to longer guns and higher velocities.

Our Construction Bureau has never turned out a more creditable design than that for the "Alabama" class of battleships, and we notice that in the successive designs, first of the "Maine" and now of the "New Jersey" class, the Bureau has wisely maintained the general distinctive features of the "Alabama," and merely added such improvements as were possible owing to the general advance which has been made in guns, armor and motive power.

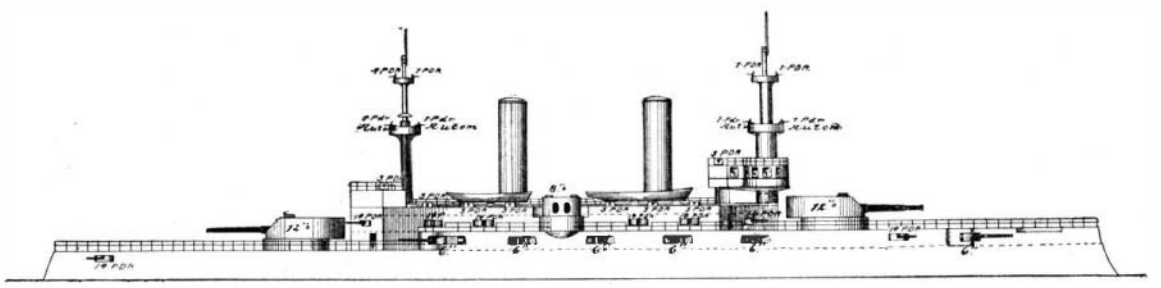
Rear-Admiral O'Neil has prepared five separate plans for the new ships. They all possess the highly meritorious and characteristic features of carrying extremely powerful batteries and being provided with a very complete system of protection. While all of the designs are creditable, we must confess that the first of them, known as type A, of which we present two different views, appeals to us as being decidedly the most efficient, and containing the best combination and proportion of the different types of guns. The five designs are identical in displacement, speed, and in the arrangement of the protective armor. Each plan, moreover, provides the same number of guns of each caliber and the same distribution in the secondary batteries, indeed the only modifications in the plans are those relating to the main battery in which are included the armor-piercing guns and the heavier rapid-fire weapons above 6 inches in caliber.

The distribution of the armor is in every way admirable, and is far more complete than anything that has yet been attempted in any of the navies of the world. In the first place, there is a complete waterline belt 8 feet in depth, which extends from stem to stern. It is 9 inches thick at its upper edge and carries this thickness for a depth of 4½ feet, from which level it tapers gradually to 6 inches at the lower edge. This belt maintains these thicknesses over that portion of the ship extending between the 12-inch turrets, and at its extremities transverse bulkheads, 9 inches in thickness, extend diagonally inward to meet the barbette armor of the 12-inch guns. From abreast of these barbettes to the stem and stern the waterline armor is gradually reduced to 4 inches in thickness. From the top of the waterline belt to the level of the upper deck, and extending forward and aft, as shown on the plans, the sides are protected by 6-inch armor, at whose ends are diagonal walls 6 inches in thickness, the whole forming a complete central casemate or redoubt, within which are placed ten of the 6-inch rapid-fire guns. Every 6-inch gun is further protected on both sides by splinter bulkheads 2½ inches in thickness, and each of these separate casemates is closed at the rear by bulkheads of 2½-inch steel. The 6-inch guns in the bow of the vessel on the main deck are each protected by a complete casemate 6 inches in thickness on the outside, and with walls 5 inches thick in the interior of the ship. These casemates, like the main central casemate, extend from the protective deck clear to the upper deck. Above the central 6-inch gun redoubt there is another complete redoubt of 3-inch steel, within which is carried a battery of twelve 3-inch 14-pounder guns. There are also two 14-pounders on either bow on the main deck, just abaft of the 6-inch bow guns, while two others are placed on either quarter near the stern on the berth deck, all four of these guns being also protected by 3-inch armor.

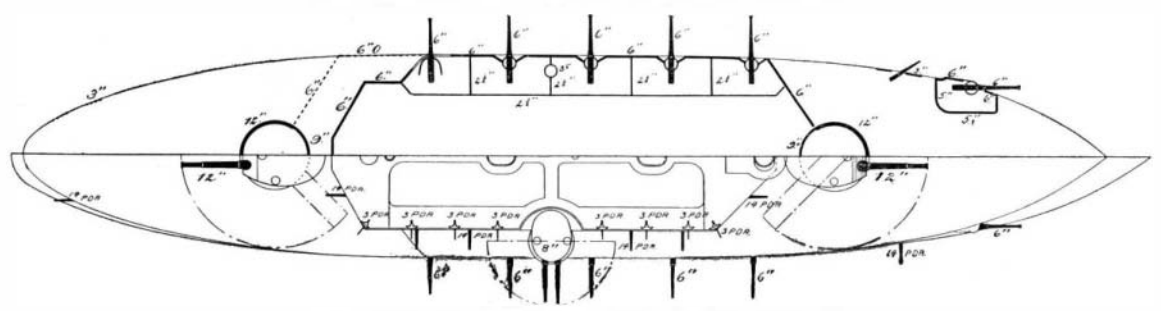
The deck protection is also very complete. A protective deck, which is 2½ inches in



