the use of a ball of this size is limited to specimens not much less than one-tenth of an inch in thickness and half an inch in width. In 1913 the necessity arose for the accurate determination of the hardness of the walls of small-arm cartridge-cases at different positions along the length. The thickness of wall, diminishing in some cases to about one-hundredth of an inch near the shoulder, is quite insufficient for the application of the usual Brinell test. Accordingly, a machine was designed and constructed by Messrs. H. Moore and R. Mather for the Research Department, Woolwich, in which very small balls with correspondingly small loads could be employed. A description of this machine has been given by Mr. Moore in

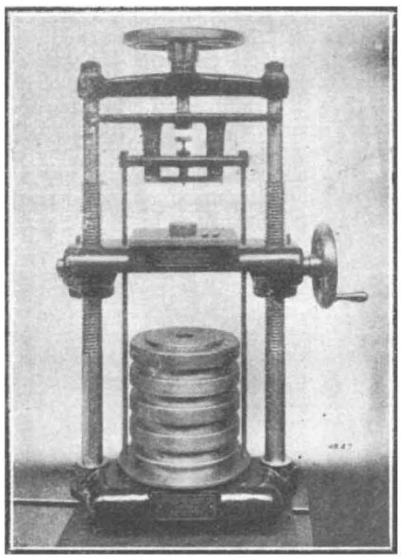

FIG. 1.—A small Brinell hardness testing machine.

the Proceedings of the Institution of Mechanical Engineers of January, 1921. It was designed to permit of great latitude in the dimensions of the test specimen, of the use of various sizes of ball from 1 mm. diameter upwards, and of loads from 5 to 100 kg. The first machine was in continuous use during the war, and was the subject of a secret patent (Craig, Moore, and Mather's patent), which, however, has now been published. The illustration (Fig. 1) shows a simplified form of the machine constructed by Messrs. Alfred Herbert, Ltd., of Coventry.

The machine stands upon a base-plate furnished with levelling screws. This plate supports two vertical threaded columns which carry the table for the reception of the specimens to be tested. By turning the hand-wheel at the side of the machine the table may be set at the required height. The load seen in the lower part of the photograph is composed of a set of graduated cylindrical weights totalling 50 kg. It is carried by the loading stirrup, to the upper portion of which is attached the ball-holder. The ball is fastened to the ball-holder by india-rubber solution so as to render the changing of balls an easy matter. The most important point in the design of the apparatus is the method by which the load is transferred from the cross-head of the machine to the specimen under test. By turning the hand-wheel at the top a non-rotating screw of fine pitch can be raised or lowered. The lower end of the screw carries a suspension stirrup, which is prevented from rotating by arms bearing against the columns, and from this suspension stirrup is hung the loading stirrup by means of a ball-and-socket joint. When the stirrup is lowered gently, so that the ball rests upon the specimen, the loading stirrup becomes free and disconnected from the suspension stirrup. At this stage the whole of the weight is upon the specimen, there being no parts in friction or rubbing contact. The upper hand-wheel is then turned back to take the load off the specimen, which can now be removed for the purpose of measuring the diameter of the impression by means of a high-power microscope with graduations of 1/200 mm. on the graticule. The hardness numbers are calculated as in the ordinary Brinell test, the load being divided by the area of the impression, and are directly comparable with the usual Brinell numbers when a load proportional to the square of the ball diameter is employed.

The impressions are so small as to be scarcely perceptible to the eye, and tests may be made on parts of delicate mechanisms without injury to the part tested. Loaded small-arm cartridge-cases may be tested without removal of bullet or charge. The hardness of wire at successive stages of drawing can be measured. Cutlery blades, however thin, may be tested, and the hardness of a cutting tool may be determined close to the cutting edge. Interesting applications of this microscopic Brinell test have been made in the exploration of strain-hardening, for when a metal object has been unequally strained the distribution of strain will usually be indicated by differences in hardness from point to point.

Attention may also be directed to the micro-Brinell apparatus developed by the Ordnance Department of the U.S. Army (Bureau of Standards, Bulletin 16, 1920, p. 557). This has been used with a load of 15 kg. for 30 seconds upon a ball 1/16 in. in diameter for measuring the hardness of individual crystals or small aggregates in annealed carbon steels.

H. S. A.

The Coal-mining Industry.

By PROF. H. LOUIS.

THE July issue of the *Quarterly Review* contains an article upon the recent coal dispute by Dr. Arthur Shadwell, to which he has given the somewhat unfortunate title "The War of the Mines." Dr. Shadwell points out at the beginning that this dispute was really not a war, and that there was in reality no need at all for a difference, which might have been arranged by mutual concessions, to have degenerated into industrial strife. He recognises that this was not a case of the men striking against any arbitrary action of the employers, but was rather an expression of their irritation at the inevitable development of the economic situation, and he states clearly and definitely the only remedy: "There is only one way out—the way of work. Other nations in a similar position have taken it; they are at work, and working hard. Here less work is being done than ever before."

It is pointed out quite correctly that the mining industry is distinguishing itself above all others in the readiness with which it resorts to industrial strife, and that the real cause of many of these difficulties, and the basal reason for the present grave position of the coal industry, are to be sought in the Minimum Wage Act of 1911, which is accurately described as "the first instance of a minimum wage established by Parliament in an industry in which the workmen are well organised and able to protect themselves."

