cost of the line-of-battle ships of our navy usually varied from $425,000 to $550,000. President John Quincy Adams, who went aboard the "Pennsylvania" in 1827, wrote that she was "said to be the largest ship that will float upon the ocean. She is built chiefly of live oak, and looks like a city in herself."

The first 44-gun frigates in the American navy, the rate next in size to the line-of-battle ships, were the historic vessels "Constitution," "United States," and "President," whose construction was begun in 1794. No additional vessels of this rate were built until the war of 1812, when five of them were placed upon the stocks—the "Plattsburg" and "Superior," at Sacketts Harbor, N. Y.; the "Guerrière," at Philadelphia; the "Java," at Baltimore; and the "Columbia," at Washington. The latter vessel was burned by order of the Secretary of the Navy when the British were advancing on the capital in August, 1814. The "Plattsburg" was never completed. The "Superior" was the largest naval sailing ship ever on the Great Lakes.

After the war of 1812 the construction of nine 44-gun frigates was commenced—"Potomac," "Brandywine," "Columbia," "Cumberland," "Savannah," "Raritan," "St. Lawrence," "Santee," and "Sabine." The completion of several of these ships was long delayed. Two of them were still on the stocks in 1850. About 1828 the "Hudson," 44, was purchased, and in 1841 the "Congress," 44, was launched. Altogether the old navy contained nineteen 44's. They were very serviceable and efficient vessels. During the war of 1812 the 44-gun frigates were the largest vessels in the navy, and they were usually successful in their engagements with the British vessels. For frigates they were very heavily built and strongly armed. Their cost of construction was $300,000 to $430,000. Their size may be judged from the dimensions of the "Constitution." She was 175 feet long, 43.6 feet beam, 14.3 feet hold, and 21 feet draft forward.

Several historic vessels of the old navy were rated as 36's. This was the rating of the "Constellation," "Chesapeake," "Philadelphia," and "Macedonian." The "sloops" were divided into first, second, and third class, rating respectively 20, 18, and 16 guns. The sloops tended to increase in size. The "Saratoga," one of the later sloops, carrying twenty-two guns, had a tonnage of 882 tons. Her complement of men was 210. Her dimensions were as follows: Length 150 feet, beam 36.9 feet, and hold 16.6 feet. A 20-gun sloop cost about $170,000.

During the war of 1812 our naval vessels mounted two kinds of guns, the long gun and the carronade. The former was very long and thick-barreled in comparison with its bore. It possessed great range and penetrative power. The carronade was introduced into the British navy in 1779, and into the American navy about 1798. It was a short, light gun; it had a large caliber, but a short range; it had little penetrative, but great smashing power. In the war of 1812 our 44-gun frigates were underrated. They usually carried fifty-two or fifty-four guns. These consisted of thirty long 24's on the main deck, two long guns as bow chasers, and twenty or twenty-two carronades, 32-pounders or 42-pounders. The brig-sloops carried 24-pounder or 18-pounder carronades. Long 12's and 18's were common. The schooner "Nonesuch," an active cruiser on the Southern coast, mounted long 6's and 12-pounder carronades. Generally speaking, the American ships were better built and better armed than the British ships of the same classes. During the war a third kind of gun, the columbiad, was coming into use. In size it was intermediate between the long gun and the carronade. The projectiles in common use at this time were solid shot, shrapnel, canister, bar shot, and chain shot. There were no explosive shells used in the navy.

