British and foreign markets, and in this matter, too, they will look for active assistance and co-operation from all the Colonies.

No account of the organisation of the Scientific and Technical Research Department would be complete without some reference to the part which Sir Frederick Abel, the Secretary and Director of the Institute, has played in this matter. The bringing into existence and into prominence of this side of the work of the Imperial Institute, the importance of which was fully realised by its founders, is mainly due to his enthusiasm and energy, and indomitable courage in face of numerous difficulties.

The following is a brief epitome of the more important work which is at the present time occupying the attention of the Department.

The Indian Coal Supply.—Chemical analyses are being made in order to determine the value of the coal deposits occurring in different parts of India, and the results thus obtained are being supplemented by practical tests.

The Iron Ores of India.—Chemical examinations are being made of the deposits of iron ore occurring in different districts of India, and after the analytical results have been obtained the question of the best methods of smelting these ores will be investigated. The examination of a number of specimens derived from the Salem district of Madras, and composed generally of magnetite, has already been completed.

Indian and Colonial Fibres.—The chemical examination is being conducted, and practical tests are being made of the chief Indian and Colonial fibres, with a view to the cultivation of those which prove to be of commercial value. A chemical investigation is also being made of the composition of jute fibre at different stages of its growth, with the view of determining the influence of age on the composition and strength of jute fibre cultivated in India. Special experiments are in progress in reference to the possibility of chemical treatment of jute fibre in India, with a view of retarding or preventing certain changes which occur during its transport to this or other countries. In their inquiries the Department has the advantage of the advice of Mr. G. F. Cross and Mr. C. E. Collyer.

Indian Opium.—A systematic inquiry is being conducted into the methods used in the production of opium in India, with a view to improving the quality of Indian opium for medical use and for the manufacture of morphia and other valuable alkaloids. In connection with this inquiry the Government of India is causing to be collected a number of specimens of poppies, of opium, and of the bye-products and materials used in preparing it in each of the opium districts of India.

Indian and Colonial Medicinal Plants.—The chemical examination and therapeutic trial of the constituents of a number of important Indian and Colonial medicinal plants is in progress, with the object of determining which are of real medical value, and a similar examination is being made of certain well-known drugs which it would appear might be successfully cultivated in India and the Colonies.

Essential Oils and Perfumes.—A preliminary chemical examination of a number of essential oils and perfumes produced at the Government Flower Farm at Dunolly in Victoria has been completed, by M. Umney, and these are also being compared, with especial reference to their commercial value, with the best English and French oils now in commerce.

Indian Dye-stuffs.—The chemical examination of the principal Indian dye-stuffs has been undertaken in order to ascertain the nature of the chief colouring matters, and to determine which are likely to be valuable as dyes, and to ascertain the best methods or employing them. Most of this work is being carried on by Prof. Hummel and Mr. A. G. Perkins in the Clothworkers' Research Laboratory at the Yorkshire College, Leeds.

The Food Grains of India.—A systematic investigation of the constituents of Indian food grains is being conducted, their chief constituents are being ascertained, and their dietetic value determined. This inquiry includes not merely new grains, but also the effect which climate, altitude and other conditions may have upon various well-known grains which are grown in India. On these subjects the Department has secured the valuable assistance of Prof. B. H. Church, F.R.S., and of Mr. Horace Brown, F.R.S.

Indian and Colonial Tanning Materials.—A number of Indian and Colonial plants which have been proved to possess, or are likely to have, value as tanning materials, is being conducted, and information is being obtained as to the best methods of cultivating them, and the most suitable time of collecting them for use as tanning agents.

Indian and Colonial Timbers.—A large number of Indian and Colonial timbers, specially selected by the Governments, have been submitted to mechanical tests and practical trial, so that their commercial value might be accurately determined. This work has been conducted by Prof. W. C. Unwin, F.R.S., at the Central Technical College.

All that has been attempted in this lecture is to afford a general idea of the character of the principal work on which the Scientific Department is engaged, and of its commercial bearings. The technical results of the inquiries, when complete, will be communicated to the Colonies and afterwards published, whilst any results of strictly scientific interest which may be gained will be communicated to the appropriate Scientific Society. The results of many of the inquiries must necessarily be almost entirely of technical interest, but in some cases problems of considerable scientific interest are raised. The dividing line between science and practice is hard to draw in investigations of this kind, and the interests at stake will not be faithfully served if scientific, as well as immediately practical ends, are not kept in view. It often happens that the science of to-day becomes the practice of to-morrow.

