THURSDAY, AUGUST 11, 1887.

THE TOPOGRAPHY OF GALLOWAY.

Studies in the Topography of Galloway; being a List of nearly 4000 *Names of Places with Remarks on their Origin and Meaning.* By Sir Herbert Eustace Maxwell, Bart., M.P. (Edinburgh: Douglas, 1887.)

SIR HERBERT MAXWELL will strike a sympathetic chord in the minds of many readers, who have not themselves time to search for the origin of place-names over which they have pondered, and perhaps speculated, without avail. We do not mean that the limited district so thoroughly sifted by Sir Herbert Maxwell affords illustrations for place-names everywhere, but his method of handling the subject serves as a model for the useful imitation of students in other districts where such a convenient hand-list is wanting.

On a clear day, one ascending the backbone of England, say at Cross Fell, beholds, beyond the Vale of Eden, far to the south, Ingleborough and the Shap Fells, on the west the Lake mountains, and towards the north a broad arm of the sea, which he recognizes as the Solway Firth, cutting off the wide-extended plain of the Vale of Eden, which lies spread like a carpet far below him. Beyond the Solway Firth there rises a huge hill capped with cloud and backed by hilly country, cut off by the sinuous coast-line as far as the eye can reach. The hill is Criffel, "a hill of 1850 feet," called on a map in the Bodleian Library, circ. 1330, "Mons Crefel," and by Pont, in Blaeu's Atlas, 1654, "Crafel," a hill whose peculiar granite boulders lie scattered plentifully in the drift over the new red sandstone of the Vale of Eden. It is one of the outposts of Galloway, the origin and meaning of whose place-names form the subject of a most thorough and searching investigation in the present work. These names are conveniently arranged in dictionary form in 322 pages. Many are entered and left unexplained; Sir Herbert Maxwell, with true statesmanship, leaving to others the invidious task of applying the unscientific knot-cutting, or "guessing etymology," which he so scornfully repudiates in the, if anything, somewhat prolix introduction of 44 pages.

We in England, who do not all know our *Bobelloth* and *Bethluisnion* as well as we might, come as learners to Sir Herbert Maxwell's book, which displays much real learning and a fair amount of bibliographical research. Treating, as it does, of a language which is foreign to our ears, a language rejoicing not only in "eclipses," or a vast superfluity of unsounded consonants, but of "triphthongs" or sequences of three vowels, equally unknown to our modern English, Sir Herbert Maxwell's task lies very much in expanding to the full Gaelic form the words from which the vast majority of the names are derived, and at first sight it seems almost as hopeless a task to follow him as to sit down unassisted to master Russian. We can only make one or two observations on the introduction, which digests much from O'Donovan and Joyce. "The Basque word for water is *ur*," hence "the rivers called Oure, Urr, Ure," &c. Like most other words meaning a river, it also means a "bank" of a river: *e.g.* beck; burn (bruinne, a *brink*); river (*ripa*), &c. "*Ur* denotat rivos aquarum impetuose ex alto delabentium" (Junius, "Alph. Run.," 21); cf. Lat. ora, A.S. ore, Eng. ore, the *shore*. In Norway, *ur* is the rough slope of a mountain; Irish, *ur*, a border, *brink*. The author, "dismissing as unattainable" all record of pre-Celtic speech, finds, "from the evidence of these names," that the Pictish of Galloway "belonged to the Goidhelic or Gaelic rather than to the Brythonic or Welsh branch." "No doubt," he adds, "there are names whose forms would bear being assigned to a Brythonic origin, but with these I have not ventured to deal." We will not venture either, but in such glaring cases as the "Rhinns" of Galloway; "maiden craigs" (W. Meiddyn, a cliff, precipice), common in North England; "cors," the fenny district on the coast of Kirkbean (Chalm. "Caled." iii. 234); "carse," Kirkcudbright, "carse gowan," "carse thorn," "carse land," in all of which the physical character answers to the Welsh "cors," "a *marsh*, according to the common acceptation" (Ed. Luid, "Adversaria," p. 268); and in "Corsock," New Abbey, Wel. "corsawg," *fenny* (Chalm. "Caled."), and several others, it is plain that Welsh words do occur, and therefore have to be dealt with. With the principles admirably set forth in the introduction we fully agree. One or two slips occur, as (p. 41) where the author attributes to Pont, as original, a passage copied from Camden's "Britannia." Sir H. Maxwell seems to have followed Murray's error (Note D, Append. to "Hist. of Gall.," 1822). The sentence is "Neirunto this (Vigtoune) Ptolemee placed the city Leucophibia," &c. Now, this sentence appeared in the original Latin edition of Camden, 1586, p. 480, "Galloway . . . Hac regione Leucopibiam urbem statuit Polemeus," &c., published when Pont was about nineteen; and for comparison with the passage from Pont's manuscript we give that from the first English translation o Camden, 1610:—"Neere unto this Ptolomee placed the city Leucopibia, which I know not to say truth where to seeke. Yet the place requireth that it should bee that episcopall seat of Ninian which Bede calleth *Candida Casa*, and the English and Scotish in the very same sense *Whitherne*: What say you then if Ptolomee after his maner ("suo more," 1586) translated that name in Greek Λεὺ οικιδια [*sic*], that is Whitehouses," &c.

Again, the supposed identification of *Rerigonium* with *Bargeny*, attributed by our author (p. 42) to Heylin, 1669, should be attributed to Camden. Thus, under *Carricta*, Camden, 1610, has Rerigonium, "a towne. For which *Berigonium* is read in a very ancient copie of Ptolomee printed at Rome in the year 1480, so that we cannot but verily think it was that which is now called *Bargeney*." Sir Herbert Maxwell rightly points out the anachronism between Loukopibia and Candida Casa. Horsley—with several others who have discussed the Ptolemaic names—avoids the trap, saying, with a side glance at Camden, "others from a fancied etymology place it at Whithern," which error the followers of Camden have perpetuated to our own day. The form "Lucotion" ("Brit. Chorog."), is conclusive. "Brigomono," however, in which form *Rerigonium* appears in "Brit. Chorog." (given in Gale, and Horsley, "Rom. Brit." p. 490), does offer some suggestion of Bargeny.

Of the forty-seven authorities given by the author, sixteen are works exclusively relating to Ireland. We suggest that many of the "Gallowaie" place-names are well illustrated or explained in the following works not consulted by him, viz.:—

(1) Hector Boethius, c. iii. "The Description of Gallowaie (in Holinshed, 1587, p. 9), "Aboue Nidderdale is Gallowaie," &c. Thus "the two other lakes, the *Salset* and the *Neutramen*, of equall length and bredth with the *Loch Mirton*," do not appear in Sir Herbert Maxwell's list. Of the Mull of Galloway, Boethius writes, "which the Scots call a *mule* or *nuke*. . . . The common sort name it the *mules nuke*," an evident reduplication, "newk," which occurs several times in Maxwell's list, being Old Norsk *Hnjúkr*, common in North England for a projecting hill. The forms for "the two great lakes *Rean* and *Lois*" (Ryan and Luce) are also worth entering.

(2) Chr. Irvine, "Historiæ Scoticæ Nomenclatura Latino-vernacula, multis flosculis, &c.," "enriched with many select phrases from the ancient monuments of the Scots and the aboriginal language of the Gael," Edin., 1682. Here (p. 84), "Gallovidia et Wallowithia (for it is so named by the Welshmen)" offers a form not found in Maxwell *s.v.* Galloway, and with many other forms we have before us is well worth entering. In the article (p. 186) on the word Galloway, Sir H. Maxwell, passing by Lloyd's etymology ("Church Government," appended to Stillingfleet, "Orig. Brit.," vol. ii. p. 72), cites Skene for the "stranger-Gael," but has he not observed how Prof. Rhys shakes his head at this ("Celtic Btn.," 1882, p. 153)? The form Galwychya, in "Bulla Innocenti V. *De Holmcolt.*," 1207, is worth recording, but the complete list of forms, which is a very long one, should be given.

(3) Sibbald, "Hist. Animalium in Scotiâ," 1684, Part 2, cap. iv., may be cited under Sir H. Maxwell's "Fumart Liggat" (p. 184), "*Foina* est Boethii." "Nostra arborea est. Sylvas incolat abiegnas. Nidumque super Abietes, sciurorum instar struit." The pine marten inhabits pine-woods and, squirrel-like, builds its nest in the fir-trees.