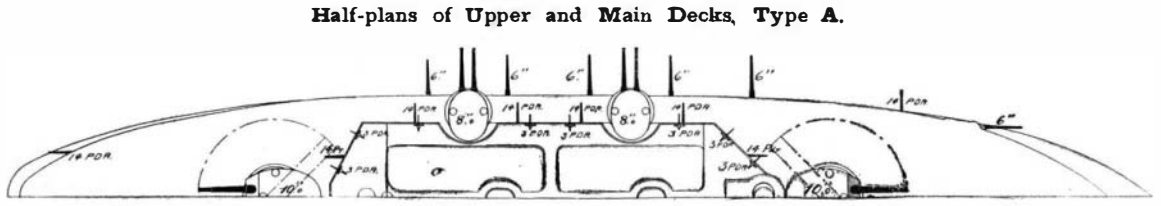
Armor Protection for the Five Types of Battleship.



Side Elevation of Proposed Battleship, Type A.



Half-plans of Upper and Main Decks, Type A.



Half-plan of Type B.

ALTERNATIVE PLANS FOR THE PROPOSED BATTLESHIPS OF THE "NEW JERSEY" CLASS.

thickness on the flat and 3 inches in thickness on the slopes, extends throughout the vessel. The deck above the central casemate or redoubt, in which the 6-inch rapid-fire guns are located, is to be of 2-inch plates at the extremities of these casemates, as shown in the accompanying armor plan. The barbettes for the 12-inch guns will be 12 inches in thickness outside the diagonal armor and 9 inches in thickness on the inside, while the turrets are to have 12 inches of armor for the inclined port plates, the sides and the rear plates are to be 11 inches, and the top plates 1½ inches thick.

Amidships, on each side of the vessel, are to be a barbette and turret for a pair of 8-inch guns, the barbette armor to be 7 inches and the turret armor 6 inches in thickness, while a 3-inch ammunition tube will extend down to the protective deck. Forward, above the 14-pounder battery, will be a conning tower with 10-inch armor and a 6-inch armored tube below leading to the protective deck, while aft, standing above the 14-pounder redoubt, will be a signal tower protected with seven inches of steel.

The armament will be extremely powerful. The main battery will consist of four 12-inch guns, 40-caliber guns each of 58,221 foot tons energy, disposed in the two main turrets fore and aft; four 45-caliber 8-inch rifles, each of 13,602 foot tons energy, disposed in the two turrets amidships on either beam; and twelve 6-inch 50-caliber guns each of 5,838 foot tons energy, carried in the closed central casemate and the two bow casemates on the main deck. The secondary battery will consist of sixteen 3-inch 14-pounder guns, sixteen 3-pounders, sixteen 4-shot automatic pounders, six single-shot 1-pounders, ten machine guns, and two field pieces.

There is no ship afloat carrying a battery of such enormous energy as this, although by the time these three vessels are afloat—such is the rapidity of the development of naval armament—it is probable that they will be equaled, if not outmatched, by vessels already built or building in other parts of the world.

We welcome the return of the 8-inch gun. It proved itself to be the most efficient weapon used at Santiago and Manila, for although the hits were not as numerous as those made by the rapid-fire weapons of 6 and 5-inch caliber, the destructive effect was greater than that of any other type of gun carried in the war.

One of the plans herewith reproduced shows a modification in which there are eight in place of four 8-inch guns, arranged in four turrets, two on each beam. There are two other plans identical with this last except that one of them substitutes four 10-inch guns for the 12-inch, and the other substitutes two 10-inch and two 12-inch for the four 12-inch. In the second, third and fourth plans the fore and aft fire is the same as in the first plan, while the broadside fire is increased by two 8-inch guns. The fifth plan differs from all the others in having no 8-inch guns and in carrying sixteen instead of twelve 6-inch guns, eight of these firing on each broadside, four dead ahead and two dead astern. We think it is likely that the first of these designs will find most favor with our naval officers.

If, on a displacement of 13,500 tons, the Construction Bureau succeeds in building ships with this magnificent system of protection with such an unprecedented battery and with 18 knots speed, without reducing the necessary amount of stores, ammunition and berthing accommodation, it will produce by far the most effective battleship that the world has ever seen.

