ing with the working of any particular portion of the ozonizing plant. The disturbances which are liable to occur are two:

1. The current in the electrical apparatus may fail.

2. The current of air through the plant may fail.

In either case an automatic device leads to the closing of the valve through which water is admitted to the sterilizing towers, and at the same time a bell informs the attendant of the mishap. In this way the supply of unsterilized water to the consumers is effectually prevented by means of apparatus which is of the simplest construction and easily controlled.

Each half of the plant, yielding a supply of 33,000 gallons, expends 50 horse power, of which 27 go to the ozonizers and about 22 to the pumping plant, the remainder being used up for the air blast, for feeding the boiler, etc.

The cost of the plant figures out to one and one-third cents per 1,000 gallons of sterilized water, of which about one-third of a cent falls to the coal consumed in effecting the ozonization. (The price of one ton of coal yielding 7.7 times its weight of steam being reckoned at $5.) To this must be added about two-thirds of a cent in payment of interest and for keeping in repair. But it must be remarked that the Wiesbaden plant is not typical, as there were no pre-existing water works, and pumping has to be done, which does not properly form part of the work of an ozonizing plant.

Prof. Proskauer and Dr. Schüder, of the Koch Institute for Infectious Diseases at Berlin, have carefully investigated the efficiency of the ozone sterilizing process, with results which are highly satisfactory. They worked with water which was grossly infected with virulent bacilli (of the cholera and typhus kind). Their result only confirmed the conclusion previously arrived at in the preliminary experiments at Martinikenfelde by the same investigators, namely, that ozone, in the concentration in which it issues from the Siemens apparatus will destroy all pathogenic bacteria and nearly all harmless microbes, excepting just a few highly resistant and innocent forms, provided a suitable gravel filling is used in the sterilizing towers.

A month after the opening of the Wiesbaden water works, there was also inaugurated a similar plant, on a smaller scale, however, at Paderborn. The sterilizing apparatus of this is a precise copy of that at Wiesbaden, the only difference being that the water delivered from the sterilizing towers is allowed to flow down in a series of cascades, so as to work out the last traces of ozone.

The Paderborn waterworks have to supply 13,000 to 15,000 gallons of sterilized water daily. The plant has nine ozonizers of the Siemens type (of which three are for reserve) and two sterilizing towers with four sections each. The power for the electric plant is supplied from a gas engine. The former consists of direct and alternating current dynamos, two blowers and three transformers, and has arrangements preventing the supply of unsterilized water similar to those at Wiesbaden. The cost of power is a little higher at Paderborn, but on the other hand there is less ozone used per gallon of water, so that the total expenses are much the same as at Wiesbaden.

