and typhoid bacilli respectively. Various points were investigated as to whether insolation *previous* to inoculation increased the animal's susceptibility to these diseases, also what was the effect of insolation on the animal after infection, and whether the same results were obtained when the temperature of the surrounding air during insolation was not permitted to rise. The toxic properties of the cholera and typhoid broth cultures employed were carefully tested, and it was ascertained that the lethal dose in the case of cholera, procuring death in twenty-four hours, was secured by employing cultures in the proportion of 0·20 per cent of the weight of the animal operated upon, whilst to obtain similar results with typhoid cultures, 0·40 per cent. of the weight of the animal was the proportion in which they had to be used.

In the case of both cholera and typhoid it was found that previous exposure to sunshine increased the animals' susceptibility to these diseases, for not only did they die more rapidly when subsequently inoculated with these cultures than the guinea-pigs similarly treated, exposed, however, only to diffused light, but they succumbed to smaller doses, and doses which did not prove fatal to the guinea-pigs which had been previously protected from sunshine. When the exposure to sunshine took place *after* infection fatal results were greatly accelerated, for instead of dying in from 15 to 24 hours they succumbed in from 3 to 5 hours. These experiments were, however, open to the objection that the accelerated lethal action through subsequent insolation might be due to the higher temperature which necessarily prevailed in boxes exposed to sunshine over those to which diffused light only was admitted. To dispose of this difficulty, boxes were constructed with double cases through which a current of water was kept circulating; in the "sunshine" boxes, as before, only glass was used, whilst in the "diffused light" boxes the outer case was made of zinc. In spite, however, of these precautions as regards temperature the results confirmed those previously obtained, the insolated animals still exhibiting the same increased susceptibility to infection from these diseases over the non-isolated animals.

Dr. Masella does not attempt to give any explanation of the remarkable results he has obtained, but we would suggest that the action of sunshine should be tried on anti-toxines. It would be of great interest to ascertain how the potency of these protective fluids outside the body was affected by exposure to sunshine, and also what result, if any, isolation had on their generation within the animal system.

We know that the toxic properties or, for example, tetanus cultures may be entirely destroyed in from 15 to 18 hours in direct sunshine at a temperature of from 35° to 43° C., and Roux and Yersin state that five hours' direct insolation greatly modifies the toxic properties of diphtheria cultures; again, Calmette has found that after two weeks' insolation the poison of the *Naya tripudians* is completely destroyed, whilst a similar exposure has a damaging effect on the poison of the rattlesnake. So far as we are aware, the action of sunshine on the immunising properties of serum has not been investigated, and its study should prove of immense interest and importance.

The results obtained by De Renzi with tuberculous infection have a practical confirmation in the acknowledged benefit which patients suffering from tuberculosis derive from residence in places such as Davos, where the maximum amount of sunshine may be secured. On the other hand, Dr. Masella's experiments leave us with an uncomfortable uncertainty as to the wisdom of basking in the sunshine. He would have us believe that his investigations explain the greater prevalence and virulence of typhoid and cholera (which he states as an accepted fact) in hot countries where the sun shines with greater power and more continuously. After all, our smoke-laden atmosphere and dreary yellow fogs may be turned to account seemingly, and the London water companies may congratulate themselves that these two water-borne diseases, *par excellence*, may be made to yield not only to efficient purifying processes at their hands, but that such an unexpected ally, according to Dr. Masella, is to be found in the limited amount of sunshine which Londoners can enjoy!

G. C. FRANKLAND.

## THE CONSTRUCTION OF STANDARD THERMOMETERS.

A SERIES of important articles on the preparation and testing of standard thermometers have been communicated to the *Zeitschrift für Instrumentenkunde* by Drs. Pernet, Jaeger, and Gumlich, of the Physikalisch-Technische Reichsanstalt. The selection of the best glass, the calibration of the thermometers, the determination of the coefficients of external and internal pressure, and the verification of the principal points are fully dealt with. One source of error in thermometers as usually constructed, lies in the fact of the bulbs being blown from the tubes. The vaporisation of certain constituents of the glass during this operation leads to a difference of chemical constitution between the stem and the bulb. This may be obviated by making the bulbs out of thin walled tubes of the same kind of glass, and welding them on to the stems. As regards the depression of the freezing point, it was found by Wiebe and Schott, of Jena, that glasses containing either sodium or potassium, but not both, showed this after-effect to the least extent. In order to render the reading of temperatures accurate to within 0°·002, the length of a degree should not be less than 6 mm., and since the length of the stem cannot conveniently exceed 60 cm., the range of measurable temperature is practically limited to 100°. Stem thermometers without enamel backs or enclosing tubes were the only ones found suitable for first-class standards. When certain fixed points outside the scale were to be brought in, this was accomplished by widening out the tube above them. An equal linear division of the scale was adopted, this having great advantages over the more or less untrustworthy division by equal volumes. For calibration, threads of mercury of different lengths were cut off from the main portion and measured with micrometer microscopes, viewing them both through the face and the back of the stem. But the threads were not cut off by local heating, since that is apt to produce a permanent change of capacity. The small and almost microscopic bubble which remains in every thermometer was made use of. It was brought to the entrance of the bulb when the desired portion of the thread had been driven into the stem, and then a slight jerk sufficed to cut off the required length. To facilitate this operation, the bulb was narrowed to a neck at the entrance to the stem. As regards pressure, two factors had to be considered. The external atmospheric pressure, and the pressure of the liquid in which it is immersed, tend to compress the glass vessel and to produce an apparent elevation of temperature. The capillary pressure of the mercury, and its hydrostatic pressure, on the other hand, tend to widen the bulb and produce an apparent cooling. The first of these elements was investigated by exposing the thermometer to various high and low pressures in a glycerine bath, and the second by observing the readings when the thermometer stood horizontally and vertically respectively, at its highest measurable temperature. The capillary pressure was found to be too capricious to be accurately measured, but it is a negligible quantity. The coefficient of apparent expansion of mercury in the new Jena glass thermometer $16^{\text{III}}$ was found to be 0·0001571 between 0° and 100°.

