loaded, trained, elevated, and depressed with ease and comparative rapidity under the guidance of a few men. Mr. George Rendel was one of the first, as well as one of the most successful, workers in the design of mechanical appliances for working heavy guns by hydraulic power. Messrs. Armstrong have from the first taken a leading position in this class of work. Messrs. Whitworth, and, in more recent times, Messrs. Vickers, have also undertaken it on a large scale. Hydraulic power finds most favour in the Royal Navy. Abroad, electrical power is now extensively used. Pneumatic power has been employed in a few cases.

Improvements in gun-design and in explosives have resulted in an increased ratio of power to weight in the latest types of guns. As a result, in the latest completed battleships, guns of 12-inch calibre, weighing 46 tons, firing 850-lb. projectiles, with muzzle velocities of about 2400 feet per second, and energies of 33,000 foot-tons have been used instead of the 67-ton and 110-ton guns of early date. These reduced weights of charges and projectiles are more easily handled; and this fact, together with certain changes in the system of mounting, have enabled many of the operations of loading and working the guns to be performed by manual power as well as by hydraulic power. This duplication is obviously advantageous, and reduces greatly the risk of heavy guns being put out of action. There was a time when a return to guns of still smaller dimensions, capable of being worked exclusively by hand-power, was strongly advocated. It was urged that it was unwise to depend at all on mechanical power, because it might fail at a critical moment. Such arguments are now but little heard. Experience does not demonstrate that any serious risk of "breakdown" need be feared in mechanical appliances. Moreover, the advocates of manual power overlooked the fact that, supposing that system had been adopted, there must still remain in all modern mountings and breech mechanisms many comparatively delicate parts, perhaps more liable to injury or derangement than the appliances which were condemned.

Steady improvement has been made in heavy gun mountings and in rapidity of fire. For example, with 12-inch guns from two and a half to three minutes were formerly considered to be a reasonable interval between successive rounds; now that interval has been brought below one minute, when pairs of guns are loaded and fired. Loading has also been made possible with the guns in any position, whereas formerly the guns were brought to fixed hoists, and to a definite angle of elevation for loading. It is most interesting to watch the working of these heavy guns, by means of mechanisms controlled by a few men. All the operations are performed with rapidity and precision, from the moment projectiles and charges are moved from their stowing positions in shell rooms and magazines situated deep down in the holds, up to the time when they are rammed home in the gun, the breech closed and the gun made ready for firing. Then one sees the captain of the barbette or turret training or changing the elevation of the gun up to the instant when he fires by electricity, and the huge projectile is discharged.

Passing from guns to torpedoes, one finds a fresh example of the important work done by mechanical engineers. The inventor of the automobile torpedo, Mr. Whitehead, is an eminent member of the profession. The torpedo itself is a beautiful example of mechanical engineering. All the machinery connected with air compression and storage, all the arrangements for ejecting above or below water, involve skilful mechanical design. Nor is this all. From the introduction of the torpedo has sprung the necessity for special structural and defensive arrangements in warships, as well as the construction of the swift torpedo flotilla-boats, destroyers, gunboats and depot ships, whose performances are not merely remarkable, but suggestive of possibilities in regard to steam navigation at high speeds.

The smaller classes of boats using the locomotive torpedo have to be carried by warships. They weigh, fully equipped, 18 to 20 tons, or about three times as much as the heaviest load ordinarily dealt with in merchant ships by their own lifting gear. This has involved the design of special lifting appliances for warships. After long experience in the Royal Navy, the most suitable arrangement has been found to be a strong steel derrick carried by the mast, with powerful steam or hydraulic hoists working tackles which lift the boats and top the derrick. Winches or capstans are also used in some instances for swinging the derricks. Admiralty specifications require that the lifting gear shall be capable of dealing with a load of about 18 tons lifted by a single wire rope, as well as with a load of 9 tons raised 30 feet per minute. In one ship, the *Vulcan*, built as a torpedo depot ship and boat carrier, instead of derricks two powerful hydraulic cranes are fitted. She carries six steel torpedo boats, 60 feet long and of 16 knots speed, besides sixteen other boats, some of large size. The total weight of these boats is 150 tons, and they are placed 27 feet above water. The two cranes and their gear weigh 140 tons; the tops of the cranes are 55 feet above water. It required careful designing to meet such exceptional conditions satisfactorily and to produce a stable and seaworthy ship. She has now been many years on service and has a good reputation.