The Princeton Patagonian Expedition.

Prof. J. B. Hatcher of Princeton University has just returned from his geological expedition to Patagonia. After reaching the Straits of Magellan, Sandy Point was selected as the headquarters of the party and they then set out for the purpose of exploration and the collection of fossils, vertebrates and invertebrates. As no museum in the northern hemisphere contained any considerable collection of Patagonian fossils, no direct comparison of the northern and southern forms could be made. The primary object of Prof. Hatcher's expedition was to make the most extensive collections possible of fossils of Patagonia. He also devoted considerable attention to gathering ethnological, botanical and zoological specimens. The first Mesozoic mammals ever discovered were found in Patagonia on this expedition, and upward of thirty cases of Mezozoic vertebrates were shipped north. Naturally Prof. Hatcher gathered much valuable material illustrating the life and customs of the Patagonian Indian tribes, and he has obtained an important series of photographic negatives which depict the geological and physiographic features of that region.

ACCORDING to The Canadian Engineer, the last relic of the first epoch of railway engineering in Canada is passing away in the form of the tubular bridge which spans the Ottawa River, near its junction with the St. Lawrence, and a truss bridge is to be erected in its place. The old bridge is not only the last of the tubular bridges in Canada, but is also the last on this continent, so that its removal is really a historial event.

Engineering Notes.

An elevated railroad is to be constructed between Chattanooga and Lookout Mountain. The new line will be 2,300 feet long.

Liquid asphalt is being employed to sprinkle the highways of Kern County, Cal., near Bakersfield. The indications are that the experiment will be successful.

Two fine bronze breech-loading cannons captured from the Spanish at the battle of Manila Bay are to be remounted at the main entrance of the Navy Department.

French railroad companies believe in advertising even on railroad tickets, and the courts have at last ordered the companies to provide passengers with season tickets with no extraneous matter. One railroad company increased the number of advertisements until a season ticket was as thick as a pocketbook and commuters refused to carry them.

According to investigations which have been made on the spontaneous combustion of coal, care should be taken that the coal on ships be stored only on iron floors and it should be covered. The height of the heap should not exceed 7 or 8 feet, and steam pipes and flues should be at least 20 feet away. For sea voyages the coal should not be loaded earlier than one month after it is mined.

The effect of scraping a water main twenty-four inches in diameter is shown by the recent work of this kind done at Plymouth, England. According to The Engineering Record, a pipe scraper or "go-devil" was passed through the main and several tons of material were removed in this manner. The cleaning of the pipe resulted in an increase of its discharge from 2,000,000 to 3,000,000 gallons per day.

To prevent the formation of cracks in hardening steel the metal is coated with lime, and finally is heated to a cherry red heat, and is then immersed for some seconds in warm water, after which it is immediately plunged for about double the former period into a bath of rapeseed oil, and is finally transferred to a moderately cool bath of rock oil or water mixed with waste lime. This forms the subject of an English patent.

The Bureau of Construction of the Navy Department has ordered the work of outfitting the converted yachts "Wasp," "Frolic" and "Dorothea" to proceed at the Norfolk navy yard. The Bureau of Navigation believes that these small vessels can be advantageously used in coast survey work, which has heretofore been done by vessels of much larger type. The converted yachts "Eagle" and "Yankee" have been engaged in this work for some little time.

The old firm of R. Stephenson & Company have now joined the ranks of public liability companies. This is a historical factory, having been established in 1823 by George Stephenson, Edward Pease, of Darlington, and his relative Thomas Richardson, and Robert Stephenson. They built not only locomotives, but also marine engines. Now the new company has begun a shipbuilding yard at Hepburn, and a new graving dock is to be constructed, which will be the largest on the eastern coast of England.

In railway building in Soudan there are two harp players and a flute player to every gang of 40 or 50 men. As long as the music is brisk, the laborers do not seem to feel fatigued, and generally the musicians are the first to flag. It is a well known fact that even in our own country the foreman of a construction gang of negroes knows that he can get a larger amount of work out of them if they are kept singing. In Cuban tobacco factories, in the big room where the cigar makers work, there is always a reader who reads novels and papers while the men make the cigars.

In the reign of the English King Henry VII. (1485-1509), there existed a company of mariners who had authority by charter to prosecute persons who destroyed sea marks, etc. In May, 1514, Henry VIII. formed this company into a perpetual corporation by the style of the "Master Wardens and Assistants of the Guild of the Undivided Trinity, in the Parish of Deptford Strond, in the County of Kent." Although the functions of this society have been very much curtailed, the shipping world owes it a debt of gratitude, since it was the originator of the first attempt at the scientific illumination of dangerous spots on the coast. A further history of "Lighthouse Illumination" will be found in the current SUPPLEMENT.