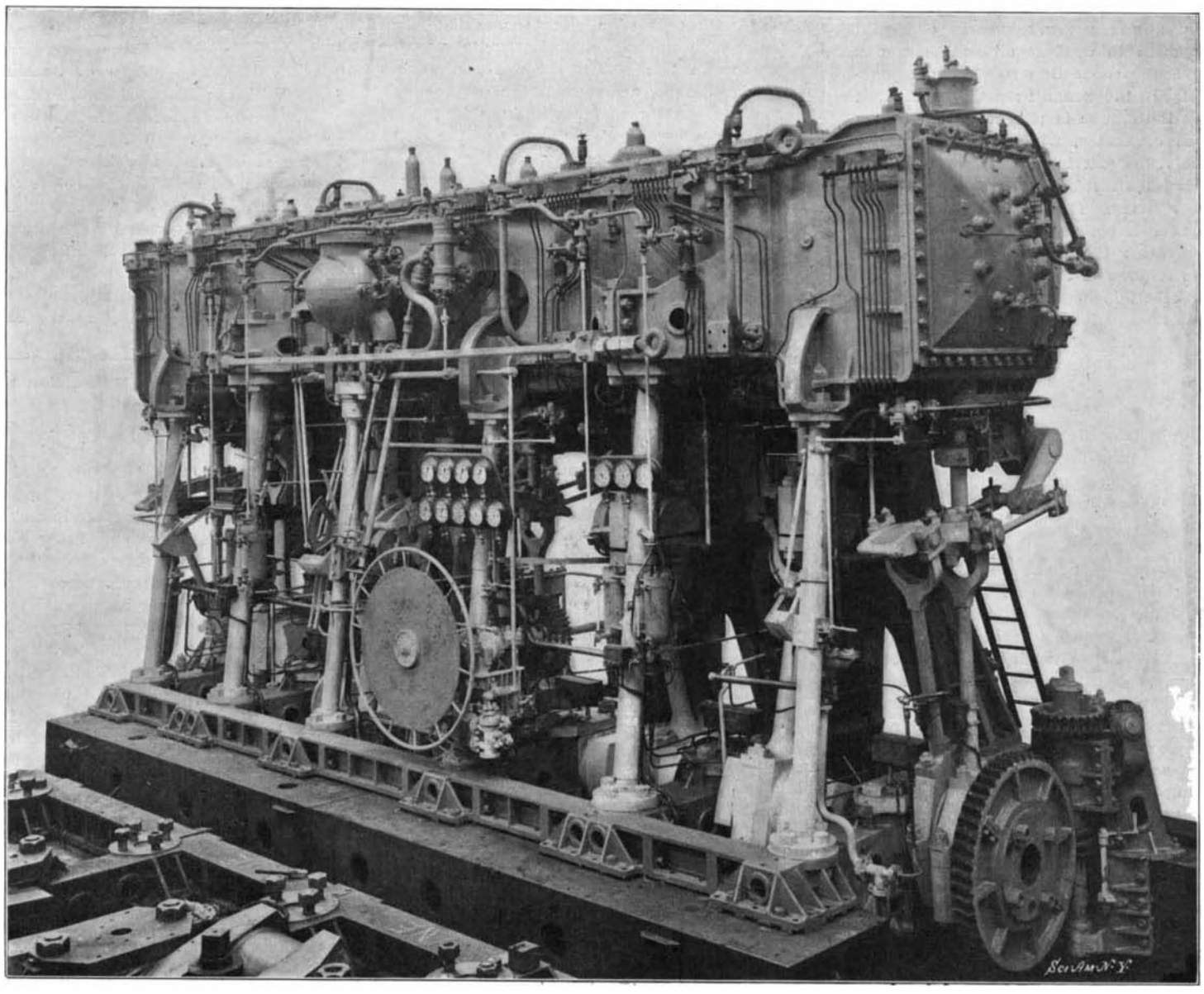
The establishment of the plants at Wiesbaden and Paderborn marks the début from the laboratory into the technical world of a process which is likely to prove a serious rival to older methods of purifying drinking waters, which have been in vogue hitherto.

THE NEW CHILIAN BATTLESHIP "LIBERTAD."

The striking illustration on our front page is reproduced from a photograph taken from the launching ways, just as the new Chilian battleship "Libertad" had taken the water. The heavy chains which are seen hanging from the sides of the ship were dropped to assist by their friction upon the bottom in checking the vessel's way through the water, while a part of her launching cradle will be noticed still in position under her starboard bow. We have seen many handsome photographs of a launch, but never one that approached this in dramatic interest.

The "Libertad" was launched on January 6 at the yards of Messrs. Vickers, Sons & Maxim, Barrow-in-Furness, England. She is a sister ship to the "Constitucion," which was recently launched for the Chilian government by Armstrong, Whitworth & Co. from the Elswick shipyard, Newcastle.

It is claimed for the "Libertad," and we think with much show of truth, that she is, for her size—11,800 tons—the most powerful fighting ship afloat. The European-built Chilian vessels, probably because they have come chiefly from the Armstrong yards, are all remarkable for their powerful offensive qualities, the armament of these vessels being, in proportion to their displacement, more powerful than that of any ships in the world; unless indeed we make an exception in the case of the United States navy.



THE QUADRUPLE-EXPANSION ENGINES OF THE "LIBERTAD."