Besides these special boat-lifting appliances, warships commonly have special coal-hoists, transporters and other gear for the purpose of accelerating the taking of coal on board. Rapidity in coaling must be of great importance in time of war, and keen competition between ships in the various squadrons as to the rates attained have led to great improvements in details of gear, as well as to remarkably rapid coaling becoming the rule in the Royal Navy. Recently, at Gibraltar, the *Majestic* took on board 1070 tons of coal in 6 hours and 10 minutes—a very fine performance.

All the larger ships in the Royal Navy have engineers' workshops fitted with a considerable number of machine-tools, driven by power, and of sufficient size to deal with ordinary repairs. The *Vulcan* is a special vessel in this sense also, as she has an exceptionally well-equipped workshop, a small foundry and a hydraulic press for forgings. For repairs of the boats she carries, or for those of torpedo boats and destroyers in company, or for certain repairs to ships of the fleet to which she is attached, the *Vulcan* has been found most useful. Besides being a floating factory and a boat carrier, she has a large torpedo and mining equipment, an electrical laboratory, and serves as a school of instruction for mining and torpedo work. In addition, she is a swift cruiser, with a fair armament and well protected. As an armed ship, she represents the fullest application of mechanical appliances afloat. Her construction was commenced in 1887. Other navies have since imitated her.

Another *Vulcan* was fitted up as a floating factory to serve with the American fleet during the recent war. She was originally a merchant steamer, but is said to have proved of great service. Naval opinion seems to favour the use of vessels of this class with fleets. It is held, moreover, that no modern fleet can be considered to be complete unless the fighting ships are supplemented by ships specially equipped for distilling and storing fresh water, or carrying coals, ammunition and reserve stores.

SATURN'S NEW SATELLITE.

IN *Harvard College Observatory Circular*, No. 43, just received, Prof. E. C. Pickering gives the following detailed account of the discovery and observations of the new satellite of Saturn:—

Nearly all of the astronomical discoveries made by the aid of photography have related to the fixed stars. In the study of the members of the solar system, the results obtained by the eye are generally better than those derived from a photograph. For many years it has been supposed that photography might be used for the discovery of new satellites, and in April 1888 a careful study of the vicinity of the outer planets was made by Prof. William H. Pickering. Photographs were taken with the 13-inch Boyden telescope, with exposures of about one hour, and images were obtained of all the satellites of Saturn then known except Mimas, whose light is obscured by that of its primary. It was then shown that Saturn probably had no satellite, as yet undiscovered, revolving in an orbit outside of that of Enceladus, unless it was more than a magnitude fainter than Hyperion (Forty-third Report Harv. Coll. Obs., p. 8).

In planning the Bruce photographic telescope, a search for distant and faint satellites was regarded as an important part of its work, and accordingly plates for this purpose were taken at Arequipa by Dr. Stewart. A careful examination of these plates has been made by Prof. William H. Pickering, and by superposing two of them, A 3228 and A 3233, taken August 16 and 18, 1898, with exposures of 120 m., a faint object was found which appeared in different positions on the two plates. The same object is shown on two other plates A 3227 and A 3230, taken on August 16 and 17, 1898, with exposures of 60m. and 122m. respectively.