From what has been said to-night, it will be evident that the operations of the Imperial Institute in its Scientific and Technical Department are such as to command sympathy and active support in this country, as well as in India and the Colonies. It is to be hoped that all possible assistance may be rendered in extending the sphere of influence of this Department, so that it ultimately may become an Imperial Bureau of Scientific and Technical Advice, having for its chief object the acquisition of exact knowledge of the natural resources of this great empire.

EXPERIMENTS ON RÖNTGEN RAYS.

The Introduction of the use of the Camera to reduce the Size of Plates.

WE have yet no means of bringing Röntgen rays to a focus, but the thought occurred to me that instead of using large plates to cover half of the body, one might photograph the shadows as seen on the fluorescent screen by means of the camera. It was evident uniformity and steadiness of illumination for a period would be necessary; these were obtained by the methods adopted under the next heading. I tried this experiment by simply placing the camera and lens in front of the fluorescent screen and focusing on the ordinary ground glass. This experiment gave a much-reduced picture in an exposure of 1 minute 50 seconds, but a very curious result was also obtained. Clearly enough I got a photograph of the screen with the pair of forceps on it reduced in the proportion of 12 to 2 in size, but all the X-rays had not been stopped by the potassium platino-cyanide screen, and although the camera was four feet from the tube, a sufficient number of rays had passed through the screen to give me a picture (on the same plate) of the brass mountings and lens of the camera. On the sensitive plate, therefore, I had obtained two pictures, one due to the ordinary rays of light from the fluorescent screen, and the other due to Röntgen rays. In the former the object was reduced, the ordinary rays having been focused by the lens, and in the latter the shadow of the brass mountings and lens of the camera were enlarged owing to the divergence of the Röntgen rays. In my next attempt I covered the front of the camera with a sheet of lead, in which I had cut a hole sufficient to allow the lens to pass through. The lens prevented the Röntgen rays going through the centre, and the lead on the outside protected the remainder of the plate, so that only one picture was got, showing a reduced photograph of the hand with the bones of the fingers quite well defined. By this means I hope to reduce the time of exposure. Now, by this new method we may be able to reduce a picture of a large portion of the human body to magic-lantern slide size right away. Another thing was noticed in this experiment—the barium salt did not photograph as easily as the potassium; but it must be remembered that the barium is yellowish-green in colour, while the potassium is blue or even slightly violet.

Another important point to be gathered from the above experiments may be noted. While we have been striving to produce more Röntgen rays in the tube, it is evident we are not utilising what we have with our present fluorescent screens. I placed three ordinary screens in front of each other, one foot apart, and found that while each became luminous under the influence of Röntgen rays, a sufficient number of them were still

passing through the whole three to give a shadow of the bones of the hand on another screen. I have advantageously employed a large screen, therefore, in which the crystals are even coarser than those previously used, and the thickness very much increased. By this means I have now no difficulty in seeing many of the deep structures of the body in movement.

Different Conditions of the Tube may be utilised for Different Effects.

Lately I have been trying to follow up Prof. J. J. Thomson's suggestion about there being different kinds of X-rays, in order to discover, if possible, whether a particular set of rays might be utilised for different tissues. Whether it be a matter of difference or intensity or difference in quality (as Prof. Thomson suggests), there can be no doubt with the tube in a certain condition the bones of the hand appear jet black on the fluorescent screen, while the soft tissues are scarcely visible. On the other hand, in a different condition of the tube the soft tissues are much more prominent and the bones faint. Following up this inquiry, I made a series of experiments by way of placing metal rings near the kathode, some of them earthed and all adjustable. I am quite aware others have placed rings of metal near the kathode, and described alterations in the tube which they have attributed to different causes. The sole object in my experiments was to afford an indication of alteration in a given condition of the tube. These experiments were so far successful, but I found much the same results could be obtained by using the discharge rods of the coil. The method adopted was, first, to heat the tube by means of a Bunsen burner until I got the exact condition required. The discharge rods were approximated until they cut out the focus tube, and then one was very slightly withdrawn until the tube again became fluorescent. The slightest alteration in the vacuum afterwards was immediately indicated by sparking across the gap. It need hardly be pointed out that an arrangement like Mr. Campbell Swinton's for correcting the vacuum by means of a magnet instead of heat would be an advantage if it could be applied to the ordinary focus tube. Once having selected the particular condition required, a small Bunsen burner below the tube may be so regulated as to give the necessary heat. By these means a particular condition of the tube may be kept up for a very long period without trouble. I have had it going on constantly in some instances for half-an-hour at a time with little or no apparent change in the appearance of the shadow of the tissues, and consequently had no difficulty in focusing the fluorescent screen on the ground glass of the camera, nor in photographing the screen with shadows of objects thereon.

Action upon Tissues and Fluorescent Screens.