(4) W. Baxter, "Glossarium Antiq. Brit.," Lond. 1719, deals with the Ptolemaic Galloway names; but much more welcome are the "Adversaria Posthuma" of the learned Ed. Lhuyd, given as an appendix to that work. The title is "D. Edvardi Luidi de Fluvm., Montm., Urbm., &c., in Britanniâ nominibus Ad. Posth." Sir H. Maxwell has "Fînen hill" (p. 182); Luid (p. 268), "Fynnon though generally used for a well [*i.e.* spring], signified also the first or highest lakes of the great mountains." In Luid's "Adversaria" is a mine of wealth, from which we select two names, (p. 274) "Turch, *porcus*," (p. 267) Türch, a *hog*, in Brecknockshire. O'Reilly (p. 542) gives Irish, Turc, and (p. 528) Torc, Wel. Torch, a *hog*, *swine*. Sir H. Maxwell has "Turkey Hill" unexplained (p. 306), which is translated by "Swinefell, the fell or hill of the swine" (p. 299). Again, "Hespin" (p. 200) in Whithorn is left unexplained. Luid (p. 267) has, Wel. "Hespin, a sheep that yields no milk. There are two or three *brooks* of this name about Ystrad Vehlte, in Brecknockshire, so called because their channels consisting of limestone have great caverns which in summer-time take up all the water the springs afford, so that, the channels being left dry, the brooks are called *Hespin*."

(5) How could Sir H. Maxwell overlook Kirk's list of over 400 Gaelic words in Append. II. p. 99, to Bp. Nicholson's "Scottish Hist. Liby.," Lond., editn. 1776, "A vocabulary of the Irish dialect spoken by the Highlanders of Scotland, collected by Mr. Kirk," with a few words added by Ed. Lhuyd? They are in twelve chapters, several of which relate to Nature and her productions, and help to form place-names.

(6) Horsley, "Brit. Rom.," Lond., 1732, cited.

(7) "Etymology of the Names of Places in Ireland," "by a gentleman well versed in the language and antiquities of that country," contributed by "C. L." to *Ant. Repertory*, vol. iv. 1809, gives a list of eighteen words used in place-names.

(8) Thos. Murray, "Lit. Hist. of Galloway," Edin., 1822, Append., Note D. He has also a fairly full article on the forms of the name "Galloway" in Note A, the oldest of which, in a charter of Earl David, A.D. 1124, is Galwegia [? Galweyia].

(9) W. Mackenzie, "Hist. of Gall.," Kirkcudbright, 1841, has (pp. 12–22) several place-names taken from Chalmers's "Caledonia," without acknowledgment.

(10) M. M. Harper's beautiful "Rambles in Galloway," with illustrations by Faed, &c., Edin. 1876, smooths away the difficulties that lie in the path of the name-hunter, and his terse descriptions of sites are a model, *e.g.* (p. 99) "*Rusco* Castle, beautifully situated on a rising knoll in the Vale of Fleet, near the margin of the river." That is what we want to know. But "Rusco" can only be assumed to be here, as it is known to be in Nidderdale, after a man's name. Throughout Sir H. Maxwell's list, terse physical descriptions are much missed. Again, facing p. 109, Harper gives a view of "Kirkclaugh shore" that goes a long way to convince one that "Kirkstone" is meant. He gives etymological notes on place-names, no doubt from Chalmers, *e.g.* "Minnigaff," p. 133, differently explained by Maxwell (p. 254) and by Symson. Who shall then decide? On p. 151 several names. But his most important hint is in the admirable picture of the "Cow Clout Stone" (p. 187), which in the "Stat. Acct." is described by Crosbie as "a flat stone about 3 feet in diameter," in which are the marks of what might be supposed a *cow's foot*, a horse-shoe and the four nails on each side being very distinct, &c. Were cows formerly shod in Galloway as oxen are near Naples? Sir H. Maxwell has "Cowloot" (p. 128) unexplained. O'Reilly gives—Irish, *luat*, *the foot*, ("Ir. Eng. Dic.," p. 337), which explains the name.

(11) Chalmers's "Caledonia" requires mention apart, for in that work many, if not most, of the names treated in Sir H. Maxwell's painstaking work have been considered, generally with satisfaction to the reader, as will be found in vols. i. and iii., where he will be found to have anticipated some of Sir H. Maxwell's explanations, as "Loch Brack," "Loch Breac, in the Scoto-Irish the *lake of trouts*."

(12) Prof. Rhys, "Celtic Britain," 1882, a good antidote to Skene for those who may require it, has several ancient Galloway names.

(13) Dugdale, "Monasticon," gives a host of charters with the old forms of Galloway place-names. No less than twelve of the eighty-seven charters relating to the Abbey of Holmcoltram, whence the monks had a pleasant row

across Solway to their lands in Galloway, contain forms, too numerous to be enumerated here, of Kirkewinni, Kirkwyni, Kyrkewynwi, Kirkewenny, Kirkgunny, Kirkwynnyn, &c., &c., now Kirkgunzeon. The same St. Winnin probably explains Kirkennan, Kilennan, the ancient name of Buittle (Chalm. iii. c. iii.), and Kirvennie. Here also the River *Urr* is spelt "Hur"—"a portu *Hur* usque ad 'Pouesterbened'" (No. xxiv.), or "Pollesterheved" (No. lxxxii.); perhaps the same "Pow, a *slow-moving rivulet* in flat lands" (Jamieson), recorded by Sir Herbert Maxwell at New Abbey, which last was formerly called "Loch Kendelock" or "Loch Kenderloch" (Chalm. iii. 296, 305), "Loghendello" in a charter of Roland, son of Huctred (No. lxxxi., Holmcoltram, Dugd.), and now "Loch Kinder," after Cendaelaidh, King of the Picts, D. 580, q.v. We find also "Lotchitdale," "Bulla Lucii III." (No. xxi. Holmc., Dugd.), and "Lochent" (No. lxxxi. fol. 103); "Millebronna," "Bulla Alexandri III." (No. xxiv.), which, unless the same as "Millbawn," is wanting in our author's list. So also "Salternes," *i.e.* salthouses (*ib.*); "Polben," probably our author's Polbae (*ib.*); and "Sivchaye," now Southwick, according to Chalmers, iii. 296; "Glenlus," now Glenluce (No. lxxxii.); "Mayby" (*ib.*), now Mabie, in Troqueer, and "Achencork" (*ib.*); "Pollackercin" (No. lxxxi.); "Polleychos," or "Polthos" (No. lxxxii.), some stream, and "Genesik," *i.e. sandy*, "sandy-sike," or gutter (A.S. Sik), for which see "Genoch" and "Gannock" in our author's list, the last form occuring several times in Middlesex and Hertfordshire. Then we find "Mustard Garth," evidence of the Northman, in "Kirkoneville," or the manor of Kirkconnel (*ib.* fol. 112) west of the estuary of the river "Nud," now "Nith," formerly "Nid," the Novios of Ptolemy, a river-name of pre-Celtic origin, ranging from Wales to Trondhjem. "Trenguer" (lxxxiii.) preserves an *n* dropped in the modern Troqueer. "Botil" (*ib.*), A.S. Botl, perhaps "Buittle" (?). The charter of William the Lion also preserves the names Kirche Cormack (Maxwell, "Kilcormack"); S. Andreæ; "Balincros" (not in Maxwell), and "Cheletun," now Kelton.

We will now take at random a few names from Sir Herbert Maxwell's list. We cannot concede that the northern adjectival termination *et* represents A.S. wudu, as claimed by our author (Introd., p. 9), in "Aiket," &c. "Thornit," *thorny*, also occurs in Anglian North England. Are we to understand that the stream which "was rolling along its wild and turbid waters with a *freshet* upon it" was rolling along a fresh *wood?* "Bail Fell," Old Norsk Bali, "monticule," a *grassy bank*, cf. "Bale bank," Nidderdale, so also, "Bailie Hill," but see a learned article, *s.v.* Baillie, Baille, and *s.v.* Bel, Boel, *cour intérieure*, in Duméril, "Patois Normand," 1849, which clears away the fog from "Baillie, meaning doubtful," of Jamieson. "Barean," "Barend," and "Borron," unexplained by our author, a well-known word in North England, a *rocky slope*, or *hill*, where foxes and badgers burrow. It ranges at least as far south as Kettlewell, where it appears as "Borrance," the stony screes below the limestone girdles or cliffs. It is also called "Burran," and, among the Yetholm gipsies, "Burran" means a badger. O'Reilly ("Ir. Eng. Dic.") has:—"Barran, the *tops of mountains;*" "Boireand [Barend], a large rock; a *stony, rocky district*. Is the name of several rocky districts in the north and south of Ireland. It is applied to the face of a desolate mountain in Achil," &c. Similarly used in North England. His last form "Boireand, *Borron*, a large rock," identifies the word completely. Duméril, *s.v.* "Buret," *porcherie*, records low Latin "*Burum* le *Bure* vieil anglais et le vieux français *Buron*," &c. "Bine Hill," O'Reilly has "Binn, a *hill*," which may also explain "Byng Hill," though Old Norsk "Bingr" looks tempting. However, it is not found directly applied to hills as hills. "Caughie Stone" reminds us of numerous "Cockle Hills" in North England, all on moorlands. "Hecla," the *cloak*, and "Cloak Hill" (p. 123), suggests Ir. *Cocal*, a *cloak*, which is intelligible if the cloak be *peat*, as in "Caugh Moss," Girthon. Old Norsk forms are scattered through our author's list, *e.g.* Cawvis Hill, *if* Old Norsk Kálfr, a *calf* (?), as Sir Herbert Maxwell suggests.

