

their decision their photograph of the sternum, which is typically Dromæan, alone gives ample support.

Other remarkable features are the slenderness of the tarso-metatarsus and lower portion of the tibio-tarsus, and the general feebleness of the digits, the ungual phalanges of which are small, and believed to have borne "flattened nails rather than sharp and powerful claws, which could have been of little service for scratching purposes," the whole pedal skeleton, in fact, being in striking contrast with the massive proportions of the upper-leg bones and sternum. There is a moderate fibula well preserved.

Two small fragments of the coraco-scapula and some three or four ribs are described. Of the carpus there is no trace, and doubt besets a small bone referred to as a possible phalanx of the fore-limb. Concerning the anti-brachium, however, the radius and a possible ulna are preserved; and for the former the authors give measurements which show that, in contradistinction to that of all other Ratitæ, it far exceeds the humerus in length—a feature in respect to which the Emeu comes most nearly approximate but is still a long way behind.

Of remains in good preservation, or that, by the ingenious method of preparation adopted, upon which we have already commented (NATURE, vol. lxi. p. 276), could be rendered serviceable, those of the tibio-tarsalia were by far the most numerous; and in the present memoir the authors devote special attention to chemical action brought to bear upon those bones found nearest the surface, to which is due their friability and peculiar texture, associated with the formation of crystals, mostly of halite, admixed with gypsum, glauberite and alunite, by which they had become impregnated. The Memoir gives promise of further interesting results, and any one at home desirous of examining the remains will now find in the Geological Department of our National Museum at South Kensington a fine example of a hind-limb, in which the extraordinary diversity in bulk of the opposite ends of the tibio-tarsus, and the still more noteworthy slenderness of the innermost digit, must be seen to be appreciated.

SOME EXPERIMENTS ON THE DIRECT-CURRENT ARC.

ON Thursday last, December 13, Mr. W. Duddell read before the Institution of Electrical Engineers a paper on "Rapid Variations in the Current through the Direct-Current Arc," which he illustrated by experiments. Members of the Institution have already learnt from the experimental demonstration given by Mr. Duddell in 1898, when he read the paper by Dr. Marchant and himself on the alternate current arc, to expect from him most interesting experiments. Nor were they disappointed last Thursday. It is perhaps too much to say that the experiments then shown excelled in beauty and interest those exhibited on the former occasion, but they fully maintained the same high level of excellence.

Mr. Duddell has been carrying out experimental research on the arc for the past five or six years, and during the last two has, we understand, completed a series of experiments on the vexed question of the resistance of the arc. The questions dealt with in the paper read last Thursday were mainly side issues which had cropped up in the course of these researches. They embody, however, a number of most interesting and important results, many of which are suggestive of great possibilities.

The paper was divided into two parts, the first dealing with those cases in which the cause of the variation of the current was in the circuit outside the arc, the second with the cases where the cause was in the arc itself. Under the first heading, Mr. Duddell gave the results

of experiments which he had made on the rapidity with which the P.D. between the electrodes of the arc, and the light emitted by the arc itself and the crater on the positive carbon, can follow variations of the current. The results show that the rapidity is surprisingly great. It is well known that with ordinary slow variations of the current through an arc a rise in current is accompanied by a fall in P.D. If the conditions of the arc were to remain unchanged, the P.D. would rise with a rise of current; but Mr. Duddell has found that the conditions of the arc can change as rapidly as 5000 times a second or more, and that when the current through an arc between *solid* carbons is suddenly increased it is only for the first 1/5000th of a second that the P.D. rises with the current. Messrs. Frith and Rodgers endeavoured, in 1896, to find the resistance of the arc by superimposing on a direct-current arc an alternating current having a frequency of 250 alternations per second, and measuring the change in P.D. thereby produced on the assumption that at this frequency the conditions of the arc did not change. The results of Mr. Duddell's work show that a frequency of at least 5000 alternations per second must be employed before such an assumption is justified.