In the new process of manufacturing sheet glass the plastic glass is rolled between metal plates and rollers covered with a soft permeable material, such as paper, wood pulp, asbestos or cellulose. It is said by means of this process sheets of unusual thinness and very smooth and transparent can be produced. The glass may be rolled in various ways, such as between rollers, arranged so as to deposit the rolled sheet upon a plate, or by several pairs of rollers arranged so as to roll the plate thinner and thinner. Provision is also made by the inventor to keep the fibrous materials moist during the rolling by having hollow spaces in the plates and rollers with perforations extending to the surfaces, by which water can be supplied from within.

Electrical Notes.

The United States navy will equip a tugboat with an electric light plant which will enable the boat to light vessels which may be out of commission or that may be undergoing repairs.

The street railway companies of Great Britain are using on roads now in operation, and have ordered for roads which are being constructed, between 2,500 and 3,000 electric motors, and according to a street railway journal, nearly or quite 20,000 horse power of American electric railway generators.

Electricity will play an important part in the coming Dewey celebration. The City Halls in Manhattan and Brooklyn will be brilliantly illuminated as will also be Grant's Tomb, and the Brooklyn Bridge will display magnificent lamps so as to show the words "Welcome Dewey." The letters will be 36 feet long and they will extend for 300 feet.

High voltage incandescent lamps are not used to any very large extent, but, according to Electricity, there is an installation of a 250-volt system at a small town in Italy called Arenzano. The installation is on the three-wire direct current system. The power is derived from a water power a mile and a half distant, and current comes without transformation. The work is said to be very successful.

Prof. Blake, of the University of Kansas City, Kansas, who has lately been studying the effect of electrolysis upon water mains and gas pipes, states that there are some places in that city where an incandescent lamp can be lighted by simply attaching it to a fire hydrant. Some of the water pipes taken up seemed ready to go to pieces, and in some of the pipes it was possible to penetrate the metal with the blade of a knife.

The Electrical Congress will be held at Paris during the Exposition, and will begin August 18, 1900. The work is divided into the following classes: 1. Scientific methods and instruments of measurement. 2. Production of electric energy; transformers; transfer and distribution; electric lighting; traction. 3. Electro-chemistry; electro-metallurgy; accumulators; electric furnaces. 4. Telegraphy; telephones and various applications. 5. Electro-physiology.

A water fall on the Platte River west of Fremont, Nebraska, will probably be utilized to transmit power to Omaha, thirty-five miles distant. The water fall is 130 feet high and is sufficient to operate a 25,000 horse power electric plant. It is proposed to make a canal having a grade of one foot per mile along the base of the ridge which runs parallel with the river for some distance. The construction of the canal and reservoir will entail an expense of about two million dollars.

Among the industries where electricity is particularly valuable is in hat manufacture. The power is required, not only to turn machinery, but to heat tools that must be used for finishing. The Western Electrician recently had an interesting article on the subject which showed a number of devices for the use of this industry, including electrically heated pressing machines for straw hats, electrically heated ironing machines, soft hat curling machines, internally heated flanging bag, etc.

The Navy Department has prepared plans for an extensive electrically-operated machine shop, to be erected at the New York navy yard. The current consists of three 400-kilowatt directly-connected two-phase generators supplying current at a pressure of 220 volts. A complete system of motor-driven machinery will be installed, and every machine tool requiring more than five horse power will require an independent motor connection. Thirteen electric cranes will be installed in various parts of the shop.

Some interesting experiments in wireless telegraphy have recently been carried on between the Blue Hill Observatory and the Harvard Memorial Tower in Cambridge, Mass., the distance being about twelve miles. The results have been encouraging, although there is considerable disturbance, owing to the many electrical influences in the vicinity. Special attention is being devoted to the elimination of these disturbing factors. The experiments are being carried on under the direction of Prof. A. L. Rotch. The apparatus at the Blue Hill Observatory is attached to a kite.

G. Hellmann points out in Terrestrial Magnetism that after Columbus discovered the variation of the magnetic declination in 1492, the belief gained ground among mariners that the longitude could be immediately determined from the variation; but Mr. Hellmann points out that the variation remained unknown, outside nautical circles, until it was independently discovered in connection with the use of the compass for portable sun dials. It was Georg Hartmann, a mathematical instrument maker at Nuremberg, who discovered the magnetic variation on land and found it to be only six degrees east at Rome in 1510. For nearly one hundred years after this discovery most of the writers on magnetism and dials omitted all mention of the declination and assumed that the needle pointed true to the polar star. By sighting along the needle to the polar star, the variation was measured.