

THE INTERNATIONAL BUREAU OF WEIGHTS AND MEASURES.

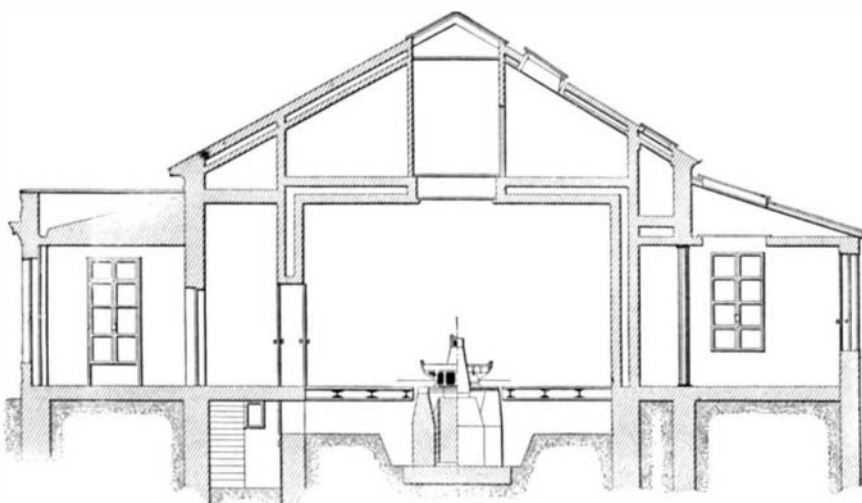
BY HERBERT T. WADE.

We described last week the method by which standard measures of length are prepared and tested in France. The International Bureau of Weights and Measures, in which the work is done, is worthy of notice. For more than thirty years the Bureau has been situated near Sèvres in the environs of Paris, on ground made absolutely neutral by international treaty. This treaty was signed in 1875 by the delegates of seventeen nations interested in the construction of a new meter and kilogramme to replace those determined on in 1799.

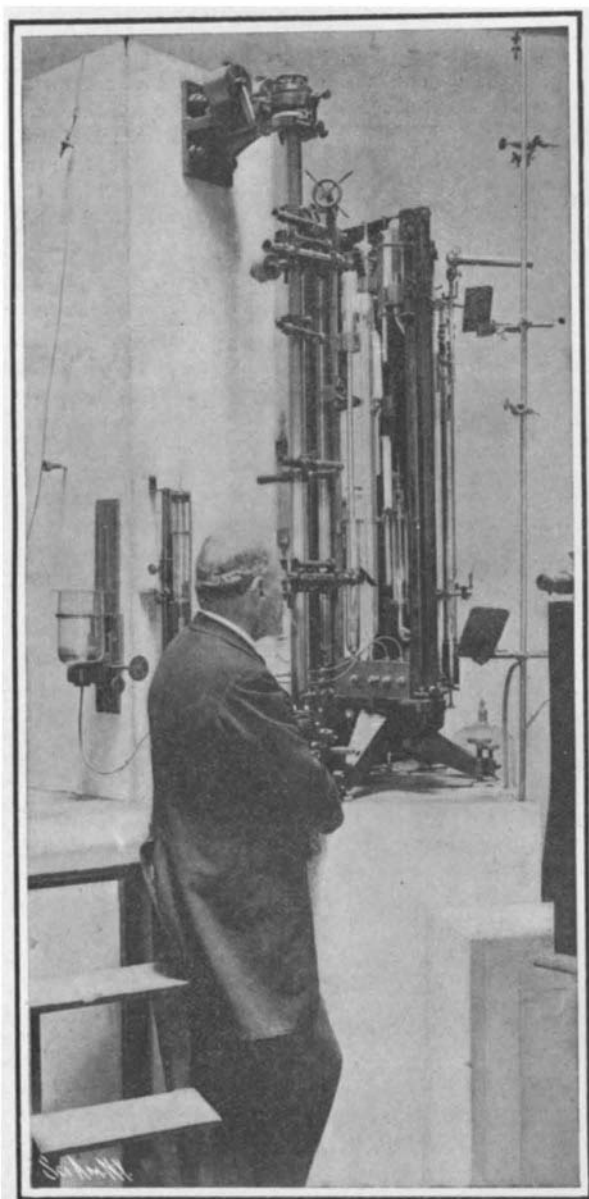
At the outset it may not be amiss to explain the importance of this Bureau, not only to science, but to ordinary commerce and industry, which at first thought hardly would seem to be concerned with the minute measurements of the physicist. This perhaps will be more apparent if we consider for a moment the analogous condition of a nation's currency, which must be absolutely uniform and unvarying. While a uniform currency can be secured through a national mint,