It is remarkable also to find that the light emitted by the arc is affected by such small and rapid variations as Mr. Duddell found was the case. The light emitted by the crater and the vapour column varies sufficiently distinctly for a photographic record to be obtained even when the frequency of the superimposed variations in current is as high as 4300 alternations per second and the amplitude of the variation as low as 3 per cent. of the mean.

When the current through the arc is altered, a change in the cross section of the vapour column is caused; and these changes, when the variations are rapid and periodic, give rise to audible sounds. Mr. Duddell has found that a variation of the order of one part in 10,000 from the mean current will alter the vapour column sufficiently to produce sound-waves. In this way an arc may be made to act as a telephone receiver by causing the varying currents in a telephone circuit to pass through the arc. An experiment was shown at the meeting in which the arc in the meeting room was used as a receiver for telephone currents from a transmitter spoken into in the basement of the building. The sounds were distinctly audible throughout the room, though the words could hardly be distinguished beyond a distance of some 10 or 12 feet. These results were obtained with a cored carbon arc—some 20-30 mm. in length and with a current of about 10 ampères.

The second part of the paper, dealing with changes of current produced by the arc, was full of interest and importance, and was illustrated by some very striking experiments. Mr. Duddell first described some experiments on the humming arc, in which he had found, by means of curves obtained with his oscillograph, that the P.D., current, and light emitted by the arc varied with the same frequency, this frequency being identical with the pitch of the note emitted. With the hissing arc Mr. Duddell finds a double variation—a large slow one, which is due, he considers, to the rotation of the arc as a whole, on which is superimposed a small rapid variation in the P.D. and current corresponding with the variation of the light emitted by the crater, this variation being produced, as Mrs. Ayrton has shown, by air obtaining access to the surface of the crater.

Perhaps the most remarkable points brought out by Mr. Duddell in his paper were those relating to the effects produced by shunting the arc with a condenser and self-induction. He has shown that the arc, if it be formed between *solid* carbons, when so shunted immediately becomes intermittent and emits a musical note. Mr. Duddell was led to this discovery by attempting to use the arc as a generator of alternating current by

rendering it intermittent by blowing it with a magnet. This method did not answer, as the intermittence was too irregular; and in order to try and overcome this irregularity Mr. Duddell shunted the arc with a condenser, and found that the arc immediately became intermittent without any blowing, and emitted a musical note. It appeared that the leads from the arc to the condenser possessed appreciable self-induction, and that if this were destroyed the musical note ceased. It thus became evident that a direct current arc between *solid* carbons, when shunted by a capacity in series with self-induction, supplied alternating current to the shunt circuit—the complete circuit consisting of the arc, self-induction, and capacity in series, the arc thus acting as a converter of direct into alternating current energy.

This effect can only be produced when the arc has the ratio of a small change in P.D. (∂V) to the corresponding change in current (∂A) *negative*; and when this ratio $\partial V/\partial A$ is numerically greater than r , the resistance of the condenser circuit. This was proved by Mr. Duddell with two experiments. With a cored carbon arc for which $\partial V/\partial A$ is positive he showed it was impossible to obtain a musical note. And using a solid carbon arc shunted by a condenser and self-induction and giving out a clear note, he showed that by increasing the resistance of the condenser circuit the sound steadily diminished and finally completely died out when this resistance became numerically equal to $\partial V/\partial A$. Any cause tending to dissipate the energy in the condenser circuit, such as, for example, the hysteresis of an iron wire core introduced into the self-induction, or any complete circuit, such as a sheet of iron or a closed ring of wire, brought near it, will also stop the note. This phenomenon suggests, as was experimentally demonstrated, a very simple and valuable method of obtaining oscillating currents of any desired frequency for experiments on magnetic space telegraphy.