"Cockplay, a hill of 950 ft." (p. 124), seems to be a translation of "Cocklakes," or properly "Cocklaiks," *dry ridges on the moors*, which has been explained ("Stud. in Nidderdale") as "the *playing-ground* of the grouse or moorcock." The keepers and others familiar with their habits understand this. "Cokelayk" is often mentioned in the early charters of Holmcoltram Abbey, Cumberland, given in Dugdale. The prefix "Darn" in "Darnarbel," "Darncree," &c., reminds us of "Darnetal," a place-name at Caen. "Darne" in "Patois Normand," and "Darn" in Breton, means a *piece, portion* (Duméril). "Dub," a pool, common in North England, and in our author's list "Dub of Hass," "Duchdubs," is evidently Celtic, as it occurs as "Douve, grand fossé plein d'eau, étang," in "Patois Normand." The necessity for a brief physical description is well illustrated by the name "Knockmullin." Our author observes that the same words serve for eminences and hollows, hills and valleys, and the fact is well known. All his "Knocks" are hills, and he does not say what kind of thing "Knockmullin" is. The second half is clear—"mill," and the word might mean *mill-race*, for we have, "Patois Normand," "*Noc*. Dalle, goutiére en bois, canal qui apporte l'eau sur la roue d'un moulin." "Laicht, on the eastern shore of Loch Ryan" (Skene, "Chron. Picts and Scots." Pref. clxxv. 1867), is omitted in Maxwell's list, though we believe there is a farm of the name there yet. "Rerrick, anciently called *Dundrainan*, the hill of thorns" (Chalm. "Caled." iii. 313) renders the spelling "Rerwick" very questionable. Is there not an initial *d* dropped? "Wigg," certainly the "Wigstones" of the Nidderdale moors, a huge projecting rock, or, rather, pile of rocks, records the Gaelic "Wig," a *rock*. The old forms given by Sir Herbert Maxwell divorce the Whithorn "Wigg" from the A.S. "Wic," to which he would assign it.

We conclude an imperfect review of this important work with a question to which our personal knowledge of Runic inscriptions on British soil suggests that there is no satisfactory answer. Why send the two Runic inscriptions (Introd. p. 18) to Denmark? No Danish scholar has ever deciphered an English Runic inscription correctly from the days of Spelman and Ole Worm to July 21, 1887. We have read our own A.S. Runes from the *Futhorc* Otho B. 10 in Hickes's "Thesaurus," by the true learning of *Kemble;* and, moreover, no known Runic inscription on British soil corresponds to the Scandinavian formula by which, "from analogy," Prof. Stephens would read those found, but unfortunately not given, by Sir Herbert Maxwell. JOSEPH LUCAS.

OUR BOOK SHELF.

The Prevention of Consumption. By C. Candler, Melbourne, Victoria. (London: Kegan Paul and Co., 1887.)

THIS may be considered a book of theories. The author promises by "his theory" to revolutionize the treatment of phthisis, and almost to bring the disease to an end among civilized nations.

The theory is briefly stated thus: "Ordinary phthisis is invariably caused by a local bacillary malaria governed by chemical light." When the author speaks of bacillary malaria, he means that the tubercle Bacillus is like a saprophyte, capable of growing and thriving in the soil, and that from the soil, which is its true birthplace and home, the Bacillus or its spores find entrance into the human system: fortunately for humanity solar light destroys many of these Bacilli.

"It will be observed," says the author, on page 191, "that it is presupposed that the consumptive, and they who are sickening with consumption, are, or have recently been, exposed to a bacillary malaria fostered by an insufficiency of solar radiation, and this is one of the inferences which urgently requires to be verified." Quite so; and this the author ought to have done himself, though he hopes that somebody else will furnish the proof.

The prevention of phthisis the author has no doubt of achieving by plenty of sunlight; and he would force the Governments to supply more sunlight to the inhabitants of big cities, where, as is known, consumption is rife. It is a pity the author does not tell us how this is to be achieved in London or Manchester during a great part of the year. E. KLEIN.

Metal Plate Work: Its Patterns and their Geometry. By C. T. Millis. (London: E. and F. Spon, 1887.)

THIS work is one of the series of Finsbury Technical Manuals, and teaches how all ordinary patterns required by sheet metal-workers can be set out on one geometric principle. It is the first work in which the setting out of such patterns has been systematized. The manufacture of every article in common use is treated as a separate problem, but the principle in all cases is that the parts composing it shall be set out mathematically, so that any worker having become accustomed to cut out his work on this principle could equally apply it to new forms. The first chapters are of the most elementary character, so that the work is not necessarily above the head of ordinary mechanics. That the book is an admirable manual there can be no question, but whether such a book will be widely consulted appears doubtful. In the opinion of two of the chief tinplate workers in Birmingham the knowledge it imparts will save time and prevent waste of material, which results when the rule of thumb and guess-work are in vogue, whilst the workman using it will gain confidence, and his value be increased by the certainty of his pattern working out true. Nevertheless, the great mass of workmen in metals are not yet educated up to the use of such a work, and in all probability in a centre like Birmingham it will only fall into the hands of managers of manufacturing establishments and a limited number of first-class workmen. It is a book, however, that must be required by the artisan more and more to meet the rapid strides of education, and it will, we hope, command a satisfactory sale.

Walks in the Ardennes. Edited by Percy Lindley. (London: W. H. Smith and Son, 1887.)

THIS hand-book, which only costs sixpence, contains all the information the ordinary tourist is likely to want in walking in the Ardennes. The writer is very familiar with the country, and describes clearly and simply the various routes and the chief centres of interest. There are a sketch map of the Ardennes, and a good many illustrations.

LETTERS TO THE EDITOR.

[*The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, or to correspond with the writers of, rejected manuscripts. No notice is taken of anonymous communications.*

[*The Editor urgently requests correspondents to keep their letters as short as possible. The pressure on his space is so great that it is impossible otherwise to insure the appearance even of communications containing interesting and novel facts.*]

The Parietal Eye in Fishes.

IN my short paper on this subject which appeared in NATURE of July 14 (p. 246) there are one or two points which need better elucidation than I then gave them.

In the first place, for the sake of brevity, my reference to Ahlborn's valuable paper is too scanty, and I am unwilling to do any injustice to that excellent observer. I did not believe he had ever really been fortunate enough to get sections of the "pineal gland" of a fully adult *Petromyzon planeri*; for, judging from what I had found in every adult examined, I imagined that had he possessed fully adult Petromyzon he must have noticed the black pigment in the parietal eye, and moreover must also have seen and figured the deep fossa in the skull (*vide* my figure in NATURE, p. 247), in which, in the adult, the parietal eye rests. It appeared as though his descriptions and figures of the adult brain had been taken from specimens in which the metamorphosis was not quite complete. I have again studied his figures, and must admit that in other respects some of his drawings represent the brain of adult Petromyzon. The apparent contradiction seemed strange, but it is fortunately not inexplicable.

I must here mention that *Petromyzon planeri* is no longer here in Freiburg so plentiful as when Calberla worked on it, now more than ten years ago. Indeed, I have had great difficulty in obtaining adult and very young specimens. The older Ammocœtes, though not common, are not so rare.

This being the case, I could not examine the number of individuals I should have otherwise wished to do. However, I have now found one adult Petromyzon in which there was no black pigment in the parietal eye and no fossa for the eye in the skull. That the specimen was otherwise adult is certain. This find accounts for the non-discovery by other observers of the black pigment I have described. The parietal eye in Petromyzon, which is a rudimentary organ, like many other rudimentary organs is probably also variable in different individuals, and it is not impossible that the black pigment of the parietal eye is entirely absent in the Petromyzon found in many places.