The principal sea duels of our sailing navy during the nineteenth century were fought during the war of 1812. The latter part of the year 1812 and the winter of 1813 will ever be memorable in our naval annals. The five naval engagements of this period all resulted favorably to the Americans. The "Constitution" captured the "Guerrière" and the "Java"; the "Wasp," the "Frolic"; the "United States," the "Macedonian"; and the "Hornet," the "Peacock." The first severe reverse of the Americans was the capture of the "Chesapeake," Capt. James Lawrence, by the "Shannon," Capt. Philip Vere Broke, in May, 1813. This well-known engagement, off Boston, in which the American captain was killed, lasted but a few minutes. It was an artillery fight at close range, and was decided before the boarding of the "Chesapeake" took place, as the result of the superior discipline of the British crew. The American ship was manned with raw recruits. The engagement between the "Constitution," Capt. William Bainbridge, and the "Java," Capt. Henry Lambert, off the coast of Brazil, lasted about three hours. Here the maneuvering of the ships played a most important part. The "Java" was too much injured to be worth taking to the United States. Bainbridge therefore ordered her to be burned.

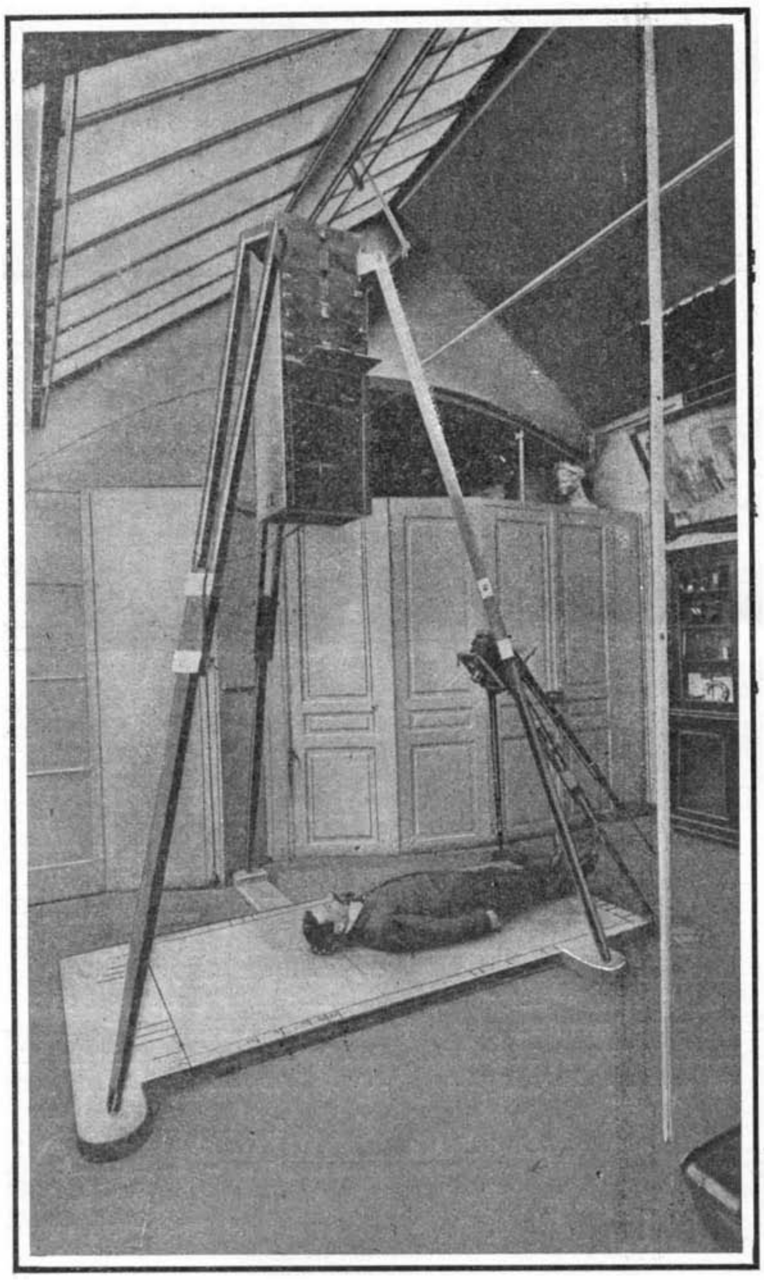
A typical line-of-battle ship of our navy of the date 1820 mounted thirty-two long 42-pounders, thirty-four long 32-pounders, and twenty-two 42-pounder carronades. The weight of its broadside was 1,710 pounds. The long 42-pounders had great range and penetrative power. About 1845 the "Pennsylvania," the largest ship in the navy, mounted sixteen 8-inch guns and one hundred and four 32-pounders. During the early part of the nineteenth century there was a "chaos of calibers" in our navy. For instance, a line-of-battle ship might require "three sizes of shot and four classes of full charge, with as many reduces as caprice might suggest." A uniform caliber throughout the fleet became the ideal of the naval officers of both this country and Europe. This ideal was in large part realized in France in 1829, in England in 1839, and in the United States in 1845. In the latter year the Navy Department adopted the 32-pounder as the unit caliber of our navy, and directed that in the future the batteries of our naval ships should consist of 32-pounders and 8-inch shell guns. The latter type of ordnance had come into use in our navy about 1840, when the Paixhans shell guns had been introduced. The improvements that were made in ordnance during the decade preceding the civil war again complicated our naval batteries, and brought into use the 9-inch, 10-inch, and 11-inch Dahlgren guns, 64-pounders, and rifled cannon.

