small portions of tungsten. "Tungsten steel," especially excited much attention some seven or eight years ago. It was first produced in some Austrian steel works, and at first, says Dr. Hoffman, "appeared so successful as to threaten a complete revolution in the working of cast steel." Never before, according to the partisans of the new alloy, had steel been produced of such tenacity and hardness. They declared that ordinary cast steel of best quality, hardened by the usual means, could be turned and bored by tools of tungsten steel. They cited analyses to show that the swords of Damascus, so celebrated for their hardness and elasticity, contained traces of tungsten, and to these they attributed the fine qualities of those weapons. They alleged that the new steel cost less than the best English cast steel, and lasted four times as long. Every where patents were taken out for alloys of steel and tungsten, in this country Mr. Mashet alone obtaining nine in one year. Tungsten steel seems, nevertheless, to have been a delusion. Many eminent metallurgists, among them Dr. Percy, Mr. E. F. Sanderson, of Sheffield, and Professor Tunner, of Leoben, declined to believe in it from the first, and nobody believes in it now. There seems ground, however, for the idea that the addition of tungsten to cast iron improves its quality. A recent number of the *Annales de Chemie* contains an account of numerous experiments which have lately been made by M. le Gruen at the Marine Foundry at Nevers, which appear to prove pretty conclusively that cast iron has its tenacity increased by about one sixth by the addition to it of about two per cent. of tungsten. The tungsten was added, of course, as wolfram, metallic tungsten not having hitherto been available.

On Chain-testing Machines. By SIR W. G. ARMSTRONG, C. B.

From the London Journal of the Society of Arts, No. 730.

The engineering firm of which I am a member having been entrusted with the construction of the apparatus for testing chain cables and anchors, lately established at Birkenhead by the Mersey Harbor Trustees, had occasion to enter into a very careful consideration of the conditions requisite for effecting the operation in the best possible manner. As public attention has been forcibly directed of late to the importance of more accurate methods of testing chains and anchors, a few observations on the subject of the Birkenhead machine will not at the present moment be mistimed.

The most important consideration in the construction of a chain-testing machine is to obtain an accurate indication of the strain upon the chain. The hydraulic press has been for many years the appliance usually employed for exerting the strain, and nothing can be better fitted for the purpose; but the methods of determining the amount of the strain have been extremely imperfect. Most commonly the strain has been estimated by the indications of a mitred valve pressed down by a lever and weight. The impossibility, however, of

restricting the tightening surface of the valve to a definite annular line, so as to exclude any variation of area, rendered this mode of indication highly delusive; so much so, indeed, that the attendants generally paid more regard to the indication afforded by the crackling of the scale on the surface of the iron than to the amount of load upon the valve. By substituting a loaded plunger for a loaded valve, the uncertainty arising from variability of surface is obviated, but a plunger requires a packing to make it water-tight, and the effect of the friction of this packing has to be considered in relation to the friction of the press. A plunger without friction would give untrue indications of the strain, unless the press were also without friction; but friction cannot be avoided in the press, and therefore friction becomes a necessary element of accuracy in an indicating plunger. To make this more apparent it is only necessary to consider that in the press the friction of the packing lessens the tension exerted on the chain, while in the case of the indicator the friction of the packing lessens the weight necessary to indicate the pressure. If, therefore, these two frictions be in harmony, the load on the indicator will be diminished in the same proportion as the tension on the chain, and thus a direct indication of the strain upon the chain will be obtained.

The proper and usual packing for the hydraulic press is a cupped leather, but as the lip of the leather is pressed against the surface of the ram by the action of the water, the amount of its friction varies directly as the pressure. It is therefore necessary that the indicating plunger should also be packed with a cupped leather, in order that its friction may likewise vary directly as the pressure. But as the ratio of circumference to area is very much greater in the small ram of the indicator than in the large ram of the press, it is obvious that with similar leathers the relative friction would be widely different in the two cases. The friction may, however, be brought to a proper adjustment by reducing the breadth of the lip in the leather of the indicator until its friction is in unison with that of the press leather. This adjustment should be made when the press ram and the indicator plunger are both perfectly clean and free from any lubricating substance, and in no subsequent use of the machine should either oil or grease be applied to these parts. The effect of employing a lubricator is to diminish the friction in the first instance, but afterwards to increase it, because the unctuous character of the lubricant is soon exchanged for a stickiness which produces an opposite effect. In fact, when grease or oil is used the frictions become so irregular as to render impossible an accurate correspondence between the press and the indicator.