The position is nearly the same on the two plates taken on August 16, but on August 17 it followed this position 33″, and was south 19″, while on August 18 it followed 72″, south 43″. Its motion was direct, and less than that of Saturn, though nearly in the same direction. It cannot, therefore, be an asteroid, but must either be a satellite of Saturn or a more distant outside planet. The proximity of Saturn renders the first supposition much more probable. On August 17 the position angle from Saturn was 106°, and the distance 1480″. Assuming that it was at elongation, and that its orbit is circular, its period would be 400 days, or five times that of Japetus. It was at first identified with a very faint object found on plates taken in 1897, and the period of seventeen months was derived from them. This supposition has not been confirmed.

Measurements of the positions of the images give additional material for determining the form of the orbit. The method of measurement is that described in the *Annals*, vol. xxvi. p. 236. The uncorrected positions of the four images referred to the first plate of August 16 as an origin, are for *x*, 0″·0, +1″·2, +33″·6, and +71″·8; for *y*, 0″·0, −1″·7, −19″·8, and −42″·1; the corresponding Greenwich mean times are 12h. 16m., 14h. 18m., 12h. 56m., and 13h. 12m. Correcting for the motion of Saturn, the relative motion with reference to that body is in *x*, 0″·0, −2″·4, −10″·7, and −22″·0; in *y*, 0″·0, +0″·1, +2″·4, and +2″·9. It appears from this that the apparent motion is about 10″·4 a day, at a distance of 1480″. A computation shows that if the orbit is circular, the period must be either 4200 or 490 days, according as the satellite is near conjunction or elongation. These values may be greatly altered if the orbit is elliptical. Since the interval of time between the first and last photographs on which the satellite appears is only two days, it is impossible to predict its position with accuracy. It is probable that its position angle from Saturn now lies between 280° and 290°, and its distance between 20′ and 30′. These uncertainties will probably be greatly diminished from measures of plates of Saturn taken in Arequipa on September 15, 16, and 17, 1898, which for some unexplained reason have not yet been received in Cambridge.

The direction of the motion, which is nearly towards Saturn, shows that the apparent orbit is a very elongated ellipse, and that it lies nearly in the plane of the ecliptic. Prof. Asaph Hall has pointed out that this is to be expected in a body so distant from Saturn. The attraction of the latter only slightly exceeds that of the sun. Hyperion appears as a conspicuous object on all four of the plates, and the new satellite appears about a magnitude and a half fainter on each. The approximate magnitude is therefore about 15·5. As seen from Saturn, it would appear as a faint star of about the sixth magnitude. Assuming that its reflecting power is the same as that of Titan, its diameter would be about two hundred miles. It will, therefore, be noticed that while it is probably the faintest body yet found in the solar system, it is also the largest discovered since the inner satellites of Uranus in 1851. The last discovery of a satellite of Saturn was made in September 1848 by Prof. William C. Bond, then director of this Observatory, and his son, Prof. George P. Bond. The satellite Hyperion was seen by the son on September 16 and 18, but its true character was first recognised on September 19, when its position was measured by both father and son (see *Annals*, ii. p. 12). Soon afterwards it was discovered independently by Lassell, at Liverpool.

Prof. William H. Pickering, as the discoverer, suggests that the name Phœbe, a sister of Saturn, be given to the new satellite. Three of the satellites—Tethys, Dione, and Rhea—have already been named for Saturn's sisters, and two, Hyperion and Japetus, for his brothers.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

CAMBRIDGE.—The following are the speeches delivered on April 27 by the Public Orator, Dr. Sandys, in presenting (1) Prof. Sir William Turner and (2) the Rev. Prof. Wiltshire, for the honorary degree of Doctor in Science:—