The "Libertad" is 436 feet long and 71 feet broad, and her mean draft is 24 feet 7½ inches. Her motive power consists of Yarrow boilers of the large-tube type, and twin-screw, triple-expansion engines of 12,500 horse power, and her estimated sea speed is 19 knots an hour. The normal coal capacity is 800 tons, but the full bunker capacity is 2,000 tons. The vessel will carry a complement of 700 officers and men.

The armament consists of four 10-inch breech-loading rifles with quick-action breech mechanism; fourteen 7.5-inch rapid-fire guns, fourteen 3-inch rapid-firers; four 6-pounders; four Maxims, and three submerged torpedo tubes; and from this heavy battery it is estimated that with all the guns firing at their maximum speed, this vessel could deliver in one minute 13½ tons of metal whose combined energy would amount to 1,700,000 foot-tons. In explanation of this great total, it is sufficient to mention that the guns are all of the modern, long-caliber, high-velocity type, with the latest pattern of breech mechanism designed to facilitate rapid loading. Thus, the 10-inch guns will fire a 500-pound shell with a muzzle velocity of 2,850 feet per second and a muzzle energy of 28,160 foot-tons. At the muzzle these guns will be capable of penetrating 31 inches of steel armor. The 7.5-inch gun of the broadside battery is a 50-caliber piece, which fires a 200-pound shell with a muzzle velocity of 3,018 feet per second, and a muzzle energy of 12,638 foot-tons. This piece, which can fire eight rounds per minute and has, therefore, about equal rapidity of fire with the 6-inch piece, can penetrate at the muzzle nearly the same thickness of steel plate as the 10-inch gun, or 29.4 inches. The adoption of such a heavy gun for the secondary battery is in accordance with the best modern practice, which recognizes that the 6-inch piece is not sufficiently powerful to penetrate the modern Krupp armor with which the secondary batteries of modern warships are protected. This 7.5-inch gun, however, is capable of effecting penetration at ordinary battle ranges, and therefore marks a great advance on the secondary batteries carried by most existing warships and cruisers.

While the defensive features of the "Libertad" are, perhaps, not quite equal to her tremendous powers of offense, they are fully up to the average of the latest ships. She carries a practically complete belt at the water line which has a maximum thickness of 7 inches amidships and is associated with athwartship screen bulkheads 10 inches in thickness. This belt is 8 feet in depth. Side armor of the same thickness extends to the upper deck over the whole side of the ship lying between the two main barbettes, and by its association with transverse bulkheads of 6-inch armor, it forms a complete armored central citadel. The upper deck is formed of 1-inch steel plating, while the protective deck, which is 1½ inches in thickness within the citadel and 3 inches in thickness at the ends outside the citadel, extends completely from stem to stern at the level of the top of the waterline belt. The barbettes for the 10-inch guns are 10 inches in thickness in the front where they project beyond the central citadel armor and 8 inches in the rear. The 7.5-inch guns are carried, four of them in casemates on the upper deck at the four corners of the central citadel, and the other ten are within the citadel on the gun deck, five on either side. This battery of ten guns is further protected by 1-inch screens of steel plating placed transversely between each pair of guns. These two battleships will be considerably the most powerful war vessels in the Chilian fleet, which possesses some of the most notable armored cruisers in existence.

Not the least remarkable feature about the "Libertad" is the great speed at which she has been built. The first keel plate was laid March 13, 1902, and the launch took place on January 6, 1903, the vessel being therefore, completed in the remarkably short space of ten months. We commend this record to the consideration of our private shipbuilding firms, who are largely responsible for the backward condition of our navy. The contract for the construction of the "Missouri" (which is a vessel only 400 tons larger than the "Libertad") was signed December 30, 1898. Last December, after the expiration of four years, the vessel was no less than twenty months behind contract, and she is not yet completed.

SCIENTIFIC AMERICAN

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$3.00 A YEAR.

Displacement, 11,800 tons. **Speed,** 19 knots. **Coal Capacity,** 2,000 tons. **Armor:** Belt and sides, 7 inches; gun positions, 10 inches. **Battery:** Four 10-inch; fourteen 7.5-inch; fourteen 3-inch. **Torpedo Tubes,** submerged, 3. **Complement,** 700.