There is another desideratum in the testing of chains which requires a further elaboration of the indicating apparatus. When a chain breaks in the test it is desirable to show, not only that it failed to bear the full test strain, but also what was the amount of the strain exerted at the moment of fracture. In the case of the Birkenhead machine, various indicators, upon the principle of those commonly used for steam pressure, were tried for the purpose of effecting this latter object, but none of them gave satisfactory results. An apparatus was therefore

designed for the object, which has since come into very general use, under the name of the "pendulum indicator." In this apparatus the pressure upon the indicating plunger is exhibited by the travel of a pendulum through a graduated arc. The movement is communicated from the plunger to the pendulum through the medium of a compound lever. When a chain breaks the pendulum falls back until stopped by a ratchet, but leaves a marker at the exact point on the scale attained by the pendulum at the point of rupture.

I have hitherto spoken of friction only in reference to the packing of the apparatus. This friction, as I have already stated, varies with the pressure, but there is also the constant friction due to the weight of the moving parts to consider. If the machine be used exclusively for high strains in relation to its weight, this constant friction will be unimportant, but if a heavy machine be used for testing light chains, a considerable element of error will be introduced, unless a proportionate friction of the same constant character be added to the indicator. Still, however, it is better that very heavy machines should not be used for testing very light chains, unless they be constructed with more than one press, to act separately for light chains and conjointly for heavy chains. With this view the Birkenhead machine has three presses, the centre one being used alone for light strains, and the three acting in concert when great strains are to be exerted.

Although an hydraulic indicator, properly constructed and correctly adjusted in regard to its friction, may be safely relied upon as indicating with sufficient precision the strain exercised by the machine, yet, for the purpose of ascertaining in the first instance when correct adjustment has been attained, and also for detecting any discrepancy which may subsequently arise from dirt upon the ram or plunger, or from any other cause producing irregular friction, it is necessary that every machine should be provided with a lever indicator, to which the strain may be immediately applied, and the strain ascertained by the lifting of a weight. Such an apparatus requires to be accurately fitted with knife-edge bearings, in order to afford delicate indications, but as these are liable to deterioration by too frequent use, it is better to reserve the lever apparatus as a standard of reference for adjusting the hydraulic indicator, which is not liable to deterioration by use. It is not necessary that the lever indicator should range as high as the hydraulic indicator; for if the two indicators register alike through a sufficient series of the lower strains, no discrepancy would be manifested if the comparison were carried to the highest powers of the machine.

I may here mention that nothing so soon deteriorates the lever apparatus as inadequate length of the knife-edges in relation to the strain upon them. The conclusion arrived at in the Elswick Works is, that not less than one inch length of edge should be allowed to every five tons of strain upon the bearing.

In the arrangement of a public chain-testing establishment, it is desirable that the apparatus for the various operations should be placed in such succession as will allow the chains to move from pro-

cess to process without any retrogression. The Birkenhead Chain-testing Establishment commences with a store room for the reception of unproved chains. From this store each chain is dragged by a steam power capstan through an opening in the partition wall on to the testing bench of the machine. It is there made fast, at the one end to the press and at the other to the cross-head, supported on live rollers, which cross-head may either abut against a stop or be connected with the lever indicator. After the chain has been proved it is dragged by a second capstan directly forward in the same line into the examining room, and there stretched upon one of the benches, where it undergoes a close inspection. If found perfect it is then hauled forward by a third capstan through the heating oven and blocking trough, and is thence passed complete into the delivery store at the opposite end of the establishment. The course of the chain being thus in one straight line, it is necessary to carry it over the machinery at each end of the testing bench, and to accomplish this a channel of wrought iron is fixed over the machinery to support the chain in its passage. Should the chain fail in the test, or be found defective on examination, it is drawn off by one of the capstans to the smiths' fires, placed on the floor of the examining room, and after repair is again hauled to the testing bench for a second proof. For the convenience of handling heavy chains at the smiths' fires, a hydraulic crane is connected with each fire. Between the testing and examining rooms there is an intermediate room, called the indicator room, in which the lever and hydraulic indicators are placed, and the valves of the apparatus manipulated by an attendant in view of the indicators.

anchors are received into the same store room as the chains, and the usual appliances are provided for fixing them in the test. Overhead cranes are employed for lifting the anchors as well as for lifting the chains in the two stores.