So far as I can judge at present—and I intend to further examine the point—the parietal eye in the Blindworm (*Anguis fragilis*) is also variable. It certainly varies in size and in distinctness.

The second point relates to the black pigment. Wiedersheim and Ahlborn have stated that the pineal gland in Ammocœtes possesses a gray-white pigment. Owing to scarcity of living Ammocœtes I have not verified this, but I do not for a moment doubt it, and I did not mention it, firstly because I did not think it important, and secondly because I did not wish to lengthen the paper.

I did not describe the pigment in the adult as black, but that such was the case could be inferred from the description, and in not stating its colour I was only following an excellent authority, Prof. Carrière, who, in his book "Die Sehorgane der Thiere," in many cases does not state the colour of eye-pigments. One usually assumes that a retinal pigment is black.

Thus we may say, in very young Ammocœtes the parietal eye possesses black pigment, in older Ammocœtes white pigment, and in adult Petromyzon there is a reversion to black pigment. In what relationship these three pigments stand to each other I am unable to say.

The last point concerns the hypotheses as to the origin of the eye. These were really two in number. The first of them—that which derives the paired eyes and the parietal eye from one common dorsal sense-plate—I hold to be fairly certain, and, indeed, there are many facts to support it.

The second, which derives the parietal eye as a later involution of a portion of this same plate, an involution which was supposed to have taken place after that of the paired eye "Anlage," I only believe to be conceivable. My hope of establishing it lay in the verification of an observation of Goette's; there are no facts to support it, and from more recent investigations of the development I am disposed to attach less value to it. For, from these developmental researches, from studies of the types of eye presented by vertebrates and some invertebrates, and lastly, but not least, from valuable discussion with and criticism by Prof. Wiedersheim, a new track has been found, which gives the explanation of a good deal, but the problem is too long and complicated for treatment here.

The first hypothesis mentioned above is taken as the starting-point, but for the further details there are several other questions which have first to be solved. J. BEARD.

Anatomisches Institut, Freiburg i/Br., July 20.

Physiological Selection.

LIKE so many others who have written on this subject, Mr. Rusden freely criticises my views without having deemed it desirable to read my paper. Had he taken the trouble to do so, he would have found a sufficient recognition of the general fact that instinctive habits not unfrequently serve to mitigate the swamping effects on incipient varieties of intercrossing with their parent forms. Moreover, he would have found that there are others of these habits mentioned by me which are probably much more effectual in this respect than is the one to which he draws attention. Nevertheless, it appears to me evident that all these habits taken together cannot count for much, even where they occur; while it is unquestionable that they occur only in a very small fractional part of organic nature considered as a whole—namely, in some among the more intelligent species of animals. The whole of the vegetable kingdom, an immense majority of the Invertebrata, and a considerable majority of the Vertebrata, cannot possibly have had any of their specific differentiations influenced by any of these forms of what I have already designated as "psychological selection." This sufficiently obvious consideration appears to have entirely escaped Mr. Rusden. He adduces a well-known and a comparatively limited form of psychological selection as a "simple solution" of the difficulty from free intercrossing in all cases!

The other parts of his letter merely indorse the views which are published in my paper. I there say that the theory of natural selection is not, strictly speaking, a theory of the origin of species, but a theory of the development of adaptations. Having read this statement, your correspondent writes:—"To consider the theory of natural selection as a theory of the origin of species is, therefore, clearly an error. . . . The theory of natural selection is one, not of the origin of species at all, but of the preservation of particular varieties," *i.e.* those which present an adaptive character. I do not see how his agreement with my views in this matter could be more clearly expressed, and therefore I cannot understand why he supposes that he is here criticising anything which I have written. If the point of his criticism is that I imagine Mr. Darwin to have fallen into the error of regarding the theory of natural selection as (primarily) a theory of the origin of species, this would merely show again that he has not read my paper. My contention from the first has been that upon this point I am in full agreement with Mr. Darwin, and differ only from those Darwinians who differ from their master in holding that *all* specific changes are likewise adaptive changes, and *vice versâ*. It is only in the presence of this non-Darwinian assumption that specific changes and adaptive changes become synonymous terms, with the consequence that the theory of natural selection is to be regarded as in all cases the only theory of the origin of species.

And this leads me to the last point in my critic's letter. I have argued that the above-mentioned non-Darwinian assumption is opposed to observable fact, seeing that "in a large proportional number of cases" specific characters appear to be wholly useless. Nothing has surprised me so much on the part of my critics as to have found this statement vehemently challenged by so accomplished a naturalist as Mr. Wallace, and therefore I am now engaged in collecting a quantity of evidence upon the subject. But the point here is that Mr. Rusden appears to think there is some ambiguity attaching to the terms "use" and "utility." For he asks whether these words have "any real significance outside human interests and considerations." Now, I can scarcely understand how anyone at this time of day could suppose that when these words are employed in their Darwinian sense they are intended to have any reference to human interests. When an evolutionist speaks of the utility of an organ, it is hardly conceivable that anyone should understand him to mean anything else than the utility of that organ to the species which presents it. Therefore, the term "utility" is equivalent to the term "adaptation," and to say that any organ or structure is of use is one and the same thing as to say that it is adapted to the performance of a function which is of benefit to the organism or to its species. Such, at any rate, is the only sense in which I have myself employed these words; and in doing so I have, of course, followed the terminology of Mr. Darwin, as my critic might have observed without going beyond one of the quotations which he himself makes from the "Origin of Species"—namely, "I have called this principle by which each slight variation, if useful, is preserved by the term 'natural selection.'"

GEORGE J. ROMANES.

Geanies, Ross-shire, N.B., July 29.

The Droseras.

MISS ANNE PRATT in her "Wild Flowers," vol. ii. p. 155, in describing the three British species, after stating the character of the stems and flowers, remarks, "but many persons who know the plant well have never seen the flowers fully open." Two of the species, *D. rotundifolia* and *D. longifolia*, are found in a bog on a common near here, and these have lately flowered in captivity. They were transferred from their habitat and placed in a large saucer with peat and Sphagnum, under a bell glass. The flowers have expanded from 10 a.m. to noon each day, after which the sun left them. A *D. longifolia* in another position was seen to flower at 2 p.m. Moisture and sun seem the conditions to bring out the blossoms. I am not aware whether they have flowered *in situ*, as my plants were gathered in the early morning.

Ramondia pyrenaica, brought from Bagnères de Luchon ten years ago, has flowered each year on an outside rockery in my garden. J. RAND CAPRON.

Guildown, Guildford, July 28.

Comrades.

MY children and their governess, when staying in the north of Ireland lately, witnessed the following curious display of feeling, in animals not usually credited with feelings. A boar pig was in the habit every morning of going to the basket where a blind kitten of about six weeks old was kept, allowing the little thing to creep on to his back, and then taking it about and caring for it during the day. The kitten got its food at the same time as the pig, and at the same trough. In the evening the man who saw to the animals used to carry the kitten back to its basket to pass the night. "Où donc la vertu va-t-elle se nicher?"

Pollokshields, Glasgow, August 1. E. R.

A NEW COSMOGONY.[1]

II.

DR. BRAUN has earned by his excellent series of observations on sunspots (NATURE, vol. xxxv. p. 227) a title to be heard with particular respect on subjects connected with solar physics. In unfolding his views

[1] "Ueber Cosmogonie vom Standpunkt christlicher Wissenschaft. Mit einer Theorie der Sonne." Von Carl Braun, S.J. (Münster: Aschendorff, 1887.) Continued from p. 323.

regarding them in the three concluding sections of his work on Cosmogony, he by no means underrates the difficulties they present. The range of our sensible experience shrinks into absolute insignificance when compared with the exalted conditions reigning in the sun. The temperature at its surface may well reach 40,000° to 100,000° C.; near the centre it mounts probably (our author considers) to ten, possibly to thirty or more million degrees. This unimaginable vehemence of heat is balanced by an unimaginable urgency of pressure. The statement that, in the depths of the sun's interior, it reaches a maximum of 2,000,000,000 atmospheres gives only nominal expression to its value. Figures can at times keep pace with facts only on the condition of being reduced to empty and meaningless symbols.

Gravity and molecular motion—the two universal antagonists—here carry on a conflict intensified far beyond the control of "laws" derived from terrestrial observation. The correlation between elasticity on the one side, and pressure and temperature severally on the other, established by Boyle and Gay-Lussac, holds good only over a strictly limited range of conditions. Calculations founded on the supposition of its continued prevalence in the sun lead at once to manifest incongruities. Solar speculators are thus left, to a great extent, without the guidance of ascertained principles. In the region frequented by them, the scientific imagination has free play. Apposite facts are scarce; misleading analogies too much abound. It cannot then be wondered at if theories of the sun often include extravagances which it is easier for their critics to discern than for their constructors to avoid.