CHILIAN BATTLESHIP "LIBERTAD;" LAUNCHED TEN MONTHS AFTER LAYING OF KEELPLATES.—[See page 133.]

Automobile News.

Now that automobiles have shown their capabilities on the road for transporting suburban sight-seeing parties, as shown by the Paris-Versailles touring buses and the New York-Tarrytown Mobile wagonettes that were run daily last summer, automobile cars are soon to be introduced on French and English railway lines for fast speeding over long distances and for taking care of suburban traffic respectively. In France, the Serpollet steam motor and flash boiler is to be used to propel single cars rapidly over long distances, while in England the Napier gasoline motor, of a type similar to that on the car that won the Gordon-Bennett race last year, is to be used on individual cars over a 30-mile stretch of track. The service required in this section is not frequent enough to warrant the installation of an electric equipment, so gasoline motor cars are to be used, and these will reduce the running time over steam trains by about 20 per cent, owing to their being more easily and quickly accelerated. From present indications, it looks as if the automobile is destined to revolutionize not only road traffic, but traffic on rails as well.

One great improvement that the French manufacturers have made on their machines this year is the method of lubricating the motor. Instead of depending on splash lubrication alone for oiling every part of the engine, positive oil feeds are led to each of the crankshaft bearings, and the crankshaft is pierced with suitable passages to conduct oil to the cranks themselves, so that the connecting rod boxes also receive plenty of oil. In the Renault motor, the oil that is splashed up by the cranks is caught in small cups at the top of the crankcase, which feed the major bearings by gravity. Centrifugal force is depended upon to send this oil afterward through small holes to the cranks themselves. The new de Dion-Bouton double-cylinder motor has a small pump driven by a worm gear, that raises the oil to the top of the crankcase, whence it flows to the bearings by gravity. A sufficient bath of oil is kept in the crankcase all the time, to splash up and lubricate the pistons. The better oiling arrangements of the motor conduce to longer life and more efficient service, and they should be introduced as far as possible on American gasoline cars.

The legislatures of many of the different States are at present considering bills regulating the speed and operation of automobiles. Connecticut, which has had the most sensible law imposing a speed limit of fifteen miles an hour in the country and twelve miles in cities and towns, is threatened through the efforts to distinguish themselves of some of her would-be farmer legislators; Massachusetts is considering a bill requiring that all operators of autos shall be registered, and prohibiting the licensing of any car capable of traveling faster than twenty miles an hour; while it remains for Maine to try to bring anti-autoists back to their senses by considering a bill providing a speed limit of eight and twenty miles an hour in towns and country, respectively. In every instance, the automobile clubs are fighting the adverse legislation and attempting to forestall it with bills giving equal rights to autoists and the drivers of horses.

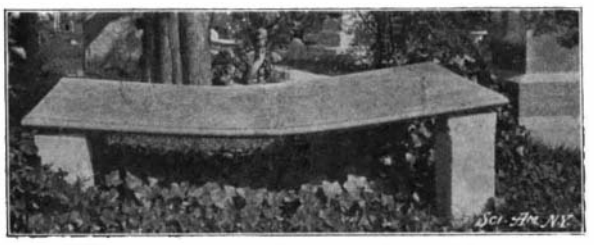
Four hundred dollars damages were awarded an automobilist of New Haven, Conn., recently because of injuries received by being thrown from his machine, which ran into a hole in the pavement between the trolley tracks 48x7x4 inches deep. The judge held that the city was primarily responsible for the condition of the pavement, but that it can exact settlement from the trolley company, as the latter, under the law, is responsible for the pavement between its tracks. This is one of the few cases where the autoist has come out victorious.

Another interesting decision has just been made by a judge in Bridgeport, Conn., which, while not affecting automobiles directly, throws some light on the right of way of trolley cars on country roads. A hack was being driven with two wheels in the track at 12:40 A. M. one dark, stormy night last winter. A car came along behind it and ran into it, throwing it down a small bank and turning it upside down. Neither the occupants nor the driver were seriously injured, but the driver was awarded $500 damages on the ground that the company was to blame in not providing a sufficiently powerful headlight for the motorman to see an object on the track in time to stop the car. The motorman testified that the gong was rung just before he saw the hack. In handing down his decision, Judge Wheeler said: "The company has no exclusive or paramount right to the use of the roadway between the tracks. It must operate its cars in the knowledge that the public has a right to use its tracks as a part of the highway. The traveler must recognize that the car cannot proceed save upon the track, and hence he must turn off from the track, when he knows the car is approaching, within reasonable time to allow it to pass. When a traveler enters upon a car track in advance of an approaching car, he must, in the exercise of reasonable care, do what he can to avoid accident, and ordinarily, if he turn upon the tracks so closely in advance of a car that an accident is inevitable or probable, such conduct will of itself be negligent. The traveler already upon the track is not obliged to keep looking around to see if a car be approaching. Such a duty on his part would be inconsistent with his right to the reasonable use to that part of the highway. When the traveler hears an approaching car, it is his duty to turn out. When he ought to hear it, not to turn out would be an important consideration in measuring his own freedom from negligence." Under the conditions given, however, that the driver did not hear it was no fault of his, and the company was to blame for not taking proper precautions toward the avoidance of accident.

THE SPONTANEOUS BENDING OF MARBLE.

One of our correspondents has sent us a photograph, which we have herewith reproduced, of a bent marble slab in Rock Creek Cemetery, Washington, D. C. The picture brings out a curious phenomenon which may be quite commonly observed in old graveyards. The slab in question has been in position over half a century, judging from the inscription, and during this time has sagged over three inches at the center. Its length is 70 inches, width 35 inches, and it has a thickness of 2 inches. The peculiar phenomenon is not to be confused with that of a slight concavity formed at the center of a slab placed in horizontal position and exposed for a long period to the weather. Such a concavity is caused by a slow solution of the marble in water caught on its surface, whereas in the present instance the thickness at the center of the stone does not vary materially from that at the sides, but a marked curvature is shown on both surfaces. In seeking for an explanation of this curvature, one is at first tempted to consider marble as a fluid, such as sealing wax or pitch, but possessed of much greater viscosity. Pitch in cold temperature is brittle and has all the appearance of a solid, but a heavier substance placed on the surface will, in time, sink to the bottom, and a lighter substance will very slowly float from the bottom of the pitch to the top. However, in the present instance, this explanation is not satisfactory.

For an authoritative opinion on the subject, we have submitted the question to the Director of the United States Geological Survey, and have been referred by



MARBLE SLAB BENT BY ITS OWN WEIGHT.

him to Vol. X. of the Tenth Census Reports, which contains some notes compiled by Alexis A. Julien, on similar occurrences in Europe, where the matter has been studied by some prominent geologists. One of the instances given is that of a slab in the marble veneer of the facade at St. Mark's, Venice, which at its lower end bulges 2¾ inches from the backing. The slab faces westward, and was found to become very warm in the afternoon sun, while its rear surface was kept cool by the backing. Another striking example may be found in the Alhambra in Granada, Spain. One of the two doorways that have been christened "La Mezquita" comprises three slabs of marble, one resting as a lintel on the other two, which are placed upright. A subsidence of the wall on the right side has exerted an enormous thrust upon one of the uprights, and the marble instead of breaking has simply bent outward about three inches. In the quarries near Rutland, Vt., the bending of thin slabs of marble supported only at the ends has frequently been observed. Fleurean de Bellevue discovered a dolomite possessed of this property, which he attributed to "a state of desiccation which has lessened the adherence of the molecules of the stone." De Bellevue seemingly confirmed this by experiments, which showed that inflexible varieties of marble, when heated, became flexible. However, owing to the exceedingly small quantity of water present in marble, this explanation is not satisfactory. A better solution of the problem has been furnished us by Geikie, who says that "irregular and closely contiguous grains of calcite which make up a white marble are united by no cement, and have apparently a feeble coherence." Prof. Julien's opinion is that "their contiguous crystallization has left them in a state of tension, on account of which the least force applied through pressure from without, or of the unsupported weight of the stone, or from external expansion by heat or frost, produces a separation of the interstitial planes in the minute rifts. Such a condition permits the play of the grains upon each other and considerable motion, as illustrated in the commonly observed sharp foldings of strata of granular limestones without fractures or faults. In such cases also I have observed that the mutual attrition of the grains has been sometimes sufficient to convert their angular, often rhomboidal, original contours into circular outlines, the interstices between the rounded grains being evidently filled up by much smaller fragments and rubbed-off particles."