There are two testing machines in the establishment, fixed at opposite sides of the room. These are similarly arranged in every respect, but one of them is adapted to test up to a strain of 200 tons and the other to 300 tons.

The hydraulic pressure is supplied from a neighboring accumulator, used for a system of hydraulic machinery, at work in the adjacent dock.

As the general practice is to make chain cable in lengths of fifteen fathoms, the Birkenhead machines are adapted for that length. The Board of Trade have recently fixed upon that length as the limit of length of chain to be tested at one time. The propriety of their so doing has been called in question, but I may state that it is the opinion of those persons who have the management of the Birkenhead machines, that no advantage of any kind would be gained by testing chains in greater lengths. If there is to be a limit it is clear that such limit is best fixed at the length at which chains are usually made. There is, besides, a positive objection to exceeding that limit, because a greater length than fifteen fathoms cannot be tested without the use of intermediate supports, which, whether they be slides or rollers, are objec-

tionable as being liable to produce variations of strain in different parts of the chain.

Another objection to permitting indefinite lengths of chain to be tested at one time arises out of the stretch to which chains are subjected in testing. This stretch occasionally amounts to five feet in fifteen fathoms, and if that length of chain were greatly exceeded, it would involve a press of very inconvenient length, or necessitate taking repeated holds of the chain, which would be highly objectionable. I think, therefore, that the Board of Trade have acted wisely in imposing a limit and in fixing that limit at fifteen fathoms.

Proc. Brit. Association.

Explosive Compound.

From the *London Mechanics' Magazine*, September, 1865.

In the *Mechanics' Magazine* for August 11 an account was given of some Swedish experiments with that highly explosive compound, nitro-glycerine, which Mr. Nobel, a Swedish engineer, is endeavoring to bring into use, instead of gunpowder, for blasting purposes. The same "blasting oil," as Mr. Nobel calls it, has since been experimented with in Cornwall, with very satisfactory results. It is an oily fluid, of a light yellow color, and of 1.6 specific gravity. It consists of three atoms of nitric acid, or 3N O^5 , combined with one atom of glycerine, or $\text{C}^6\text{H}^5\text{O}^3$, so that its ultimate composition may be represented by $\text{C}^6\text{H}^5\text{O}^{18}\text{N}$. It bears the temperature of boiling water without explosion or injury, but explodes at about 360° Fahr. The changes which occur during explosion, convert each volume of it into 469 volumes of carbonic acid, 554 volumes of steam, 39 volumes of oxygen, and 236 volumes of nitrogen, being a total of 1298 volumes of gas for each volume of the liquid oil. The gases produced by the explosion of gunpowder measure, when cold, only 250 times the bulk of the gunpowder exploded, so that, supposing the gases evolved to be in each case at the same temperature, nitro-glycerine would thus be five times more effective than its bulk of gunpowder. A great deal more heat, however, is generated by the explosion of nitro-glycerine than by the explosion of gunpowder, and the gases produced by the explosion of the former are therefore in so much higher a state of tension than those produced during the explosion of the latter that the new agent is really thirteen times more effective, bulk for bulk, and eight times more effective, weight for weight, than the old. The use of nitro-glycerine in blasting, therefore, enables thirteen times more disruptive force to be applied, by means of a hole of a given size, than can be brought to bear by means of a bore of the same dimensions when gunpowder is used, and one result of its substitution for gunpowder, for blasting purposes, is thus a very great economy of labor. When there are rents in the rock in which the bore is made, the advantage of nitro-glycerine over gunpowder is greater than thirteen to one, amounting, indeed, to between twenty and thirty to one, by reason of the explosion of nitro-glycerine being so much more rapid than