involves the most delicate operations of modern experimental science, and requires great manipulative skill as well as knowledge of practical physics. The present staff of the Bureau is headed by M. J. René Benoit director and M. Charles Eduard Guillaume

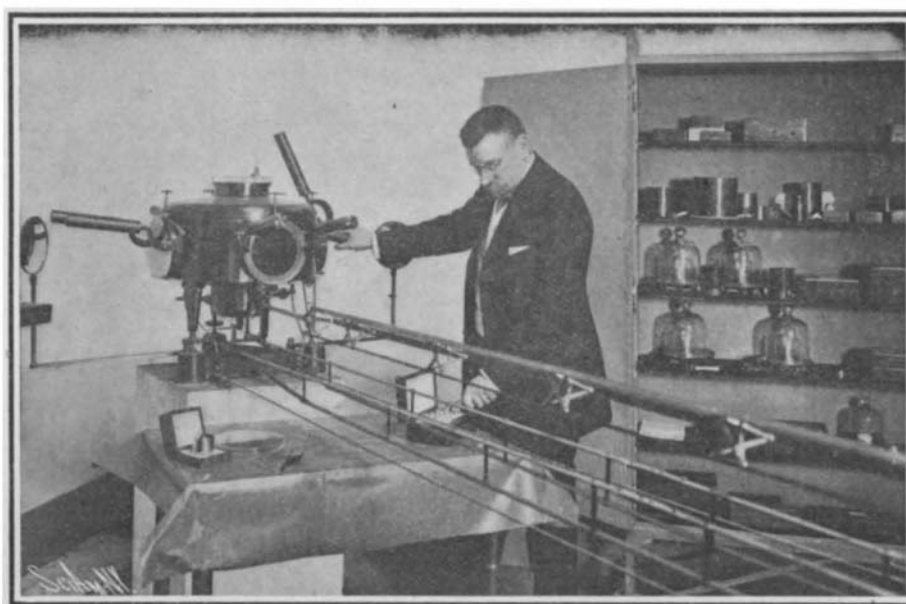
communicated to the main structure, and floor and walls of course are quite clear of the pillars supporting the instruments. The laboratories are in the center of the building, surrounded by a corridor on all sides and with an attic above, so that they never receive direct sunlight, while the doors and walls are made double, the latter being filled with material that does not conduct heat. The heating and ventilating system is so arranged that a constant temperature is maintained, and often the heat from the observer's body is the most important cause of disturbance. The maintenance of an exact temperature in winter within the laboratories, where accurate comparisons are made, is accomplished by a thermo-regulator acting on a gas stove. This device, which is shown in the accompanying illustration, consists of a large glass bulb containing gasoline, which terminates in one arm of a U-tube containing mercury. As the liquid air expands with an increase in temperature, the mercury rises in the opposite arm of the tube, and thus cuts off the main gas supply, though a small cock is always open, and permits a small amount to pass, sufficient to keep