Actions upon the tissues of the body have been recorded from several sources, and severe loss of skin and hair as a direct result of the application of the rays has been noted. Although I worked for months, it was only within the last few weeks that, having to place my hand near the tube, between it and the fluorescent screen, for long periods and several nights in succession, evidence of a dermatitis ensued. The hand looked as if it had been sunburned, and became red and swollen; there was afterwards shedding of epidermis and loss of hair. The severer effects remained for over a fortnight.

Another curious action on the tissues was noticed while photographing a fish. The apparatus used was the old form of German tube, and an induction coil with Tesla. After half-an-hour's exposure the back of the fish was covered with patches of phosphorescence, which remained for some hours afterwards.

It is usually considered that the action of the rays upon the potassium or barium screen is of very short duration. I have several times tried to see if the luminescence remained for any length of time after the current had been turned off, but could never record anything definite in this way. For reasons which need not be here entered upon, I had been experimenting with a view of putting the fluorescent screen into a particular condition for a period of time, and some metal objects were hung over the back of the screen to serve as a shadow. It was exposed to the effects of the rays for a quarter of an hour, and afterwards set aside where it was not acted upon by the daylight. The following evening I resumed my experiments, and found an image of the metal ring which had been used the previous night. The bluish colour was different inside and outside of the ring from that part of the screen which had been protected by the metal. The screen was immediately put past and examined for four nights in succession; each time, though

less distinct, I could see the image, and it did not completely disappear for a week, during which time the screen was kept in the dark.

With regard to the action upon the tissues, I think it right to point out that there are at least two other forces at work—heat and electricity—and that while the former might not have much to do with the action on the skin, the latter might. In any case, however, the above-mentioned results were obtained after, and seem to have been the direct result of exposure to the action of forces in the region of the focus tube.

JOHN MACINTYRE.

JUMPING COCOONS.

THE curious movements of jumping beans have lately attracted some attention, though to style the spasmodic jerks of the beans jumps is to court disappointment. Some "jumping cocoons," described by Dr. D. Sharp in the *Entomologist*, were however, remarkably good athletes, for they could spring out of a small vessel, such as a tumbler, in which they were placed. These cocoons were from South Africa, but in spite of their exceptional gymnastic efficiency, Dr. Sharp hardened his heart and sacrificed them upon the altar of science, in the hope of discovering something unusual that would explain the powers of jumping. The cocoons looked like a piece of oval pottery, about five millimetres long, and having a rough surface. In each of the two investigated a pupa was found; the two were similar in every respect, and they no doubt belonged to the larvae that made the cocoons. "This little pupa," says Dr. Sharp, "is shut up in a remarkably hard thick cocoon, and it has to get out. Nature has not provided it with caustic potash for the purpose, but has endowed it with a mechanism of complex perfection to accomplish this little object. On the front of the head it has a sharp chisel edge, and with this it has to cut through the pottery; contracting itself to the utmost in the posterior part of the cocoon, and retaining itself in this position by the hooks on the mobile part of the body, it is in a condition of elastic tension in consequence of the other side of the body being so differently formed and immobile; therefore, releasing the hold of the hooks, the pupa is discharged forwards, and the chisel piece strikes the front part of the cocoon; repeating this an enormous number of times a circle may be gradually inscribed on the inside of the far end of the cocoon, which gives way when sufficiently weakened, and the insect becomes free. In both the specimens the inside of the cocoon is about half-cut through; either this is done as the result of a prolonged series of wriggles, or of shocks such as I have described. It is by no means improbable that the early part of the performance is carving the groove by wriggling, the later part knocking it off by jumping against it." The pupa is thus a most interesting one to entomologists. The order of insects to which it belongs appears to be somewhat uncertain, but Dr. Sharp thinks it will prove to be an anomalous lepidopterous insect allied to Trichoptera, and possibly somewhere near to *Adela*.

MECHANICAL CONCEPTIONS OF ELECTRICAL PHENOMENA.¹

MATTER AND MOTION.

UNTIL the middle of the present century the reigning physical philosophy held to the existence of what were called imponderables. The phenomena of heat were explained as due to an imponderable substance called "caloric," which ordinary matter could absorb and emit. A hot body was one which had absorbed an imponderable substance. It was, therefore, no heavier than before, but it possessed ability to do work proportional to the amount absorbed. Carnot's ideal engine was described by him in terms that imply the materiality of heat. Light was another imponderable substance maintained by Sir David Brewster as long as he lived. Electricity and magnetism were imponderable fluids, which, when allied with ordinary matter, endowed the latter with their peculiar qualities.

During the fifty years, from about 1820 to 1870, a somewhat different kind of explanation of physical events grew up. The

¹ Abridged from a lecture delivered before the Franklin Institute by Prof. A. E. Dolbear.