A futile debate has sometimes been raised as to whether the interior constitution of the sun is liquid or gaseous. The truth seems to be that neither word is properly applicable. Without unduly stretching its original meaning, neither describes with even approximate accuracy the state of things prevailing there. The notion of "critical points" has been called in question, and may be inexact. But its introduction has at least had the not unimportant effect of abolishing an artificial distinction. It has shown the separation of the various states of matter to be merely provisional. Their characteristic qualities depend upon circumstances for their development or maintenance. At transcendental temperatures and pressures, the ordinary—probably (as Dr. Braun remarks) even the scientific—criteria of gases and liquids disappear; one state merges into the other; they interchange natures; so that we may indifferently regard the sun's interior as composed of vapours compressed, in despite of their almost boundless calorific energy, to the consistence of fresh putty, or of liquids restrained from boiling by the main force of the strata loaded upon them, while expanded to four or five times their ordinary bulk, and rendered internally mobile by the prodigious elevation of the temperature. An indisputable fact, however, and one fundamental to solar physical theory, is that the sun constitutes a vast reservoir of opposing, tremendously-constrained forces, the delicate equilibrium of which cannot be disturbed, however slightly, without producing effects on a commensurate scale.

Upon such inevitable disturbances Dr. Braun founds his *rationale* of the more obvious solar phenomena. The cooling of a body like the sun does not assuredly proceed quite equably. Local excesses of temperature lead to what we may call local revolts against gravity, signified by swift uprushes from great depths of inconceivably heated substances. These are the so-called "metallic prominences." But where the forces called into play lack energy to produce, or the attendant circumstances are not sufficiently favourable to permit, an actual outbreak, an uplifting of the unbroken photospheric surface takes place, and we see a "facula." "Hydrogen-prominences" mark a medium stage of vehemence. They originate from a commotion which primarily fails to outpass the limits of the chromosphere. The injection, however, into it of a prodigious bulk of metallic vapours rapidly heats the circumjacent hydrogen; it spouts upward in a stream which aërostatic pressure tends to perpetuate, and forms, high up above the sierra-edge of the agitated ocean it springs from, a rosy cloud conspicuous by reason of its incandescence.

But the connexion here indicated, to be significant, should be invariable, which is very far from being the case. Metallic intrusions into the chromosphere are by no means a condition *sine quâ non* to the development of quiescent prominences.

Solar theorists are now for the most part agreed that spots must be ascribed *immediately* to falls of relatively cool matter upon the photosphere; they divide on the question whether the initial disturbance comes from beneath or above it. Dr. Braun ranges himself on the side of those who assimilate outbursts on the sun to volcanic commotions on the earth. Uprushes of vividly glowing substances due to the temporary preponderance of heat over pressure are answered by downrushes of obscure absorbing vapours. Spots would thus be the reactive effects of flames or prominences. Their occurrence would be impossible without preliminary eruptions. But it is at least doubtful whether in this hypothesis the real sequence of events be not inverted. The whole tenor of Mr. Lockyer's observations goes to prove that the yawning of the photosphere leads the way as a symptom of its agitation. After a spot has begun to form, its flame and facular garnishings are added. M. Trouvelot has, indeed, often perceived a nascent spot to be completely masked by towering masses of faculæ; but it is none the less there, waiting to be disclosed. Prof. Young considers the appearance of a spot to be commonly heralded by manifest disturbances of the surface; but since the disturbance is evidenced as well by the presence of "pores" (which may be termed embryo spots) as of faculæ, his authority can scarcely be invoked as decisive of the question of precedence.

This is really the touchstone of the rival theories. Outbursts from the photosphere are either the cause or the consequence of the obscurations of it termed "spots." If the former, they should unfailingly and unmistakably take the initiative. But facts certainly warrant no such rigid conclusion. Admitting then the alternative order of connexion, we can understand that descents of relatively cool matter from coronal regions, perforating the photosphere, must overturn the precarious equilibrium of heat and gravity reigning beneath it, and may thus occasion the tumultuous heavings visible as faculæ, and the amazing escapes of imprisoned vapours challenging attention as flames.

Dr. Braun's papers on the constitution of the sun were published in *Natur und Offenbarung* previous to the appearance of Mr. Lockyer's "Chemistry of the Sun." Hence, perhaps, his complaint that the observed facts regarding the solar rotation had as yet been included in no "plausible" hypothesis. We cannot think him successful in his effort to supply the want.

Adventitious arrivals of nebular supplies from interstellar space play, as our readers are already aware, an indispensable part in the theory of planetary development sketched in the earlier chapters of the work now, in its concluding portion, engaging our attention. By their agency the primitive nebula was set whirling with a motion accelerated outward, its central sluggishness persisting throughout, and modifying the whole of its long history. The inequality is perpetuated within the body of the sun itself, the innermost parts of which may require, our author thinks, as much as forty or fifty days to complete a rotation performed at the equatorial surface in twenty-five. The quickening of angular rate continues with ascent into the solar atmosphere, until, in its higher regions, the period is reduced to ten, if not to five or fewer days. All this, we are asked to believe, is the work of the latest of our nebular annexations, which, forming an equatorial girdle round the sun, partially, and in a degree varying inversely with latitude, communicated its own more rapid movement to the superficial layers of the globe it encompassed.

The process is not even yet concluded. What Dr. Braun holds to be indisputable proof of atmospheric acceleration is derived from Prof. Young's spectroscopic measurement, in 1876, of the sun's rotational velocity. But this is to lay upon the observations in question a burden of inference heavier than they will bear. The rate of equatorial movement, as computed from the observed translation of spots, is 1·25 miles a second; it came out 1·42 miles from the Dartmouth College measures. Considering, however, the extreme minuteness of the entire displacements due to this speed, amounting, for the D lines, to but $\frac{1}{77}$ of the interval between them, the discrepancy is hardly surprising; and it is well known that, in this particular class of determinations, errors lie almost always on the side of excess. Prof. Young himself, it is true, was "inclined to think" that his result betrayed an actual sweeping forward of the absorbing layers over the underlying surface; but even were the fact established, we should expect to find for it a cause less remote than the inrush of a nebula uncounted millions of years ago. Undoubtedly, however (so far we are in agreement with Dr. Braun), that cause would be found to be closely connected with the anomalies of the sun's rotation.

As regards the distribution and periodicity of spots, we are in the present work offered simple and avowed conjectures at which we need only glance in passing. The nebulous swathing not yet completely incorporated with the sun's mass impedes, and has during past ages still more effectually impeded, equatorial radiation. Hence, cooling has, in polar tracts, penetrated further into the interior, with the result of generating an internal spheroidal surface at which temperature-gradients attain a maximum, and from the middle latitudes of which special facilities are afforded for eruptive outbreaks.

But this device is assuredly not a practicable one. The highly artificial arrangement it establishes could not endure one hour. Convection-currents would speedily and without ceremony abolish it. Indeed, augmented radiation from near the poles (which is equivalent to more rapid cooling), besides being contradicted by observation, might be expected to produce just the opposite effect of intensifying the disturbances attendant on cooling. Spots and flames should then, on the hypothesis advanced, be transferred from their "royal" zones to the polar calottes.

Heat-pulsations in a period of $11\frac{1}{9}$ years, occasioned, perhaps, by a slow mechanical oscillation of the sun's volume, the progressive contraction of which may be conducted rhythmically, or by regular alternations of shrinking and swelling, are invoked (certainly under every reserve) to solve the puzzle of the sunspot cycle. The difficulties attending what might be called the "disturbed thermal equilibrium" theory of solar phenomena could not be more forcibly illustrated than by the straits to which it reduces its advocates.

The study of coronal appearances compels our author to take refuge in the unassailable stronghold of electricity. We are far from asserting that he is not fully justified in this measure: the circumstances indeed seem to prescribe it; yet it is always felt to be a desperate one, for the reason that it lands us, almost completely, in the region of the unknown. It is right to add that Dr. Braun is at all times evidently loth to separate from the company of ascertained facts and laws. He advances without them only where their escort cannot be made available.

A. M. CLERKE.

MUSIC IN NATURE.