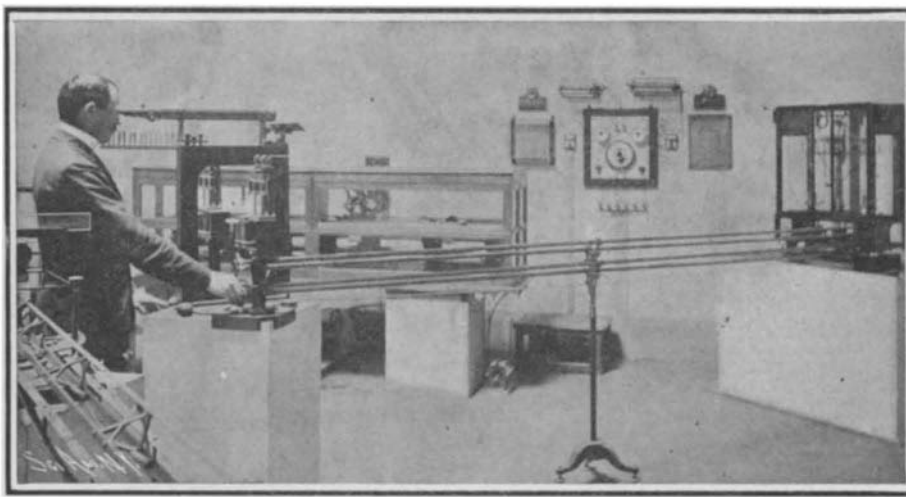
Laboratory of the International Bureau of Weights and Measures. Section Showing General Construction. The Method of Mounting the Instruments is Shown by the Large Comparator in the Center.



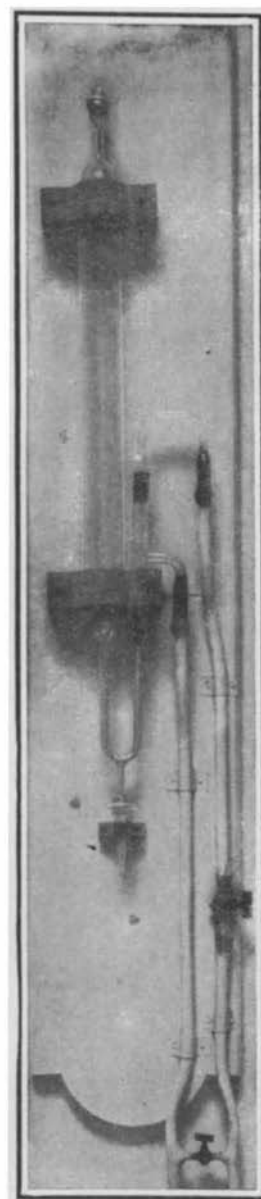
Standard Normal Barometer and Manometer. M. René Benoit is Making an Observation.



Bunge Balance for Making Weighings in Vacuum.



Balance for Comparing Standard Kilogrammes.



Temperature Regulating Device.

THE INTERNATIONAL BUREAU OF WEIGHTS AND MEASURES.

it would be next to impossible for each nation to construct and supply to its citizens weights and measures for every-day use, so that makers and users of weights and measures must be provided with some means for comparison with secondary or other standards, which bear some fixed relation with the national standards, just as the coinage must be referred to certain definite standards of weight. Now, if the national standards of one country vary materially from those of another, or there is not sufficient opportunity for government regulation and comparison, there will be a lack of uniformity in weights and measures, such as existed to a marked degree in Europe at the beginning of the nineteenth century, when over 300 different pound standards were in use. This of course interfered seriously with commerce, and largely led to the adoption of the metric system in the interest of harmony, and this in turn brought about the necessity of redetermining or improving the metric standards. As a direct result followed the institution of the Bureau and the construction of the international prototype meter and kilogramme.

The construction and comparison of standards

assistant director, both of these gentlemen being widely known for their researches and thorough knowledge of all matters connected with metrology. The buildings of the Bureau are typical of the triumph of peace, as the Pavillon Breteuil, where its offices are located, not only was once a favorite resort of Napoleon I., but suffered in the Franco-Prussian war. The Pavillon was turned over to the International Committee by the French government and was thoroughly repaired, while near by was erected a modern and specially equipped laboratory. The illustrations show some of the more important instruments of this laboratory. In regard to the building itself, in the first place, there must be absolute stability and freedom from vibration or other disturbance for the instruments, and to secure this there are independent mountings on masonry piers, with individual foundations that are independent of each other as well as of the structural walls. This is made clear in the cross section of the building, which shows the mounting of a large comparator for comparing standards of length on an independent concrete base. The floor is supported so that a minimum of vibration caused by walking is

the flame alive in the stove. This regulator can maintain the temperature of the room constant to within 1/10 of a degree Centigrade, so long as the outside temperature is less than that for which it is regulated.