BERTILLON'S NEW SYSTEM OF ANTHROPOMETRY.

BY JACQUES BOYER.

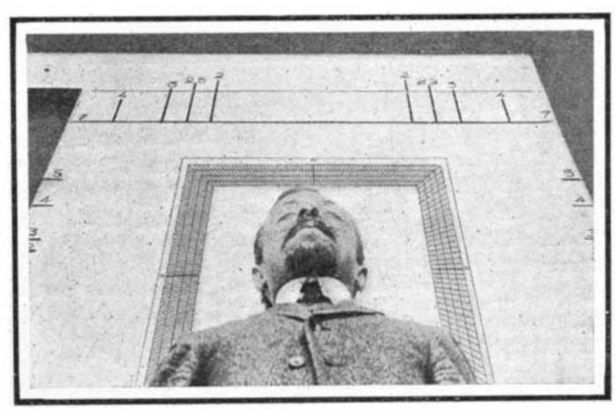
Dr. Bertillon, chief of the department of identification of the Paris prefecture of police, has devised a photographic apparatus, by the aid of which valuable evidence can be obtained in the investigation of crimes. The new method is based on an ingenious application of the laws of perspective to photography.

The apparatus, invented by Bertillon and constructed by Lacour, furnishes an elegant solution of the following problem: Given an object of a thickness not exceeding 40 centimeters (16 inches), with its median plane at a fixed distance (2 meters or about 6½ feet) from the lens, it is required to make photographs of the object on various scales of dimensions, without moving the camera or displacing the optical center of the lenses, so that the real dimensions of the object can be calculated from measurements of the photographs. Theoretically the problem is simple, but in practice it is complicated by several difficulties. In the first place, in order to obtain a number of photographs on different scales of an object placed at a fixed distance from the camera, it is necessary to use an equal number of lenses, or combinations of lenses, of different and appropriate focal lengths. The change of the entire combination for each change in focal length would involve great expense for lenses as well as probable displacement of the optical center.



The New Bertillon Apparatus for Photographing Suspected Criminals for Identification.

A Photograph Surrounded by Perspective Scales.



A Photograph Taken Obliquely.

BERTILLON'S NEW SYSTEM OF ANTHROPOMETRY.