IN the February number of *Longman's Magazine*, there is a remarkable article "On Melody in Speech," by Mr. F. Weber, Resident Organist of the German Chapel Royal, St. James's Palace. The object of the writer is more comprehensive than his title expresses, for he says in his opening paragraph, "There is an infinite variety of interesting and pleasing sounds in Nature's music around us that may be noted by an attentive ear." This may be readily granted; but Mr. Weber goes on, "These sounds are mostly melodious and harmonious, or *in some harmonious connexion, and form exact intervals and chords.*"

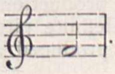
This last sentence is the point of the article. Mr. Weber is not expressing himself figuratively: he writes as a musician, and he distinctly asserts that many of the sounds spontaneously produced in Nature are truly MUSIC in the musician's, and not the poet's, sense of the term. To illustrate this assertion he has taken the trouble to identify and write down, in actual musical notes, the musical passages which he considers he has recognized in a great variety of these natural sounds, and so has challenged the public judgment on the accuracy of his theory.

Now, Mr. Weber is a gentleman of eminence in his profession, and what he says deserves attention. It is easy to say that he has given his imagination too much play in his supposed identifications; but it seems to me the subject ought to be approached from a more comprehensive point of view. The question is, Do such sounds or series of sounds constitute music? or do they not? And if not, why not? If Mr. Weber is wrong, it is probably because he has formed too hasty a view of what music really is; and this is a point that requires serious discussion.

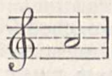
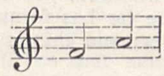
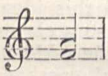
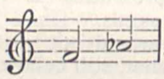
Mr. Weber is not the first who has had this idea. Half a century ago, Gardiner, of Leicester, also a clever musician, published a book called, I think, the "Music of Nature," in which he wrote down musical passages professedly representing a vast number of natural sequences of sounds. There are many other persons, who, while they would not go to the same length as Mr. Weber or Gardiner, still believe that music may be found in the sounds of Nature, and it is worth while to see what grounds there are for such a belief.

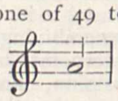
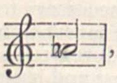
Music, in its modern form, is a very complicated structure, combining many elements, such as melody, harmony, counterpoint, tonality, measured time, rhythm, form, expression, tone-colour, and so on. But no one will suppose that the combination of all these is necessary to make what may be strictly called music. We must begin at the other end, and ask what music is if reduced to its simplest possible form? What are the fewest and least conditions absolutely necessary to constitute music, *i.e.* to give the name of music to a combination of sounds?

In the first place, we must have the proper material, namely *musical sounds*, and we must be particular that the sounds are really of a musical character. I am not going into acoustics. I need only say that the most essential quality necessary to give a sound this character is that it must have a *fixed and definite pitch*. A sound that is wavering and indefinite, like the sighing of the wind, or the *portamento* of a voice or violin, though it may be loosely said to be musical, is not strictly a "musical sound." It cannot be defined by the number of its vibrations, it cannot be expressed in any musical notation, and it cannot be used to form musical structure. For this purpose a sound, though it may be short, must be perfectly definite.

Now, suppose we have a sound of this kind, producing say this note . Does the sounding of this note of itself constitute music? We must say No; for the reason that music is an artistic *structure*, which cannot consist of one sound only. We must have other sounds to build up with it. We should hesitate, practically as well as theoretically, to give the name of music to a monotone.

Supposing, then, we add another sound, differing in pitch. Will these two sounds, heard either together or in succession, constitute music? The answer depends on the relation which the pitches of the two sounds bear to each other. For reasons which can be explained, but which it is unnecessary to go into here, it has been settled, by the universal concurrence of all nations who have made music an artistic structure, that the sounds to be used therein may not be chosen at random, but shall only be such as bear certain defined relations of pitch to each other. These relations have varied at different times and among different peoples; in our case they refer to our acknowledged musical *scales*.[1] Hence the answer to our question will be that if the two sounds are related to each other in a way accordant with our scales (but not otherwise) they may be used to form a part of our artistic musical structure, and do constitute elementary music.

Thus, suppose the second sound to vibrate quicker than the first one in the proportion of 5 to 4, or so near to this ratio that it may be mistaken by the ear for it. This will produce the note , having a relation to the former acknowledged in our scales. Then the two notes sounded successively , or together , will constitute music; the former being an element of melody, the latter of harmony. Similarly in the proportion of 6 to 5, , the same thing may be said.

But if we suppose the vibrations of the second sound to have the ratio to those of the first one of 49 to 40, giving a note about half way between  and , we should decline to acknowledge the succession or combination as music according to our understanding of the term, though it might be so in the systems of the Greeks or of other nations.

We arrive, therefore, at the conclusion that the essential feature of music, its minimum component, must be a combination of sounds of different pitches, these pitches being moreover strictly fixed and defined, and their relations to each other corresponding to certain series agreed on and adopted as standard musical scales. Such combination will of itself constitute music; we may add all sorts of other features; but without the above essential foundation we cannot have music, in an artistic point of view.

This definition will enable us now to inquire whether or to what extent "music" in this sense is actually to be met with in Nature, or in the sources mentioned by Mr. Weber.

To begin with, the natural production of the first requisite, *i.e.* notes of fixed and definite pitch, is not frequent. Most sounds naturally produced are uncertain and wavering; precision in pitch of a sound always conveys an impression of artificiality, of its being, in fact, made purposely musical. No doubt natural sounds of definite pitch, even long sustained, do occur. The nightingale is remarkable for a beautiful long steady holding note; a quail gives three notes successively, at the same definite pitch; other birds, and occasionally some animals, give short notes clearly defined; and such notes may even be produced by inanimate causes of steady action, as a waterfall, or any substance naturally set in elastic vibration. All these, however, are exceptional.

But if there is this difficulty in getting one musically-defined note, it will be still harder to find in any natural source the occurrence of two or more such notes that are musically related to each other. The case that will probably first occur to one's mind is the song of our old friend the cuckoo, who has been immortalized by Beethoven as a musical performer. There was some time ago a controversy as to the true notes of the cuckoo, in which some eminent musicians took part; but I fancy the case is the same as the well-known fable of the chameleon: each of the witnesses was right, but the true solution of the question escaped them all. The facts would appear to be as follow.

The cuckoo gives out successively two very distinct strictly musical sounds, and his vocal organs are so proportioned that the interval between them may vary from about two semitones to five. This interval changes with the bird's age. Early in the season it is at its smallest. On May 5 last I heard on the Monte Sacro, at Orta, in Italy, a bird with a splendid voice give notes about a tone apart: late in the season I have heard them fully at a fourth interval. Of course, therefore, as the change goes gradually on they will pass through a minor third and then through a major third (which is Beethoven's interval); but the *exactitude* is all a matter of chance. I have noticed sometimes that the interval lay between a minor and a major third, so that I could not decide to which it inclined. Hence the idea that the cuckoo gives, by predetermined arrangement, any interval recognized in musical scales, is quite a fallacy.

Mr. Weber asserts that "all the animals on land, quadrupeds and bipeds, have their characteristic voices and calls in distinct intervals. The cow gives a perfect fifth and octave or tenth; the dog barks in a fifth or fourth; the donkey brays in a perfect octave; the horse neighs in a descent on the chromatic scale; the cat in a meek mood cries in a fifth, or, when excited, in a major third; proud chanticleer crows in the diminished triad and [in the diminished] seventh chord." All these Mr. Weber writes down; but I fear that more careful observation would never substantiate the idea that the intervals do really correspond with those of our very artificial scales, otherwise than occasionally by pure accident.

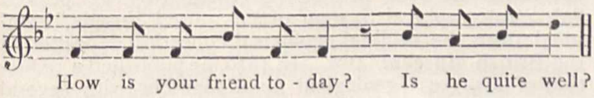
But he makes also inanimate objects conform to our musical system.[1] The wind, he says, sings certain melodies, precisely according to our scales and to our notation, in which he writes them down. This is even more incredible.

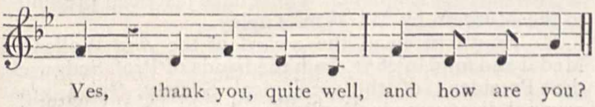
Then we come to the main topic of Mr. Weber's essay, "Melody in Speech." He gives a large number of examples, written out fully in musical notation, professing to represent natural language in different varieties: casual expressions, salutations, questions and answers, conversations, and winding up with a speech of an Oxford Professor and a sermon of an English Bishop. These representations are very curious; but it is of course open to any musician to observe for himself the language he hears every hour of the day, and to judge how far it corresponds with this alleged musical character. There is, however, a more conclusive form of test, by what we

[1] Further explanations on this point will be found in my "Philosophy of Music," Second Edition (London: Trübner; and Novello and Co., 1887).