In most of the work done at the Bureau, the measurement of the pressure and temperature of the air and other gases must be carried out with high precision. The standards represent the given unit only at some specified temperature and pressure, at which measurements and comparisons must be made, and to which all measurements must be reduced. Now, as all temperatures, whether measured by mercurial or other thermometers, must be reduced to terms of the hydrogen gas thermometer, it is necessary to have some device to measure accurately the pressure of the gas. We have for this purpose the standard mercurial normal barometer and manometer, and this instrument is illustrated, with M. Benoit, the director, engaged in making a measurement. Mounted on its pillar, this barometer is a complicated piece of apparatus, and to secure the highest precision, the tubes containing the mercury are made rather large, and

there is an elaborate system of reading telescopes and scales, forming what is termed by the physicist a cathetometer. The director is looking through the telescope in order to fix the lower surface of the mercury, and the adjustment of the cross hairs at this point is made with great accuracy by a system of reflectors. A modification of this instrument is used to measure the pressure of the hydrogen gas in the air thermometer, which is the standard now adopted not only in connection with the standards, but in all exact temperature measurements. Here at the Bureau the relation of the gas thermometer to the mercurial, platinum resistance, and other thermometers has been most carefully studied, so that now temperature measurements can be made with the greatest accuracy.

In the same room with the standard barometer are the balances of precision used in comparing the standards of mass, or kilogramme and other weights. As shown in the illustration, the observer is at a distance of about 15 feet from the balance, and looking through a telescope notes the deflection of its beam as indicated by a mirror and scale. By means of a system of rods and cranks, he is able completely to control the mechanism without approaching the apparatus. The balance shown in the illustration is of the Ruprecht type, used in comparing the standard kilogramme. In this, after the two standard weights are placed in the scale pans, the beam can be set in motion or brought to rest, and the weights interchanged in the two scale pans by the mechanism referred to without the case being approached or opened by the observer. The Bunge balance, also illustrated, combines all the essentials just mentioned, but in addition permits the weighing to be done in a vacuum. The cabinet behind the observer, it will be noticed, contains various standards, and one of the original kilogrammes of platinum-iridium is to be seen on the table in front of the balance. The sensitiveness of these balances is something marvelous, a difference of a milligramme showing a movement of from 25 to 50 divisions on the scale.

In connection with the study of standards, many important physical determinations and researches must be made, and for these the Bureau has appropriate laboratories with special instruments and equipment for chemical, optical, and electrical work and for the general study of the properties of various materials.

NEW TERMINAL STATION AND APPROACHES OF THE BROOKLYN BRIDGE.

At last, after a quarter of a century of service, the Brooklyn Bridge is to be provided with a terminal station and approaches worthy of the importance and dignity of that structure. The present station is in every way inadequate, both in its appearance and in its accommodation, to form a fitting entrance to this, the most famous bridge in the world. The overcrowding at the Manhattan terminal has long been the most serious of the many cases of congestion of traffic in Manhattan Island. Fully a decade ago, the conditions were described in the columns of this journal as "intolerable." What they are to-day passes description; and that the accidents are not more frequent, is due to the wonderful self-repression and patience, in the face of enormous inconveniences, of the many millions that pass to and fro through the station.

The decidedly ugly building which now disfigures the bridge entrance is to be entirely removed, and in its place is to be erected a much larger and more dignified structure, whose architectural features, as shown in our front-page engraving, have been so judiciously treated, that the station with its approaches will form a decided addition to the architectural features of City Hall Park; while the whole scheme has been laid out on such a spacious scale, that the days of excessive overcrowding must soon become a thing of the past. In addition to serving its purpose as a station, the new terminal building will form an appropriate annex to the municipal office building, twenty stories high, which the city will ultimately erect above the new Subway station adjoining the bridge entrance to the north. The design of the new bridge station, which will be about the height of the present terminal, has been treated in the Grecian style. The façade, whose front will be flush with the building line of the World building, will be formed of six massive columns with glass between, and at each corner of the coping line, above the masses of masonry which flank the central glass-lighted portion of the building, will be symbolic groups of statuary. The approach to the station from City Hall Park will be by way of an esplanade 40 feet in width and of richly ornamented design, which will extend across Park Row and Center Street into City Hall Park, where access to the esplanade will be had by means of four broad stairways; one to the north, another to the south, and two with an escalator between them to the east of the structure. The escalator will be inclosed, as shown in the engraving. All four stairways lead up to an impressive peristyle, which marks the termination of the esplanade. At each end will be massive figures of the Sphinx, and

the treatment of the electric light standards, the balustrades, and other features of the design admitting of decorative work, has been done with a simple dignity that harmonizes well with the general treatment of the whole work.