In Bertillon's apparatus as constructed by Lacour the back lens remains fixed and may be combined with any one of six front lenses of graduated focal length, without displacing the optical center of the entire combination, which in each case is anastigmatic and perfectly corrected, with a depth of focus of about 16 inches. Hence, as the focal center is a fixed point of known position, the compound lens may be treated, in calculation, as if it were reduced to this point, and the distance required can be computed very simply by means of the well-known elementary formula $p = f(g + 1)$, in which p is the distance between the object and the optical center of the lens (2 meters in this case), g is the ratio of the dimensions of the object to those of its image, and f is the focal length of the combination employed to produce that image. Consequently the reduction (or magnification) can be computed if the focal length is known, and *vice versa*. For example, let us suppose that we wish to obtain a photograph of dimensions 1/5 of those of the object. In this case the formula becomes $2 = f(5 + 1) = 6f$, whence $f = 2/6$. The required focal length, therefore, is 2/6 meters, or 33 centimeters. M. Bertillon has adopted the following scale of reduction: 1/7, 1/5, 1/4, 1/3, 1/2.5 and 1/2 corresponding to the focal lengths 25, 33, 40, 50, 57 and 67 centimeters, or about 10, 13, 16, 20, 23 and 27 inches.

Each of the movable front combinations is marked with the focal lengths and the reduction which it produces when combined with the fixed back lens, thus: focus 25 centimeters, reduction 1/7. The camera, which is mounted with its axis vertical as shown in the illustration, is a large rectangular wooden box supported by three legs. In one side are six slots at distances from the optical center corresponding to the focal lengths of the six combinations of lenses, and the plate holder, measuring 24 by 30 centimeters (about 10 by 12 inches) is inserted in the slit corresponding to the combination used.

The optical center is exactly 2 meters above a fixed horizontal plane, the plane of reference or median plane, which is itself 20 centimeters (8 inches) above the floor. Hence, as the lens has a focal depth of 40 centimeters it will give a sharp image of any point within a distance of 20 centimeters above or below the median plane.

Portions of the object situated above this plane and consequently within less than 2 meters of the lens will, of course, be less reduced than equal areas of the plane of reference. It has been determined that the scale of dimensions increases by 1/100 for each 2 centimeters of elevation, between the limits of 180 and 220 centimeters from the lens. Hence, if the photograph is surrounded by perspective scales, as shown in one of the illustrations, the real dimensions of a part of the object in any plane parallel to the photograph can be computed from measurements of the corresponding part of the picture. Thus the photographs possess the valuable properties of the diagrams of descriptive geometry and orthogonal projections. The method appears susceptible of numerous applications, especially to anatomy and natural history. In photographing objects smaller than the human head some such series as 1/2, 1, 2, 3, 4, and 5 diameters might be employed, and the fixed distance might be made less than 2 meters in order to diminish the space occupied by the apparatus.

A NOVEL APPARATUS FOR DEMONSTRATING ATMOSPHERIC PRESSURE.

BY DR. ALFRED GRADENWITZ.

Mr. B. Rheinisch, an engineer living in Görlitz, Germany, has for some time been engaged in systematic investigations on the upward pull exerted by the atmosphere, with a view to utilize atmospheric pressure for the lifting of loads.

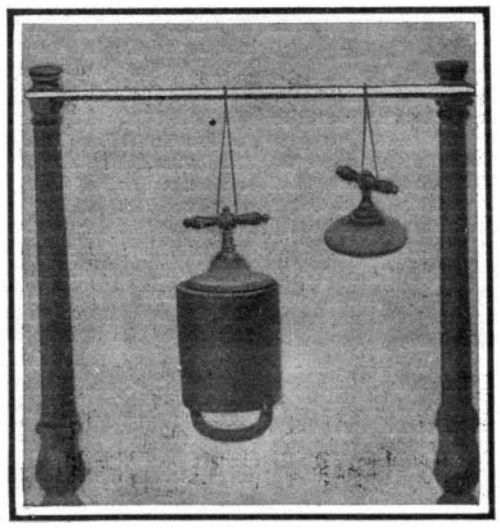
Special attention was paid to the specific weight of all animal bodies carried by the air, such as birds, beetles, and butterflies, and constant ratios between the volume and weight (within certain limits) were given in these three classes of bodies. While a full account of the scientific results reached in this connection is reserved for a future article, the first practical achievement was the construction of what the experimenter calls the "Görlitz pneumatic disks." These disks are intended to interest scientists in the investigation of the displacement of air while affording an illustrative demonstration of the essence and effects of the invisible force due to atmospheric pressure. Owing to its extreme simplicity, the apparatus can be advantageously substituted for the classic Magdeburg hemispheres designed by Otto von Guericke.