Dr. Shadwell is undoubtedly right in saying that the demand for this Act arose on account of the existence of "abnormal places" in coal-mines—that is to say, places in which men cannot make normal wages even though they work up to the normal standard, and that these conditions are due to natural causes which can be neither controlled nor foreseen. He appears to accept the Minimum Wage Act as the only means of meeting the difficulty, but in this view experienced coal-miners are not likely to concur. It should be perfectly possible to devise means other than this Act, which unfortunately encourages slack work, without the grave drawbacks which the Act has brought in its train, but such other methods must be founded on mutual confidence between masters and men.

It must be admitted that this antecedent condition does not exist; masters have in the past been only too ready to look upon hard work or successful work on the part of the men as a fair pretext for cutting piece rates, and this action has sown in the men's minds the seeds of the suspicion that they cannot rely upon the masters for fair treatment in the case of abnormal difficulties. Colliery managers to-day are, no doubt, wiser, and have learnt to appreciate the fact that it is to their advantage, no less than to that of the men, that the latter should be in a position to earn high wages, provided, of course, that they give a commensurate amount of work in return. The old suspicious feeling, however, remains, and it has been responsible for the introduction of legislation which has probably done more harm to the coal industry than any other single step that can be named.

Dr. Shadwell devotes considerable attention to the discussion of the proposal for a national pool, but he evidently fails to see the real object underlying the proposal. He says that "it is impossible to maintain that there is anything impracticable or economically ruinous in pooling or amalgamation," and cites Sir George Elliott's old proposal to amalgamate all the collieries in the kingdom into one concern. He fails to see the difference between voluntary amalgamation and compulsory pooling, which latter would necessarily bring in a large number of collieries that are no longer able to produce coal for less than its market price. He suspects, indeed, that the object with which the pool was put forward was political, but does not appear to see the real motive underlying the scheme. As a matter of fact, all the proposals put forward for a considerable time past by the Miners' Federation, the Minimum Wage Act, repeated shortening of the hours, nationalisation, the pool, as well as the less openly avowed tendency to restrict production wherever possible—all these have one and the same underlying object, namely, to keep the largest number of men in the industry.

This object has been only too successful; the coal-miner to-day produces only two-thirds of what he did fifteen years ago, so that for an equal production the number of men employed in the industry is proportionately greater. Obviously, the larger the number of men employed in the industry the greater the political power of the Federation, because it thus obtains control of a larger number of votes and of larger monetary contributions. This gain to the Federation is, however, dearly purchased by the decrease in the efficiency and prosperity of the industry, and obviously such a road can only lead to ultimate ruin and destruction. No industry can prosper if it has in its ranks more men than it can legitimately maintain. The object of nationalisation was to support out of the pockets of the taxpayers the mines incapable of producing economically; the object of the pool was to support them at the expense of the mines that could pay their way. Both schemes were political, in the sense that their object was to keep a number of men in the industry who were working at a loss, and to devise means by which that loss might be made good by someone else. If Dr. Shadwell will consider the effects of the proposed pool upon the mining industry of the country as a whole in the above light, he will readily see why both mine-owners and the Government have offered such strenuous opposition to it.

Botanical Papers from Pennsylvania.

TWO parts of the Journal of the Botanical Laboratory of the University of Pennsylvania recently received (vol. iv., No. 2, and vol. v., No. 1) contain a number of interesting papers. Dr. D. W. Steckbeck has studied the comparative histology and irritability of sensitive plants. The majority of the highly sensitive species are natives of subtropical and tropical America, and their most widespread irritable response is the nyctitropic or "sleep-movement." The author suggests that the phenomenon of propagation of stimuli is centred in the endodermis, the cells of which contain a greater or less number of crystals of oxalate of lime, the number, regularity of shape, and degree of restriction to the endodermis increasing with the increase of sensitivity shown by the plant; the climax is reached in the two highly sensitive plants *Mimosa pudica* and *Biophytum sensitivum*. Each crystal is surrounded by a protoplasmic sac, threads from which pass through adjacent cell-membranes so as to form continuous protoplasmic connections throughout the endodermal tissue; the crystals with their protoplasmic connections are regarded as the special conducting lines for stimuli. The cells of the pulvinus of the leaves are found to contain aggregation bodies, resembling those described by Darwin and others, increasing in amount and complexity with increasing sensitiveness; these show contraction and aggregation changes under stimulation. They are proteinaceous in nature, and all contractile changes resulting from external stimuli seem to be due to changes primarily in the protoplasmic sac by which each is surrounded, secondly in the aggregation body itself, and finally in the amount of liquid these may absorb or give off.

Dr. J. S. Hepburn and Dr. E. Q. St. John describe the results of their investigation of the active digestive agent in the liquor secreted in the pitchers of the pitcher-plant (Nepenthes). Does digestion result from the action of a protease secreted by the pitchers or is it due to bacterial action? The authors found that liquor taken aseptically from unopened pitchers was sterile, but liquor in partly opened pitchers which were free from insects contained bacteria. The slowness with which bacterial digestion of the protein occurred shows that bacteria play a secondary *rôle* in the digestion of insects; the leading *rôle* is undoubtedly played by the protease of the pitcher liquor. The enzymes contained in the bodies of the insects may also assist in digestion.

Miss Alice M. Russell gives a comparative study of the macroscopic and microscopic structure of some hybrid Sarracenias and their parent species. Sarracenia is the genus of pitcher-plants native to swampy districts in Atlantic North America from Labrador to Florida, and several natural hybrids have been reported. The hybrid forms are found to be inter-