[1] Of course we must exclude from consideration the natural harmonics of vibrating bodies, with which our system is purposely connected. Some really musical effects of the wind may be exceptionally produced in this way.

may call the reverse method. Take the following example given by Mr. Weber :—





Now, let anyone execute this as written ; and then ask the bystanders whether it represents the manner in which the sentences would be expressed in talking. I think they would say, "That is not *talking*; it is *singing*;—it is opera recitative." And so on for all the examples. Mr. Weber seems to ignore the essential difference between the two ; *i.e.* the absence, in speaking, of the requisites to constitute elementary music. In the first place, in natural speaking there are no musical sounds, properly so called, inasmuch as it is scarcely possible for a hearer to catch notes of fixed and definite pitch ; the voice tends constantly to wander about in a vague and indefinite way ; the vocal cords, under the natural prompting, have no tendency to remain at a permanent degree of tension ; to keep them so there must be an intentional artificial effort ; and hence the occurrence, in speaking, of a monotone long sustained is unusual, and has a distinct musical character.

But if we could occasionally trace, in speaking, sounds of definite pitch, we should find the other requisite—namely, definite relations between them—wholly wanting. The idea that a person, when he speaks naturally (be he musician or no musician), has our scales in his mind, and makes his voice conform to them, is altogether untenable. The moment this is done it ceases to be natural speaking, and becomes designed musical performance.

Here, therefore, we find a most positive and unmistakable distinction between natural speech and music. The person using his voice must, for the latter purpose, do two things which require predetermination and effort ; and which are therefore essentially artificial and not naturally prompted : he must execute tones of well-defined pitch, and he must give them certain definite pitch relations with each other.

Mr. Weber has, in this matter, unintentionally approached very nearly a matter much debated among philosophers, namely, the Origin of Music. Mr. Herbert Spencer, some years ago, propounded a theory that music had taken its rise from the inflections of the voice in ordinary language. This has been strongly controverted ; but Mr. Weber goes further, and asserts that ordinary language is actually *music ready made!*

He has given, as a part of his illustrations, some interesting examples of street cries. These have no doubt a really musical character ; but it is odd that he did not see the distinction between them and ordinary talking—namely, that such cries and calls are *purposely sung*, and not spoken in the natural way. Of course, conforming to this condition, they can be correctly written down, and reasoned upon as specimens of true musical melody.

There is a useful moral to be drawn from all this ; namely, a regret at the discouragement which is given to the study of the theory of music in a scientific point of view. Grove's Dictionary declares this to be useless to practical musicians, and so it is as long as they confine themselves to practice ; but when they meddle with theory the want of it must instantly make itself known. It is no disrespect to Mr. Weber to say that his article shows the loose way in which such matters are too often regarded. No one who has taken the very first steps in the philosophical study of the structure of music could entertain the idea that the sounds naturally emitted by birds, cows, or dogs, formed by the howling of the wind, or used in conversation, were entitled to be called either "music" or "melody." WILLIAM POLE.

THE BRITISH MUSEUM (NATURAL HISTORY BRANCH).

AMONGST the many new and interesting features connected with the British Museum (Natural History), Cromwell Road, has been the opening of a new gallery to the public, containing the Historical and Type Collections in the Department of Geology and Palæontology, under the care of Dr. Henry Woodward, F.R.S., who has favoured us with the following account of the same.

Taking the exhibition cases in *chronological order*, the earliest is the "Sloane Collection." This is the most ancient portion of the Geological Collection, having formed a part of the Museum of Sir Hans Sloane, Bart., F.R.S., acquired by purchase for the nation in 1753.

The geological specimens are stated to have consisted "in what by way of distinction are called *extraneous fossils*, comprehending petrified bodies, as trees or parts of them ; herbaceous plants ; animal substances," &c., and reported to be "the most extensive and most curious that ever was seen of its kind." Until 1857 the fossils and minerals formed one collection, so that a large part of the Sloane Collection consisted probably of mineral bodies and *not organic*, but in any case only about 100 specimens of invertebrate fossils can now be identified with certainty as forming part of the original Sloane Museum. Each specimen in the Sloane Collection had originally a number attached to it, corresponding to a carefully prepared Manuscript Catalogue, still preserved, which contains many curious entries concerning the various objects in the Museum. In the course of more than 130 years, many of these numbers have been detached from the objects or obliterated in cleaning. But as all fossils at this early date were looked upon *merely as curiosities*, but little attention was paid to the formation or locality whence they were derived. Historically, the collection has immense interest to us, marking the rapid strides which the science of geology has made of late years, especially as regards its more careful and systematic methods of study.

The next collection in chronological order is the "Brander Collection," and is the earliest one in which types of named and described species have been preserved.

This collection was formed by Gustavus Brander, F.R.S., in the earlier half of the last century, and an account of the same, with eight quarto plates, was published in 1766, entitled, "Fossilia Hantoniensia Collecta, et in Musæo Britannico deposita." The descriptions of the species given in the work were written by Dr. Solander, one of the Officers of the British Museum. They were "collected in the County of Hampshire, out of the cliffs by the sea-coast between Christchurch and Lymington, but more especially about the cliffs by the village of Hordwell, nearly midway betwixt the two former places" (*op. cit.* p. 111).

Only a small number out of the original 120 figured specimens are now capable of being identified, the rest having become, in the course of 120 years, commingled with the far more numerous and later Eocene Tertiary acquisitions, and so have lost their connexion with this admirable memoir. The engravings of the shells are equal to any modern published work descriptive of the fossils of the Eocene formation; but the names given by Dr. Solander are in many instances incorrect, according to our present knowledge of the genera of Mollusca.

The next series to which attention may be directed is the collection of Dr. William Smith. This collection, which was commenced about the year 1787, was purchased by the Trustees in 1816, a supplemental collection being added by Dr. Smith in 1818.

It is remarkable as the first attempt made to identify the various strata forming the solid crust of England and Wales by means of their fossil remains. There had been other and earlier collections of fossils, but to William Smith is due the credit of being the first to show that each bed of chalk or sandstone, limestone or clay, is marked by its own special organisms, and that these can be relied upon as characteristic of such stratum, wherever it is met with, over very wide areas of country.

The fossils contained in this cabinet were gathered together by William Smith in his journeys over all parts of England during thirty years, whilst occupied in his business as a land surveyor and engineer, and were used to illustrate his works, "Strata Identified by Organized Fossils," with coloured plates, quarto (1816; four parts only published): and his "Stratigraphical System of Organized Fossils" (quarto, 1817).

A coloured copy of his large geological map, the first geological map of England and Wales, with a part of Scotland, commenced in 1812 and published in 1815—size 8 feet 9 inches by 6 feet 2 inches wide, engraved by John Cary—is exhibited in the last wall-case on the right-hand side of this gallery, at the north end. It is well worthy of careful inspection.

William Smith was born at Churchill, a village of Oxfordshire, in 1769; he was the son of a small farmer and mechanic of the same name, but his father died when he was only eight years old, leaving him to the care of his uncle, who acted as his guardian. William's uncle did not approve of the boy's habit of collecting stones ("pundibs" = *Terebratulæ*, and "quoit-stones" = *Clypeus sinuatus*); but seeing that his nephew was studious, he gave him a little money to buy books. By means of these he taught himself the rudiments of geometry and land-surveying, and at the age of eighteen he obtained employment as a land surveyor in Oxfordshire, Gloucestershire, and other parts, and had already begun carefully and systematically to collect fossils and to observe the structure of the rocks. In 1793 he was appointed to survey the course of the intended Somersetshire Coal-Canal, near Bath. For six years he was the resident engineer of the canal, and, applying his previously-acquired knowledge, he was enabled to prove that the strata from the new red marl (Trias) upwards followed each other in a regular and orderly succession, each bed being marked by its own characteristic fossils, and having a general tendency or "dip" to the south-east.

To verify his theory he travelled in subsequent years over the greater part of England and Wales, and made careful observations of the geological succession of the rocks, proving also, by the fossils obtained, the identity of the strata over very wide areas along their outcrops.

His knowledge of fossils advanced even further, for he discovered that those *in situ* retained their sharpness, whereas the same specimens derived from the drifts or gravel-deposits were usually rounded and water-worn, and had reached their present site by subsequent erosion of the parent-rock.