Dr. Bedell's Double Electric Transmission.

In the current Supplement we publish a discussion by Dr. Frederick Bedell, of Cornell University, on the joint transmission of direct and alternating currents simultaneously over the same set of wires. The "common conductor system," of which he is the inventor, requires two pairs of wires, each pair constituting a complete circuit for direct current. By coupling the forwarding wire of one circuit to the return wire of the other, the two will serve as a path for an alternating current, while the remaining two wires may be coupled for another alternating current. The course of each alternating current will be first along the forwarding wire and then along a return wire, according to the alternating directions of its flow, the circuit being completed through the ground. Thus the currents will not interfere with each other and the fluctuations of an alternating current will not be felt in the direct current circuits sharing the same wires.

The Death of James Glaisher.

With the death of James Glaisher there has passed away an old aeronaut. Forty years ago his exploits kept him much in the public eye. In 1862 he made a series of famous balloon trips. Ascending with Mr. Coxwell in a balloon of 95,000 cubic feet capacity, he reached a height of 26,177 feet. On September 5, in an ascent at Wolverhampton, he and his companion were nearly frozen to death. After registering observations up to a height of 36,000 feet Mr. Glaisher became unconscious. Mr. Coxwell contrived to pull the valve string with his teeth, thereby causing the balloon to descend.

The Industrial Exhibition at Osaka in 1903.

Osaka, one of the three imperial cities of Japan, is the center of great activity at this time, preparing for the Fifth National Industrial Exhibition, to be held there from March 1 to July 31 of this year. The exhibition, which is situated at Imamiya in the southern part of Osaka, will surpass in magnitude and beauty all preceding ones, and will bring before the public eye a fuller, more general representation of Japanese arts, manufactures, and resources in their latest development than has ever been seen before. The exhibit will be under the direct management of the Imperial Commission which is presided over by His Imperial Highness, Prince Kan-in. There will be special buildings for classified groups of the exhibits, and important among them are those of forestry, fine arts, agriculture, fisheries, manufactures, education, zoology, foreign samples, transportation, greenhouse, cold storage, aquarium, and machinery. There will also be bazars, restaurants, tea-houses, and the Ceremonial Hall within the grounds. Visitors to the exhibition will be fortunate in witnessing the two great religious festivals which will be celebrated at that time. The festival of Tennoiji will gather over ten thousand priests to Osaka from all over Japan to parade through the streets in their ceremonial robes of rich brocades and brilliant colors. To those who attend the exhibition will be granted special privileges and free access to many places usually closed to all visitors, both foreign and Japanese.

Carnegie Institute's Grants to Johns Hopkins University.

The Carnegie Institute has made five grants of money to the members of Johns Hopkins faculty to assist original researches. They are as follows:

To Dr. Harmon N. Morse, Professor of Analytical Chemistry, $1,500 for an assistant in his researches upon the new method he has evolved for measurement of osmotic pressures.

To Prof. R. W. Wood, $1,000 to maintain a research assistant in his work. He has appointed Thomas Sidney Elston of the University of California to the position.

Dr. H. C. Jones, in new physical chemistry as it is studied in America, gets $1,000 for an assistant in his researches. Frederick Hutton Getman, of Stamford, Conn., receives the appointment. His doctoral dissertation deals with an important problem in physical chemistry.

Dr. J. J. Abel, Professor of Physiological Chemistry, $1,000, for the purchase of apparatus necessary to his researches in that subject. He is a leader in this branch of science in America.

Dr. J. B. Whitehead, in the physical department, has received a liberal grant to carry forward a research in the theory of a magnetic field developed by Maxwell, the English scientist.