result was that the total weight of each ship was increased by 415 tons. Moreover, the present Board of Admiralty have decided that war-ships are in future to coal up to their full stowage capacity; that is to say, in the case of the *Impérieuse* and *Warspite* 500 tons more fuel are to be carried than the designer allowed for. As a natural consequence, the addition of 915 tons to the total weight of each vessel has immersed these ships so deeply that the height of the armoured belt above water has been reduced from 3 feet 3 inches to a little under 1 foot, and there are not wanting those who declare that this circumstance greatly injures, if it does not totally destroy, their fighting efficacy. Sir Nathaniel Barnaby very successfully proved that the responsibility for the additions to the weights of the hull and machinery belongs to the then Board of Admiralty, and not to himself. He also demonstrated that the addition of the extra 500 tons of coal was a case of deliberate reversal of the policy of one Board by its successor, but, judging from the tone of the discussion, he failed to convince his audience that the original policy of calculating the immersion of the belt on a fuel-supply of 400 tons was a wise one.

Mr. Biles's paper, above referred to, on the armour question, was an interesting and useful attempt to solve a difficult problem. He commenced by taking, as the basis of a definite comparison, the latest type of British belted cruiser, viz. the *Aurora*, of 5000 tons displacement. This vessel has a belt 5 feet 6 inches wide, of which 1 foot 6 inches is above the load-line; the thickness of the belt is 10 inches, and its top edges are united by an armoured deck 2 inches thick, under which are placed all the vitals of the vessel. With this he compares a type of cruiser without any side armour, but protected by means of a plated deck, the sides of which curve down so as to join the bottom some feet below the water-line, the curved or sloping portions of the deck being covered with armour of the same horizontal thickness as the *Aurora's* belt. In making the comparison he assumes—

(1) That the length and draft of the proposed vessel are to be the same as in the case of the *Aurora*.

(2) That the displacements are to be the same in each case.

(3) That the costs are to be the same.

Mr. Biles claims that in design No. 1 the internally protected vessel would weigh less than the belted cruiser by about 210 tons; that it would cost nearly 40,000*l.* less; and that the designer would have the option, on the smaller displacement, of either increasing the thickness of the flat portion of the armoured deck by 40 per cent. amidships, or of adding about six-tenths of a knot to the speed, or finally of adding one 9·2-inch gun and two 6-inch guns to the armament.

In the case of design No. 2, where the displacements of the two types are equal, it is estimated that either a knot and a half might be added to the speed, or else that the thickness of the whole of the deck-plating might be increased by 44 per cent.

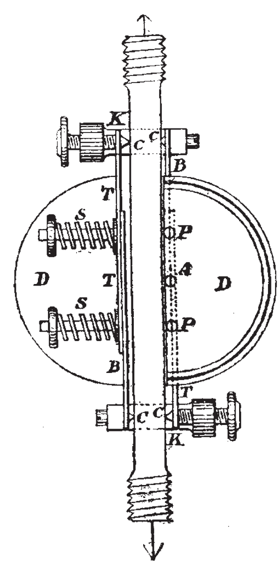
Lastly, on the assumption that the cost of the vessels is the same, Mr. Biles claims for the internally protected vessel the following important advantages: viz. 20 per cent. greater thickness of protection on the slope of the deck, 50 per cent. more on the flat, two more guns of the heaviest calibre, 20 per cent. more coal, and one knot additional speed. Mr. Biles very pertinently asks the question, Is the adoption of the belt worth the extra money paid for it with its accompanying sacrifices? or, If the money is to be spent, is the belt worth the sacrifice of speed, protection, and armament, which is entailed in its adoption?