## THE INFLUENCE OF MAGNETIC FIELDS UPON ELECTRICAL RESISTANCE.

IT is well known that the resistance (R) of a wire of bismuth, as measured with a constant current, increases under the influence of a magnetic field, and that this increase depends on the strength of the field and its direction with reference to the current in the wire. If the current traversing the bismuth is oscillatory, the resistance has a value O outside the magnetic field, or in a field in which the lines of force are parallel to the wire which is less than R. If, however, the wire is perpendicular to the lines of force of a field greater than 6000 C.G.S. units, the resistance O is greater than R; the difference O – R increases from this point pretty rapidly as the strength of the field increases. These changes are not due to alterations in the self-inductor, since they are independent of the form of the bismuth spiral. This curious phenomenon has lately been examined by M. I. Sadovsky (*Journal de la Société Physico-Chemique de Russe*, xxvi. 1894, and *Journal de Physique*, April 1895), who sums up the results of his experiments as follows: (1) The difference in the resistance of bismuth observed with constant or alternating currents is measurable outside a magnetic field with 300 alternations per second, and can be detected in magnetic fields with only three or four alternations per second; (2) this difference depends on the number of oscillations per second, and without the magnetic field increases with the increase in the frequency of the alternations; (3) the resistance which bismuth, in a strong magnetic field, offers to an increasing current is greater, and that to a decreasing current less than the resistance for steady currents. The difference between the resistances to an increasing and decreasing current increases with the rate of change in the strength of the current $\left(\frac{dC}{dt}\right)$, and this difference is more marked with strong currents than with weak. Thus M. Sadovsky has discovered the remarkable fact that for variable electric currents the resistance of bismuth changes with any change in $\frac{1}{C}$ or $\frac{dC}{dt}$ where C is the current. The author mentions that the effects observed cannot be due to self-induction, or they would occur when the bismuth is not in a magnetic field. In a note on the above paper in the *Journal de Physique*, M. Sagnac considers what would happen if the same series of experiments were repeated with an iron wire. A straight cylindrical iron wire becomes, when traversed by a current C, circularly magnetised; the energy due to this magnetisation being, according to Kirchhoff, $\pi\kappa l C^2$, where $\kappa$ is the susceptibility and $l$ the length of the wire. This energy may possibly increase the coefficient of self-induction by $2\pi\kappa l$. From Klemenčič's data the order of the change in the apparent resistance can be calculated. For weak magnetic fields in which $\kappa$ has a large value, the difference between the value of the apparent resistance for steady currents and for increasing currents may amount to several hundredths of the value of the resistance for steady currents.

## TONBRIDGE SCHOOL LABORATORIES.

I HAVE often been asked to give some account of the laboratories at Tonbridge School; and as they represent some ten years of pleasant labour on my own part, and a considerable expenditure, joined with much sympathy and help from the Governors of the School (the Company of Skinners), I feel it a privilege to do so.

It is difficult to render the subject interesting to those who are not concerned in teaching, although as an instance of an ancient foundation lending itself to the most modern of claims, it may appeal to a wider circle. I must ask to be excused from entering upon any treatment of the well-worn subject, scientific education. I am not quite sure that it is any business of mine. In course of time, no doubt, a condition of stable balance will be reached, as regards the relative weight and value of the various school subjects. Those who are in the thick of the fight cannot always tell which side is winning.

So far we have little at Tonbridge beyond the training-ground itself, consisting of laboratories and workshops, which may be mentioned in sequence as follows:—

Wood Workshops.
Metal Workshops.
Mechanical Laboratory.
Physical Laboratories.
Chemical Laboratories.
Engine-rooms with electric light plant.
Biological Laboratory and Museum.

A description of these in detail is given herewith.

*Wood Workshops.*—These shops are well lighted and airy, occupying a ground space of 48 feet by 30 feet. Work-benches to the number of sixteen, with appropriate fittings, allow about sixty boys to work at the same time. A skilled carpenter is always in attendance for teaching his craft, and a course of graduated tasks are exacted before a pupil is allowed to construct the shelves, boxes, coal-boxes, tables, and other articles which form the staple produce of school shops.