(1) Virum regni totius medicorum concilio praepositum, virum honoribus academicis plurimis cumulatum, etiam noster Senatus titulo suo decorare anno proximo decrevit. Inter Lancastrienses natus, inter Londinienses educatus, inter Edinenses, medicinae in schola celeberrima, quam tot coloniae Britannicae studiorum medicorum quasi μητρόπολιν venerantur, anatomiae scientiam per annos plus quam triginta praeclare professus, non modo Universitati suae aedificiis novis instruendae operam insignem dedit, sed etiam studiorum suorum actis per seriem edendis iamdudum maxima cum laude praefuit. Idem, rerum naturae spoliis olim in Britanniam feliciter reportatis, Australasiae praesertim anthropologiam opere in magno accuratissime expositam luculenter illustravit. Nuper societatis Britannicae scientiarum finibus proferendis praeses in annum proximum designatus, ab eadem disputationibus de anthropologiae scientia etiam inter Canadenses habendis haud ita pridem praepositus, hominum omnium plausus propterea praesertim meritus est, quod simiarum superbiam recentem repressit et generis humani dignitatem veterem denuo vindicavit.

Duco ad vos generis humani vindicem, equitem insignem, anatomiae professorem illustrem, WILLELMUM TURNER.

(2) Unus ex alumnis nostris, societatis geologicae, astronomicae, Linnaeanae socius, idcirco praesertim inter peritos laudatur, quod palaeontographicae societatis in usum, palaeontologiae studiosorum ad fructum, aevi prioris monumenta a rerum natura in saxis impressa, non sine summo ingenio et labore illustrata, per annos plurimos litterarum monumentis mandaverit. Idem Universitatem nostram beneficio singulari ad sese devinxit, quod non modo bibliothecam suam, sed etiam vitae antiquae relliquias veteres in saxis conservatas et saxorum inter se diversorum exempla quam plurima, nuper nobis in perpetuum donavit. Illa vero exempla omnia, olim inter Londinienses in Collegio Regali professor, docendi praesertim in commodum collegerat, cum Horatio (ut videtur) arbitratus "demissa per aurem quam quae sunt oculis subiecta" animum segnius excitare. Etiam ipsa fama liberalitatis tantae nuper inter nosmet ipsos inter rerum naturae praesertim studiosos animum gratum excitavit. Quanto magis iuvat Universitatem totam liberalitatis tantae auctorem ipsum hodie oculis suis redditum et auspiciis optimis praesentem contemplari. Qui prioris aevi tot exempla nobis donavit, ipse nostro in saeculo munificentiae in Universitatem nostram ab aliis imitandum praebuit exemplum.

Praesento vobis geologiae professorem emeritum, virum de rerum naturae studiis praeclare meritum, THOMAM WILTSHIRE.

Prof. A. Cornu, of the École Polytechnique of Paris, has been appointed Rede Lecturer for the present year. The lecture will be delivered in the Senate House on June 1, as a part of the proceedings relating to the jubilee of Sir G. G. Stokes. On the same evening, a conversazione will be held in the Fitzwilliam Museum. Next day an address from the University and a commemorative gold medal will be presented to the veteran Lucasian professor. The guests of the University will be received by the Chancellor, and certain honorary degrees will be conferred. A garden-party at Pembroke College, and a State dinner in the evening, will close the festivities.

Prof. Macalister announces three lectures of an historical character, on eponymous structures in human anatomy, on May 9, 13, and 16.

University tables are vacant at the Naples and the Plymouth Zoological Stations. Applications are to be sent to Prof. Newton by June 1.

THE *Times* makes the following announcement:—"We understand that Mr. Passmore Edwards has intimated his intention of giving 10,000*l.* upon trust to equip a school and building for the teaching of economics and commercial science in the New London University. The Trustees, who are to carry out the trust and offer the building when ready to the new University Senate, are the Bishop of London, Mr. Sidney Webb, and Mr. Haldane, Q.C., M.P. The work of the London School of Economics will probably be continued there. Further endowments will, of course, be wanted for chairs of banking, commercial history and geography, commercial law, insurance and other special subjects, and this munificent gift by Mr. Passmore Edwards should encourage other wealthy Londoners to imitate his generosity."