The papers on marine engineering were not quite so interesting as some which have been read at recent meetings of the Institution. There were three on the subject of screw propellers, by Prof. Cotterill, F.R.S., Mr. Calvert, and Mr. Linnington of the Admiralty, and one on the machinery of small boats, by Mr. Spyer, also of the Admiralty. In addition to the foregoing there were two papers on stability, a subject which has been perhaps lately somewhat overdone; and an important contribution by Mr. Archibald Denny on the practical application of stability calculations in relation to the stowage of steamships. Mr. Jenkins, the newly-appointed Professor of Naval Architecture at Glasgow University, prepared a paper on the subject of the shifting of cargoes.

STROMEYER'S STRAIN-INDICATOR

THIS is a very useful and ingenious apparatus for measuring the extension or compression produced on any material by tensile or compressive forces. Such deformations having been observed, the corresponding variation in the stresses to which the material has been subjected may at once be inferred by the ordinary law of elasticity connecting strains and stresses in solid bodies. The instrument affords one of the many examples of the valuable results obtainable by the simplest possible mechanical means—results which before the construction of the strain-indicator were considered altogether unattainable.

The instrument is shown in the woodcut, and consists of two flat plates, T, B, about 1½ inch wide and of any convenient length, pressed together by means of two springs, S, S, in such a manner that one plate projects at one end and the other at the other end. The plates are



free to slide over each other at their ends opposite A. Fixed centre-points, C, C, are screwed one into each end of each plate, and a graduated dial, D, is attached to the upper one of the two plates T. Two of these instruments are held together by a pair of clamps, K, K, fixed just over the centre-points, which, when screwed tight, press the centres against both sides of the test-pieces; for safety against slipping, a few taps of a hammer embed them more firmly. The figure shows a round bolt about to be operated upon by tensile force, the screwed ends forming attachments to the grips of the testing-machine. Then, when everything is ready, a pair of very fine hardened steel wire rolling pins, P, P, to which light pointers have been attached, are inserted between the plates. These rolling pins, when in position, should be in the centres of the dials. On applying the load to the test-piece, elongation takes place; the centre-points move slightly away from each other, carrying the plates with them, which, as they move in opposite directions, and as they are held apart only by the interposed rolling pin, cause it to revolve, and the angle through which it has moved can then be read off with the help of the pointer and dial. The best results have been obtained with a wire which was drawn, and which measures exactly ·015 inch in circumference. The dial is divided into fifteen equal parts, and their decimals, so that one division represents one-thousandth of an inch, and variations as small as a twenty-thousandth of an inch can be detected.

The above instrument is the outcome of another instrument invented by Mr. Stromeyer, of still greater sensitiveness, and which is based on the production of Newton's rings. Its extreme sensitiveness and certain practical difficulties, however, make it unsuitable for the use of the engineer or naval architect, to whom the present instrument is of great value, and by whom it can be very conveniently used.

The strains of a ship in a sea-way have always been very difficult to deal with. Agur and Solomon of old frankly admitted they were "too wonderful" for them, and although the same ingenuousness has not always been practised by naval architects since, the fact remains that the present state of knowledge in this subject is extremely meagre. Methods of calculation have, it is true, been in use by naval architects which have given results most useful for comparative purposes, but which in absolute units frequently indicated forces that ships could not bear. These methods therefore, except for the comparative purposes they were primarily designed to serve, threw no light whatever on the actual conditions of stress on the various parts of the structure in a sea-way. One able investigator showed that the dynamic constitution of sea-waves was such as to make the effective variation of buoyancy enormously less than the apparent variation, and that this difference meant a reduced variation of stress in large ships from, in some cases, 170 to 100. This investigation cleared up many pre-existing difficulties. Mr. Stromeyer, however, by means of his beautiful and simple apparatus, enables the variation of stress on any part of any structure, ship, or anything else under the action of any forces to be arrived at with certainty by direct experiment.

The invention of this little apparatus constitutes an era in the science of the strength of complicated structures such as ships, boilers, &c.

WILLIAM BABCOCK HAZEN

THE sudden death of Brigadier-General William B. Hazen, Chief Signal Officer of the United States Army, which occurred on Sunday, January 16, 1887, deprived the country of one of its most distinguished officers, and the Signal Corps of a chief who took a broad view of its duties and relations to the world of business and science.