The massive steel bridge which has recently been thrown across Park Row, and the rearrangement of traffic at the present terminal, must not be confused with the permanent improvements referred to above. The recently-completed structure is of a temporary character only, and is designed to offer immediate relief until the new bridge and approaches are completed. The temporary extension of the bridge terminal was made to provide additional platform space and increase the switching facilities. With its opening a couple of weeks ago, cable-car service during the rush hours was discontinued, and through elevated trains are now operated from distant points on the Brooklyn Rapid Transit system during all hours of the day and night. Although the inauguration of this improvement was attended with much confusion, it is confidently expected that ultimately the capacity of the bridge will be increased, and the congestion not a little relieved, particularly in view of the fact that the recent opening of the Subway to Brooklyn has diverted a large amount of travel from the bridge.

The new station will be considerably larger than the old. In the first place, it will be widened to occupy the whole of the available space from building line to building line; and it will be lengthened by extending it eastwardly over the present viaduct, which is being widened to accommodate it. There will be three floors, as in the present station. The ground floor, or surface, now occupied by the surface car loops, will be cleared of these, leaving an absolutely free passage for pedestrians. The eight loops will be transferred to the second, or mezzanine floor, as it will be called. The third floor will be given over entirely to the elevated service. By this arrangement there will be a complete separation of the three classes of traffic—foot passenger, surface car, and elevated. The passengers who wish to use the surface cars will pass through on the ground floor below the station, and ascend by the particular stairway which serves the line on which they wish to travel. Each loop will have its own stairway from the ground floor, and each stairway will carry a sign designating the lines which may be reached on the floor above. In this way the crossing and recrossing of the tracks, which is such a source of confusion and danger, will be entirely eliminated, and, as the mezzanine platforms will be very spacious, the present congestion will be entirely relieved.

As soon as the extension of the tracks and platforms of the new station has been completed, the temporary extension across Park Row will be taken down, and the new approaches built in its place. Passengers desiring to take the elevated trains will pass along a platform on the mezzanine floor, which will be raised above the platform of the trolley loops, and from this platform another set of stairways and escalators will lead to the elevated lines on the floor above. These escalators will also carry signs, which will enable the passengers to go direct to the platforms from which their particular trains are starting.

At the present time the work of widening the roadways of the bridge is nearing completion. This widening is done to enable the Subway cars which will cross the bridge to descend into a tunnel, which will connect the bridge with the Subway terminal station and the Subway loop. When the roadways have been widened, the trolley tracks will be moved out to permit the laying of another track on each side of the bridge to connect with the Subway. The advantages of the scheme of tracks and connections as outlined above are that if the Brooklyn Rapid Transit Company does not wish to operate the Subway loop connecting the bridges, it still can operate its elevated trains to the Park Row terminal. Moreover, in that case the company which operates the Subway loop will be independent of the Brooklyn Rapid Transit Company. The passengers who use the Subway loop will not be required to use the bridge terminal station, but can take their cars from the big Subway terminal station below the Staats Zeitung building site.

The Subway terminal station will extend for a distance of three blocks, and it will contain three loading and two unloading platforms, each 450 feet in length. The trains from the bridge will cross under William Street and Park Row, where they will enter the station. Access to the station will be amply provided for. There will be five stairways where Park Row and Center Street form a triangle; three for the loading platforms, and two from the unloading platforms, the flow of incoming and outgoing passengers being maintained in opposite directions. At the mid-length of the station there will be another series of entrances leading from Duane, Center, and Reade Streets, and at the extreme northerly end of the terminal there will be another series of exits and entrances. The center loading platform will be 40

feet wide. On either side of this will be two unloading platforms; while on each extreme side of the station there will be another loading platform.