Some experiments with metal arcs brought out two points of great practical importance. Mr. Duddell found that on shunting an arc between metal electrodes by a condenser the arc went out. The high rise of P.D. caused by thus suddenly breaking an inductive arc circuit may be sufficiently great to break down the insulation of the leads, as was shown by an experiment, in which a weak place in the insulation was introduced by bringing the two conductors to brass plates separated by a sheet of paper: every time the arc was shunted and put out, the paper was pierced by a spark. The same result was obtained by connecting the condenser permanently across the arc terminals and trying to strike the arc. This has important bearing on the practical use of metal switches, since it shows that the arcing at breaking should be encouraged rather than suppressed, since if there be capacity as a shunt to the switch-contacts and self-induction in the main circuit, a high rise in P.D. will occur, and may cause serious damage to the leads. As another instance of the practical application of this effect, Mr. Duddell showed that, when using an induction coil, a far longer spark could be obtained if the connections were made so that the contact maker first broke the circuit and then shunted a condenser across the gap to blow out the spark, instead of, as has always hitherto been done, having the gap permanently shunted by a condenser.

Mr. Duddell concluded his paper by showing that the note emitted by a musical arc could be tuned by adjusting the self-induction and capacity in the shunt circuit. A keyboard was arranged which shunted different capacities and self-inductions across the arc, and by this means two complete octaves were obtainable. Four arcs were arranged in series to increase the loudness of the sound, and a very distinct and not unmusical rendering of "God Save the Queen" was played on them.

The Central Technical College may well be congratulated on the work on the arc that has been done in its laboratories. Within the last two years there have been four most important papers on this subject read before the Institution of Electrical Engineers—Messrs. Duddell and Marchant's paper on the Alternate-current Arc, Mrs. Ayrton's paper on "Hissing Arcs," her paper at the Paris Congress on the "Light given out by the Direct Current Arc," and the paper by Mr. Duddell above described—all emanating from the College, and each contributing in no small degree to the elucidation of the many very difficult problems which the arc presents.

A BIRD-BOOK FOR YOUNG PEOPLE.¹

WHETHER designedly or no, this attractive little volume is fortunate in the time of its appearance, since it forms an appropriate Christmas gift to young persons of both sexes interested in observing the ways of the birds of their own neighbourhood. And it is not even necessary that such young people should be resident in the country to appreciate the book, for the author, as in his account of the gulls on the Thames in winter, shows that there is much to be learnt with regard to bird-life even by the dweller in the metropolis. The appearance of a bird-book of this nature at the Christmas season is also appropriate in that it tends to draw attention to the severe hardships our feathered friends have frequently to suffer at this time of year, and thus attracts sympathy and attention to their wants.

To those of our readers who are familiar with the Messrs. Kearton by their previous works, no recommendation will be necessary in the case of the volume before us; while to those who have yet to become acquainted with the earlier literary and artistic efforts of these gentlemen, their new production will come as a welcome surprise. For although primarily intended for young people, it must not for a moment be supposed that the author's latest volume is not calculated to interest readers of more mature years. Indeed, the beauty and attractive character of the illustrations (two of which, by the courtesy of the publishers, we are enabled to reproduce) are alone quite sufficient to render the volume acceptable to readers of all classes and all ages. Mr. C. Kearton seems, indeed, almost to have surpassed himself, not only in the execution of the photographs, but in the interesting phases of bird-life and bird-architecture he has portrayed. All the photographs, it appears, have been specially taken for this particular volume, and as they reach one hundred in number, while their *venue* extends from the Thames Embankment to the Hebrides, some idea may be gathered of the amount of time, labour and money expended in its production.

A feature of the book is the attention devoted to nests, eggs and young birds; and although the style is essentially popular and suited to the capacity of the readers for whom it is primarily intended, older ornithologists will scarcely fail to be interested in the chapters on these subjects. In particular we may draw attention to the eight photographs on p. 99, the first of which represents a blackbird's egg on the day previous to hatching, and the other seven the young bird from day to day. By a careful arrangement and adjustment of the camera, the young bird was photographed to the same scale, and the marvellous rapidity of its development—especially between the fourth and seventh day of its existence—will come almost as a revelation to many readers. Unfortunately the further progress of the daily portraiture was brought to an abrupt termination by the unwelcome attentions of a cat. The subject is, however, full of promise, and one worthy to be taken up by other photographers.

¹ "Our Bird Friends: a Book for all Boys and Girls." By R. Kearton. With photographic illustrations by C. Kearton. Pp. xvi + 215. Illustrated. (London: Cassell and Co., Ltd., 1900.)