General William B. Hazen was the great-grandson of Thomas Hazen, who was born 1719. Thomas Hazen was himself great-grandson of Edward Hazen, who emigrated from England before 1649, and settled at Rowley, Mass., where he died in 1683.

The descendants of Edward Hazen include many names eminent in business, theology, and war: energy, industry, and strong convictions characterise the members of the family on all sides.

General Hazen was born at West Hartford, Vermont, September 27, 1830. While he was a child his parents removed to Hiram, Portage County, Ohio. In 1851 he was appointed from Ohio as a cadet to the United States Military Academy, at West Point, from which he graduated on July 1, 1885. He was assigned to the 8th U.S. Infantry, and spent the next five years in frontier service, more especially against the Indians in California, Oregon, and Texas, in which service he displayed an energy and bravery that have been characteristic of his life. His record during these years embraces constant fights and pursuits. He was twice severely wounded, and by virtue of the latter he was, in January 1860, by the surgeon's order, granted a leave of absence as being unfit for duty. In consequence of this he was at the north while his regiment was in Texas at the breaking out of the Rebellion. The regiment having been captured and its officers released on parole, he alone was unembarrassed by the parole and was able to offer his services to the Union Army; he was at once assigned as temporary instructor at West Point. In May 1861, he became captain of the 8th Infantry of the regular army, and in October was made colonel of the 41st Regiment of Ohio Infantry in the volunteer army. During the war he distinguished himself on many occasions, and his commission as major-general was granted him December 13, 1864, for "specific distinguished services," *i.e.* "for long and continued services of the highest character, and for special gallantry and service at Fort McAllister." This placed him fifth in a list of twenty-four officers who had received commissions for distinguished service.

He continued serving on the frontier territories north and west, and was especially active in Indian affairs until 1870, in which year he was allowed leave of absence to visit the seat of war in Europe. The results of his observations and studies during his six months' absence are embraced in a volume entitled "The School and the Army in Germany and France, with a Diary of Siege Life at Versailles" (New York, 1872). This volume contains a very interesting sketch of Bismarck, and an account of the state of affairs in Europe. It contains especially a fair criticism of the relative excellencies of the German and French systems, both civil and military; in a special chapter on that subject he incidentally brought out more prominently some weak points in our own military organisation. It would seem that the courage displayed so brilliantly on the battle-field frequently nerved him to utter not only these but other fearless criticisms of things that were palpably wrong, and some of which have since been corrected.

He was married, February 15, 1871, to Millie, daughter of the Hon. Washington McLean, of Cincinnati, who, with one son, survives him.

On his return from Europe in 1871, he returned to duty in the Indian Territory, and was with his regiment in Kansas and Dakota, except for a short absence, until December 15, 1880, when he was, by President Hayes, appointed Brigadier-General and Chief Signal Officer, and has since then been stationed at Washington. The absence just referred to was occasioned by his again visiting Europe as Military Attaché to the United States Legation at Vienna, for the purpose of studying the operations of European armies during the Turko-Russian War. He was absent on this service from December 1876 to June 1877, and the results of his observations were published subsequently in a highly interesting popular volume.

The general account of his activity during the war of the Rebellion was published by him in his "Narrative of Military Service" (Boston, 1885).

His letters and pamphlets on the "Bad Lands" show that for many years General Hazen had been studying the relations of meteorology and agriculture. After his appointment as Chief Signal Officer, he was indefatigable in his efforts to improve the military and departmental relations of the Signal Service, its scientific character, its practical usefulness to farmers and herders, and its popular influence. His labours in Washington stirred up most virulent opponents, first when it became necessary for him to expose and prosecute the corruption of Capt. Howgate; again, when it became necessary in self-defence to expose the true reasons of the failure of the War Department to properly support and