Mr. Rheinisch uses two flat, elastic segments of a hollow sphere which are slightly compressed against each other, thus displacing any air contained in the intervening space. Each segment is supplied with a suitable handle, which is of great assistance in making experiments. After discontinuing the compression, the experimenter has practically an absolute vacuum between the two segments of the apparatus.

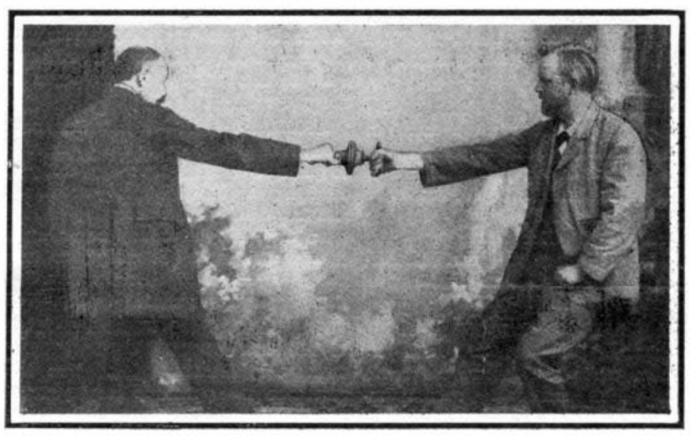
The two halves of the apparatus can be separated with difficulty by two men seizing the handles and exerting their strength to the utmost. If the disks are compressed against a smooth surface, each can be loaded with a weight of 110 pounds by a pull acting at right angles to the surface, no matter whether the load is applied in a downward, upward, or lateral direction. In the case of two elastic disks applied to the varnished wooden surface of a door frame, the charge can be represented by the weight of a grown man loading each handle with 99 to 110 pounds, while a child will be able with its weight to load one handle.

The experimenter further used marble blocks, 22 to 66 pounds in weight, and polished on one side. It was especially interesting to note how awkward were those lifting the stones from the ground without the pneumatic disks, while with the use of the disks the more comfortable position for handling the block was found to be of great advantage.

It is supposed that these disks will be used to replace ordinary gymnastic implements, because of the ease with which they are fitted to ceilings or door-frames, leaving no marks, while fully capable of bearing the weight of a grown person. The German Museum of Masterpieces of Science and Industry, which has been recently opened in Munich, is exhibiting these disks. Many schools have adopted this simple apparatus for the demonstration of the working of atmospheric pressure, thus dispensing with the use of an air pump. We are informed that the inventor is communicating with a number of foreign governments, offering his apparatus, free of patent obligations, in the interest of scientific investigation.



The Görlitz Pneumatic Disks.



Separating the Two Segments Held Together by Atmospheric Pressure.

Disks Attached to Polished Surface, Supporting the Weight of a Boy.

A NOVEL APPARATUS FOR DEMONSTRATING ATMOSPHERIC PRESSURE.

Eggs Without Shells as Freight.