In 1799, William Smith circulated in MS. the order of succession of the strata and embedded organic remains found in the vicinity of Bath. His large geological map of England and Wales is dated 1815. On June 1, 1816, he published his "Strata Identified by Organized Fossils," with illustrations of the most characteristic specimens in each stratum (4to). In 1817 he printed "A Stratigraphical System of Organized Fossils," compiled from the original geological collection deposited in the British Museum (4to). In 1819, he published a reduction of his great geological map, together with several sections across England. These have just been presented to the Museum by Mr. Wm. Topley.

Mr. Smith received the award of the *first* Wollaston Medal and fund in 1831, from the hands of Prof. Sedgwick, the President of the Geological Society, "as a great original discoverer in English geology, and especially for his having been the first, in this country, to discover and teach the identification of strata, and to determine their succession by means of their embedded fossils."

In June 1832, the Government of H.M. King William the Fourth awarded Mr. Smith a pension of £100 a year, but he only enjoyed it for seven years, as he died August 28, 1839. In 1835, the degree of LL.D. was conferred upon Mr. Smith by the Provost and Fellows of Trinity College, Dublin. The highest compliment paid him was that by Sedgwick, who rightly named him "the Father of English Geology."

The bust above the case which contains William Smith's collection is a copy of that by Chantry surmounting the tablet to his memory in the beautiful antique church of All Saints at Northampton, where his remains lie buried.

We come next to a collection, the very name of which betrays the antiquity of its origin. It is known as "Sowerby's Mineral Conchology."

This collection was begun by Mr. James Sowerby, prior to 1812, and continued by his son, Mr. James de Carle Sowerby, during the preparation of their great work entitled, "The Mineral Conchology of Great Britain," which appeared in parts, between June 1812 and December 1845, and forms six volumes octavo, illustrated with 648 plates.

The value of the work consists in the fidelity and accuracy of the figures given, and also in the fact that most of the specimens drawn are here named and described for the first time. They comprise fossils from all parts of England and from every geological formation. The small green labels mark the specimens actually figured in the work. The collection was purchased by the Trustees from Mr. J. de Carle Sowerby, January 1861. It may be interesting to record that many of the later parts were illustrated by plates drawn by the late Mr. J. W. Salter, for so many years palæontologist to the Geological Survey. When a youth, Salter was apprenticed to Mr. J. de Carle Sowerby, who was at that time both a naturalist and an engraver. The youthful apprentice afterwards married his master's daughter, and became, as is well known, one of the most brilliant palæontologists in this country.

Another curious but small series represents the "types" or "figured specimens" of "König's *Icones Fossilium Sectiles*."

This illustrated work, on miscellaneous fossils in the British Museum, was prepared by Mr. Charles König, the first Keeper of the Mineralogical and Geological Department, after its separation from the general Natural History Collections in 1825.

The engravings are rough, but characteristic, and the first "century" (or 100 figures of fossils), is accompanied by descriptions; the plates of the second "century" have names only, but no descriptions are published with them.

A far more important collection is that known as "The Gilbertson Collection."

In 1836, Prof. John Phillips published Vol. II. of his "Illustrations of the Geology of Yorkshire," which is devoted to the "Mountain Limestone District." In the introduction he writes as follows :—" My greatest obligation is to Mr. William Gilbertson, of Preston, a naturalist of high acquirements, who has for many years explored with exceeding diligence a region of mountain limestone, remarkably rich in organic remains. The collection which he has amassed from the small district of Bolland is at this moment unrivalled, and he has done for me, without solicitation, what is seldom granted to the most urgent entreaty; he has sent me for deliberate examination, at convenient intervals, THE WHOLE OF HIS MAGNIFICENT COLLECTION, accompanied by remarks dictated by long experience and a sound judgment." He (Gilbertson) had proposed to publish on the *Crinoidea* himself, but his sketches, as well as his specimens, were all placed at Prof. Phillips's disposal. Phillips adds: "An attentive examination of this rich collection rendered it unnecessary to study minutely the less extensive series preserved in other cabinets; . . . . *most of the figures of fossils are taken from specimens* in Mr. Gilbertson's collection, because these were generally the best that could be found."

The Gilbertson Collection was purchased for the British Museum in 1841.

The collections which follow mark a distinct era in the annals of geological science. Some forty-seven years ago a little Society was founded by a few London geologists—namely, Dr. J. Scott Bowerbank, F.R.S., Searles V. Wood, Prof. John Morris, Alfred White, Nathaniel T. Wetherell, James de Carle Sowerby, and Frederick E. Edwards—for the purpose of illustrating the Eocene Mollusca, and entitled the "London-Clay Club." They met at stated periods at each other's houses, and after a time they said, "Why should we not illustrate all the fossils of the British Islands, and from every formation?" No sooner proposed than a Society was founded, called the "Palæontographical Society," in the year 1847 (just forty years ago). The first volume, issued in that year, was "The Crag Mollusca, Part I., Univalves," by Mr. Searles V. Wood (with twenty-one plates).

The "Searles Wood Crag Collection" was commenced in 1826, and occupied about thirty years in its formation. It represents the Molluscan fauna of the Red and Coralline Crags of the neighbourhood of Woodbridge, and from Aldborough, Chillesford, Sudbourne, Oxford, Butley, Sutton, Ramsholt, Felixstowe, and many other localities in Suffolk, also from Walton-on-the-Naze in Essex. The specimens so collected were employed by Mr. Searles Wood in the preparation of his Monograph on the Crag Mollusca, published by the Palæontographical Society (1848-61); with supplements in 1871, 1873, and 1879, illustrated by seventy-one quarto plates. Each figured specimen is indicated by having a small green label affixed to it.

A geological description of the Crag formation by Mr. S. V. Wood, Jun., and Mr. F. W. Harmer, was issued by the Palæontographical Society in 1871 and 1873.

The collection was presented by Mr. S. V. Wood to the British Museum, January 1856, and a supplementary collection was given by Mrs. Searles V. Wood in 1885.

The next "Palæontographical Collection" is of nearly equal antiquity and fully of equal merit. It is the Eocene Molluscan Collection formed by the late Mr. Frederick E. Edwards, about the year 1835, and was continually being added to, until a few years before his death, which happened in 1875. It was acquired for the nation by purchase in 1873.

Originally intending to illustrate the fossils of the London Clay, Mr. Edwards extended his researches over the Eocene strata of Sussex, Hampshire, and the Isle of Wight, where, assisted by Mr. Henry Keeping, he made the most complete collection ever attempted by any geologist, and it still remains unrivalled.

Mr. Edwards contributed six memoirs to the Palæontographical Society, 1848-56, also separate papers to the *London Geological Magazine*, 1846, the *Geologist*, 1860, and the *Geological Magazine*, 1865, descriptive of the Eocene Mollusca, in his collection.

Mr. S. V. Wood continued the work for Mr. Edwards, describing and figuring the "Eocene Bivalves" in the annual volumes of the Palæontographical Society for 1859, 1862, 1870, and 1877. Each specimen which has been figured is specially marked.

About 500 species have been described and figured, but the collection is very rich in new and undescribed forms.

The last collection is that of a naturalist who devoted his entire life to the study and illustration of a single class of organisms, namely the Brachiopoda. It was formed by the late Dr. Thomas Davidson, F.R.S. (of 9 Salisbury Road, West Brighton, and Muir House, Midlothian), between the years 1837 and 1886, with the object of illustrating his great work on the "British Fossil Brachiopoda," published by the Palæontographical Society, in six large quarto volumes between the years 1850 and 1886, comprising 2290 pages of text, and 234 plates, with 9329 figures, and descriptions of 969 species.

Dr. Davidson was also the author of the Report on the recent Brachiopoda collected by H.M.S. *Challenger* (vol. i. 1880); of the article "Brachiopoda," in the "Encyclopædia Britannica," ninth edition, 1875; of a Monograph of "Recent Brachiopoda" (Trans. Linnean Society, 1886 and 1887), and of more than fifty other separate memoirs mostly bearing upon Brachiopoda both recent and fossil, printed in the Transactions and Journals of the various learned Societies, &c.

His collection, both of Recent and Fossil Brachiopoda, together with all Dr. Davidson's original drawings, his numerous books and pamphlets, were presented by him to the British Museum through his son Mr. William Davidson, February 1886. By his direction the entire collection of recent and fossil species are to be kept together in one series, for the convenience of reference of all men of science who may wish to consult the same.

NOTES.

ON Tuesday the Technical Instruction Bill was read a second time. The second reading having been moved by Sir W. Hart Dyke, Mr. S. Leighton proposed as an amendment that the measure should be rejected, on the ground that a new charge ought not at present to be imposed on ratepayers. The amendment was negatived; but in dealing with it Mr. Goschen and Mr. W. H. