position, and of ensuring that the movable parts shall move freely, yet without shake.

"This we may do by attending to the well-known fact in kinematics—'*A rigid body has six degrees of freedom.*'"

Designs in which this principle is carried out may be called geometrical designs. A three-legged table is a geometrical design, and a four-legged table is not. A four-legged table either rocks on two legs, or bends so that all legs touch the floor, and the amount of bending and the pressure of each foot on the floor depends on the stiffness of the table and the evenness of the floor. Every time an ordinary chair is placed in a new position, it takes a new shape. A surface plate is a familiar example of the importance of three supports, and nearly all scientific instruments rest on three feet. Other examples of geometric design were also given.

Good Design and Bad Workmanship.

A most important consideration in a good design is that the instrument shall still work well when the rubbing surfaces get worn or parts get bent, or if the workmanship is not good. With perfect workmanship and a bad design, you may get jamming in the moving pieces and bending of parts which should not bend, and the results obtained will be liable to error and the working unsatisfactory. This consideration brings out most forcibly the advantage of geometrical designs, but also it is a valuable test to all designs. It is a long way from being the only test, but it is always well worth while to consider separately the effects of imperfect workmanship, or the bending of each part and wearing of the rubbing surfaces. Take the case of wear in a wheelbarrow. The axle of the wheel usually consists of two round iron pins running in holes in wooden rails forming the frame of the wheelbarrow. Both the wood and the pins wear; the pin gets smaller but keeps circular, and wears its way into the wood and always fits it properly on the side where pressure is taken. The wheel will work perfectly until either the holes break out of the wood or the pin wears down very small and itself gives way. But sometimes the axle is made differently; an iron rod is fixed to the two wooden rails and passes through a hole bored along the centre of the wheel. With use the iron rod wears on the under side and does not remain circular, the hole in the wheel gets larger; the result is increased friction and a loose and shaky bearing.

The following test was applied to the Rocking Microtome, which has been designed so far as possible on the geometrical method. The iron castings of which it is chiefly made were taken as they left the foundry, were put together with as little work as possible, and it at once cut good sections. This was a severe ordeal, but sections as thin as 0·003 mm. were cut, proving that the instrument still worked with considerable precision.

This test for good design is not the only test, and it may fail. Ball bearings are much used, and when once used for any purpose they continue to be used more and more; this is the best test of a really good mechanical device. All must admire their design, but first-rate workmanship is essential; in this must be included the composition of the steel, the skill in hardening, as well as the accuracy of the figure of the working parts. A ball bearing, however, would be a better thing even than it is at present if it did not require such fine workmanship. It also requires careful mounting, and it is interesting to notice that the recent improvements in ball-bearing design are in the direction of allowing it to work satisfactorily on shafting which may be considerably bent.

The Advantage of Reversing the Parts of a Machine.

An improvement in the design of a machine can often be made by reversing the relative position of two parts of it, or the part that moved can be fixed and the part that was fixed can be made to move. This reversal makes it possible to compare two or more methods, and it is then easy to see which is best. It is advantageous that "the survival of the fittest" should take place early in the life of the machine, and by this means, in fact, it takes place before the design is completed.

In the before-mentioned wheelbarrow it is easy to see which is the best design, and if the designer had deliberately considered whether the iron pins should turn in the wooden rails or whether the iron bar should be fixed, the bad design would never have been made. It is surprising how often this reversal is possible and advantageous, and how difficult it is to realise that it is possible. We are so familiar with a clock in which the frame remains at rest and the hands move that it requires a considerable mental wrench to realise that it is possible and in some cases better that the clock itself should revolve and the hour hand remain at rest. But in recording apparatus it is usual to fix the clockwork in the rotating drum carrying the paper, and to prevent rotation of the hour-hand spindle.

The lecturer concluded:—"I have spoken as a manufacturer of scientific instruments, but my remarks apply equally or even more to the home-made or rather laboratory-made type of instruments. And it is with these that the greatest advances in knowledge have been made. If I could believe that what I have said would be any help to the makers of the wire, cork, and sealing-wax class of instruments, or to the orthodox instrument-maker, I should be glad to think I had done something to advance knowledge."

THE STANDARDISATION OF HYDROMETERS.

We have received from the director of the National Physical Laboratory the following memorandum for publication in NATURE:—

At the present time there appears to be considerable ambiguity as to the bases of standardisation of hydrometers graduated to read directly in specific gravity.

Three different methods have been brought to the notice of the National Physical Laboratory, and it seems desirable to determine which of these three should be considered as standard.

The instruments are in all cases graduated for use in a liquid at a definite temperature—we call this the standard temperature of the instrument—and give the specific gravity of this liquid at some definite temperature, which may or may not be the standard temperature of the instrument, referred to water at the same or at some other temperature.

The following cases have arisen in practice:—

I. (α) The liquid to be tested must be at the standard temperature of the instrument.

(β) The water to which the specific gravity is referred must also be at the standard temperature of the instrument. Thus, if 85° F. be the standard temperature of the instrument[1] the liquid must be at 85° F. when tested, and its specific gravity is referred to water also at 85° F.

II. (α) The liquid to be tested must be at the standard temperature of the instrument.

[1] A more usual value for this temperature of the instrument would be 60° F. or 62° F. The temperature 85° F. is chosen here as an example so as to bring out the differences arising from the various methods of standardisation.

(β) The water to which the specific gravity is referred must be at some other definite temperature, *e.g.* 60° F., or possibly 4° C., the temperature of maximum density. Thus, if 85° F. as before be the standard temperature of the instrument and 60° F. that of the water, the specific gravity of the liquid at 85° F. is referred to water at 60° F.

III. (α) The liquid to be tested must be at the standard temperature of the instrument.

(β) The graduations are such that they give the value which would be found for the specific gravity of the liquid if it were cooled or heated to some other temperature and referred to water at that[2] temperature. Thus the standard temperature of the instrument might be 85° F. The instrument would then be used at 85° F., but the graduations on the instrument would be such as to give the specific gravity which would be found for the liquid if it were cooled to 60° F., and referred to water at 60° F.

The following table gives the specific gravities of certain sugar solutions, as determined in accordance with these various methods, assuming coefficients of expansion as given in tables issued by the Kaiserliche Normal Eichungs-Kommission of Berlin :—

Solution	I. Specific gravity at 85° F. in terms of water at 85°	II. Specific gravity at 85° F. in terms of water at 60°	III. Specific gravity at 60° F. in terms of water at 60°*
Water ...	1·0000	0·9968	1·0000
Solution A...	1·0496	1·0462	1·0500
,, B...	1·0989	1·0954	1·1000
,, C...	1·1484	1·1447	1·1500

* In this case the liquid to be at 85° when tested, but the instrument is to give its specific gravity when cooled to 60° in terms of water at 60°.

Thus, taking solution C, and supposing in each case the liquid is at 85° F., the instrument will float immersed up to a definite division on the stem. In method I. this division would be marked 1·1484, in method II., 1·1447, and in method III., 1·1500.

Thus there would be a difference of 1·6 degrees of specific gravity between I. and III., and of 5·3 degrees between II. and III., and it is clearly necessary to specify the method of graduation.

There is one obvious objection to the use of method III. In order to graduate an instrument correctly it is necessary to observe its immersion in a liquid at the standard temperature, and then calculate from a knowledge of the coefficient of thermal expansion of the liquid and of its density at some given temperature what its specific gravity at some other temperature will be, and what mark therefore should be put on the stem. No doubt tables could be made up to do this for various liquids and temperatures, but from the point of view of a standardising institution it is preferable that the errors of graduation which have to be determined in the case of instruments sent for test should rest only on observations made during the test and not on a knowledge of the coefficient of expansion of the liquid in which the instrument is to be used.

The instrument is correctly graduated only for a liquid having one definite coefficient of expansion, and cannot be used without error for others.

Of the other two methods, I. and II., method I. has been the usual practice at Kew. The liquid under test and the water to which it is referred are both taken to be at the standard temperature of the instrument, and this, in ordinary practice in England, is about 60°. No. II. has the advantage that the reference temperature of the water is fixed and gives results in agreement with the usual definition of specific gravity, which assumes a fixed temperature for the water.

[2] A fourth variation might be added by requiring that in this case the water should not be at the temperature to which the liquid is cooled or heated.

These notes are circulated with the view of eliciting opinions from makers and users, and also of obtaining information from other countries.

The director of the National Physical Laboratory will be glad to have an expression of opinion from people interested in the subject.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

BRISTOL.—On the nomination of the Society of Merchant Venturers, in the college of which the faculty of engineering of the University is provided and maintained, the council has appointed the Right Hon. Sir William Mather, P.C., a member of the board of that faculty, in succession to the late Sir William H. White, K.C.B.

CAMBRIDGE.—The following awards are announced: Harkness Scholarship (geology) for 1913, J. M. Wordie, St. John's College. Frank Smart prizes, J. Line, Emmanuel College (botany); D. J. Gray, King's College (zoology). Wiltshire prize (mineralogy) for 1913, E. V. Appleton, St. John's College; honourable mention, W. E. Evans, St. John's College.

ST. ANDREWS.—The Senatus Academicus has resolved to confer the honorary degree of LL.D. on the following:—Lieut.-Col. Sir Chas. H. Bedford, Dr. George Albert Boulenger, F.R.S., Mr. J. Balfour Browne, K.C., Mr. F. Cornwallis Conybeare, Prof. Herbert J. C. Grierson, and Prof. W. R. Hardie.

THE issue of the *London University Gazette* for June 4 gives particulars of the advanced lectures in scientific subjects which have been arranged during the present month for students of the University and others interested. Of those lectures which have still to be delivered may be mentioned a special lecture on the work of the Carnegie Nutrition Laboratory in Boston, to be given in the Physiological Laboratory of the University, South Kensington, on June 20, at 5 p.m., by Prof. F. G. Benedict, director of the Carnegie Laboratory. The admission to the lecture is free, without ticket.

THE report of the council for the year 1913 to the members of the City and Guilds of London Institute provides full statistics and particulars of the subscriptions and donations of the great City companies to the institute since its inauguration. The total amount given to the institute during thirty-four years for the purposes of higher education reaches 889,139*l*. Three of the companies—the Goldsmiths', Clothworkers', and Fishmongers'—have each given above 120,000*l*.; eight others have each contributed above 20,000*l*., and other five more than 10,000*l*. The most recent gift is that of the Goldsmiths' Company towards the extension of the City and Guilds (Engineering) College, which is incorporated in the Imperial College of Science and Technology. During the year under review the Goldsmiths' Company supplemented by a further sum of 37,000*l*. its original gift of 50,000*l*., which was commented upon in the last report of the council.

THE King Edward VII. British-German Foundation, instituted by Sir Ernest Cassel, decided last year to assist a number of young men of British nationality to prosecute special studies in Germany after the completion of their studies at one of the British universities. The council of the British sec-