A four-track system will extend from this station, through Center Street and the Bowery, to Delancey Street. There will be stations at Leonard and Franklin Streets, at Howard and Grand Streets, and a large station, built on the general lines of the Park Row station, at the Bowery and Delancey Street. This station, which will be at the entrance of the approach to the Williamsburg Bridge, will cover nearly three city blocks, and the same system of separate loading and unloading platforms and complete separation of incoming and outgoing traffic, that has been planned for the Park Row Subway station, will also be used here.

Important improvements, designed to remove the present surface car congestion at the entrance to the bridge, are being carried out on the Brooklyn side, the main feature of which is the erection of an incline from Washington Street to the bridge yards, a short distance this side of Concord Street, and beyond the elevated spur which connects the Brooklyn elevated system on Adams Street with the bridge. By means of this elevated construction it is confidently expected that the long waits of surface cars at the Brooklyn end of the bridge will be eliminated.

The public has but little idea of the magnitude of the improvements of which the new bridge terminal forms an integral part; for the total cost of all this work will be about \$40,000,000. The Manhattan Bridge with the cost of the land and approaches will call for an expenditure of \$25,000,000. The Subway loop will cost \$10,000,000; the remodeling of the Manhattan terminal, that is to say, all that work shown in our engraving, will cost \$3,000,000; the Subway station in Delancey Street in connection with the Williamsburg Bridge will cost \$1,500,000; and other items will bring the total up to the \$40,000,000 named above.

THE PRIZE-WINNING CIRCULAR FLIGHT OF THE FARMAN AEROPLANE.

(Continued from page 92.)

a circular flight in an aeroplane is, therefore, quite difficult, and can only be attained after considerable training.

As to the type of aeroplane to be used in the immediate future, Farman believes this will be a combination of the double and single surface, following-plane machines, such as used by himself and Bleriot. Accordingly, his new aeroplane will have three pairs of superposed wings in front and two following pairs at the rear. The spread of the forward wings will be 7 meters (22.96 feet), while that of the rear wings will be somewhat less. The total supporting surface will be 45 square meters (484.36 square feet). The wings will be attached to a quadrangular body 14 meters (45.93 feet) long and mounted on three wheels. The 50-horse-power motor at the front end of this body will carry a $2\frac{1}{2}$ meter (8.2 foot) propeller directly on its crankshaft. One pair of the forward planes will be hinged and used as a horizontal rudder.

On January 13, the day on which Farman made his flight for the prize, the weather was fair and the air was calm. At 9:30 A. M., Farman and the Voisin brothers, after a minute final examination of the aeroplane, ran it out of its shed and tried the motor, which was found to operate perfectly. The aeroplane was then taken to the starting point at one end of the Parade Ground at Issy-les-Moulineaux. Two poles bearing flags of the Aero Club of France were located at a distance of 50 meters apart, while the turning post was located on the perpendicular to the line connecting these posts, at a distance of 500 meters away. Various officials were located at the starting and turning points, while other members of the Aero Club followed the aeroplane in an automobile. At about 10:15 the motor was started, and the aeroplane was released. After a run of several hundred feet, it rose in the air, and crossed the starting line at a height of about 12 feet. It flew straight for the turning post at a speed of fully 30 miles an hour, rising meanwhile to a height of 20 to 25 feet; and, turning about the post at right angles some 300 feet away, it flew a considerable distance—fully 1,000 feet—parallel to the starting line, after which, another right-angled turn was made, and a long straight flight continued back to the goal. The total distance actually covered is estimated to have been between 1,300 and 1,500 meters (4,265 and 4,921 feet), which would bring the average speed up to as high as $28\frac{1}{2}$ miles an hour. The flight lasted 1 minute and 28 seconds. In finishing, the machine crossed the line at about the same height as before, and landed about 100 feet beyond. Farman was given a great ovation, and was heartily cheered by the on-lookers. Not content with having so easily won the prize, he made another circular flight before housing the machine in its shed and going back by automobile to Paris. At a banquet of the Aero Club a few days later, he received the prize, in addition to a number of other commemorative medals.