Russian exporters, to avoid an excessive freight on eggs as well as to avoid loss from breakage and from spoiling by heat, ship them without the shell, i. e., broken, and the contents put up in air-tight block tin boxes, with or without salt, according to the taste of the customer. Each box contains several eggs, and is sold by weight, the size running from half a kilogramme up to a *pud* (some 16 kilogrammes). The price of the latter is 5 rubles. For use in cooking and for a limited time, these tinned or preserved eggs seem to answer very well; that is, on the Continent, for England doesn't take kindly to them. London, for instance, which buys large quantities of Russian eggs, pays 8 rubles per *pud* for them (against 5 for the preserved eggs), besides the weight of the shells and the extra freight tariff on eggs. Each block-tin box of "conserved" eggs, whether it be of half-kilo (a kilo is a little over two pounds) or 2 *pud* size, must bear the date and hour of its closing, thus guarding against getting stale eggs. The amount of eggs put up in boxes and annually exported is enormous and constantly growing.—National Druggist.

Paper Pinions.

The driving of machinery by means of gear wheels is rapidly extending, the three chief factors in the development being the increasing use of electric motors, the tendency to save every inch of space occupied by machinery, and the greater attention now paid to the prevention of variation in speed and loss of power.

Where belts are used for driving it is impossible to avoid "slip" with consequent undue wear and tear, loss of power and great variations in speed. Gear wheels give a positive drive with no loss in speed between the driver and driven, and if properly designed and constructed the wear and tear and loss of power is extremely small.

Noise is the chief objection to driving by means of gear wheels, and although this objection has to a great extent been overcome by the use of rawhide pinions which gear with spur wheels having machine-cut teeth, these pinions cannot be considered as finally solving the problem, because under the most favorable conditions their life is comparatively short and they must be protected from moisture, oil, and changes in temperature—three difficult things to avoid in ordinary practice. In consequence of these difficulties experienced, a British firm began experimenting with different materials, and found that pinions made from a high-grade Manila paper were the best available. The paper after being cut into blanks was subjected to the requisite pressure in 1,000-ton hydraulic presses, and the result is a paper pinion that has the strength of a cast-iron gear of the same dimensions.

Different from the rawhide pinions, those made of paper are not subject to variations of temperature and other untoward conditions. A paper pinion is more elastic than one of cast iron, and it is even lighter in weight—i. e., 23 cubic inches equal 1 pound—than rawhide; consequently it has a very decided advantage over either of these gears. When in operation there is no vibration, and there is a total absence of the ringing sound so prevalent in metal gears when they become a trifle worn. After working a short time and being lubricated with graphite, the compressed paper assumes a highly polished surface, which reduces to an appreciable extent the friction between the paper and the metal teeth.

A paper pinion is very simply manufactured by compressing the paper between flanges of hard brass, gun metal, or steel; in the smaller sizes the flanges are held up to their work by suitably spaced rivets, and in the larger sizes by special steel studs with conical heads countersunk.

Prof. Pickering Elected a Member of the Royal Society.

Dr. Edward Charles Pickering, the well-known Director of Harvard College Observatory, was elected June 6 a foreign member of the Royal Society of London, for his signal contributions to astronomical knowledge. The importance of the election may be gathered from the fact that only fifty foreign members have thus far been elected to the Royal Society, a very jealously-guarded list. Those in America who are already foreign members are Simon Newcomb, Alexander Agassiz, George William Hill, and Albert A. Michelson.

In 1886 the Royal Astronomical Society of London awarded Dr. Pickering its gold medal for his photometric work in connection with astronomy.

Prof. Pickering was born in Boston in 1846, and was graduated from Harvard in 1865 with the degree of Bachelor of Sciences. He started his pedagogic career as an instructor in mathematics in the Lawrence Scientific School of Harvard, which post he held from 1865 to 1867. From 1867 to 1877 he was professor of physics at the Massachusetts Institute of Technology, which chair he relinquished to assume the directorship of the Harvard College Observatory, a post he still holds. He has received many academic and honorary degrees from many institutions, notably California, Michigan, Chicago, Harvard, and Victoria (England). Besides two Royal Astronomical Society medals, he has also received the Rumford and Draper medals.

From 1893 to 1905 the tractive power of passenger locomotives in the United States has increased from 15,250 pounds to 24,648 pounds, an increase of 55.6 per cent.