*Metal Workshops.*—The wood workshops lead on to the metal shops, in use as well as in fact. They are under the care of a practical instrument-maker, and the physical laboratory owes much to his skill. It may be mentioned here that no physical laboratory can be considered complete unless it is in connection with suitable workshops wherein instruments may be constructed and repaired. These shops are devised to accommodate about twenty boys working together. They are fitted with all the necessary appliances, including planing and drilling machines and six lathes (from 4 in. centre up to 7 in.). The ground space devoted to metal work is 40 feet by 20 feet. After a course of woodwork, boys are taught to make their own tools, forging and tempering them themselves, to use the file properly, to turn, and afterwards to construct such instruments as they may fancy, it being always required that a working drawing should be made beforehand. The favourite occupation is the construction of electric bells, small dynamos, microscopes, and levels.

*Mechanical Laboratory.*—This room, which measures 40 feet by 21 feet, is fitted for those important lessons in accuracy of observation to which I give the name of Elementary Physical Measurements, *i.e.* the measurements of length, mass, and time, and for Practical Mechanics, *i.e.* the simpler measurements of forces and the conditions of equilibrium, the measurement of gravitation, and observations of the general properties of matter and the behaviour of matter under stress. All the work-tables are movable, and the walls are fitted with brackets and boards for the support of models and apparatus.

*Physical Laboratory.*—This laboratory opens out from the Mechanical Laboratory, and like it is well-lit and lofty. It is 42 feet long and 30 feet broad. The centre of the room is fitted with five solid benches attached to the floor and provided with gas. These benches are arranged to enable elementary classes to work together at the same experiment. With this object, drawers in the benches are stocked with a large quantity of apparatus which enables a class of twenty-four boys to work together through a long series of experiments in practical physics. Each experiment has to be represented by at least twelve sets of apparatus for this purpose, and some years have been occupied in organising this branch of work. The work-benches along the walls of the room lend themselves to the more advanced work in practical physics. It is needless to say that here the apparatus is not twelve-fold. Beyond the physical laboratory is the science master's private room, which has a tendency to shape itself as an advanced physical laboratory.

*Chemical Laboratory.*—This is a fine room, with both skylight and side windows. It is 45 feet long, 30 feet broad, and 30 feet high. Eight benches are fixed, two abreast, across the room, allowing the greatest possible freedom of movement. The benches are arranged to admit forty-eight students working together. They are fitted with shelves for reagents, fixed across the bench, and not lengthways, whereby reaching over one's work is avoided, and also a more complete view and control of the whole room is possible for the master. Each student is provided with a most efficient draught-box, serving also as a support for the vessels he is using. This arrangement keeps the laboratory thoroughly free from fumes, in spite of all well-meant efforts to the contrary on the part of pupils. The shelves and draught-boxes are removable from the benches, so that a clear space can be obtained when required for setting up apparatus on an extensive scale. The wall space is occupied by shelves for reagents, and by lead troughs for washing-up purposes. By this arrangement of confining the water-supply to the walls of the room, most of the ordinary splashing and untidiness of laboratories is avoided. The transverse arrangement of the benches reduces to a minimum the walking about occasioned by this plan. The cupboards and drawers of these benches recede, so that it is possible to sit close up to one's work. A balance-room, 30 by 15 feet, leads out from the laboratory, and beyond this is a large theatre or lecture-room capable of seating about 150 boys. The balance-room is provided with chemical balances and books of reference. The lecture-room has a suitably furnished lecture-table, blackboards, screen for lantern, and cases of minerals and chemical specimens.

*Engine and Electric Light Rooms.*—The electric light, being used for the main portion of the school, puts the Science Department in possession of valuable plant. A gas-engine of 12 indicated horse-power, and a reserve steam-engine of 6 indicated horse-power, fitted with a Crosby indicator, together with dynamos and accumulators, give plenty of opportunity for gaining a practical knowledge of electric engineering. In addition to this, the current obtained is most useful in providing means for practical work and testing in the physical laboratory. The electric light is also used with the mirror galvanometer, to the great advantage of cleanliness and convenience.

*Biological Laboratory and Museum.*—It is appropriate that the description of this laboratory should come last. It is one of the most recent additions to the school, and it should undoubtedly be the last laboratory for the schoolboy to enter. Biology, unless it is approached through a training in physics and chemistry, is not to be considered as a suitable subject for preparatory education. The roots of biological sciences must always be in physical and chemical ground.

The room devoted to this work is carefully planned to ensure the most perfect light. The work-benches face windows which come down to the level of the benches, and in the roof is fixed a good skylight. The work-benches are formed of plate glass, gently sloping at the back into a white glazed gutter running into large white-ware troughs or sinks. Water-supply is at the hand of each worker, and the benches can be kept continually flushed and clean. Standing away from the work-bench is the small writing-table and cupboard, &c., of each student. The arrange-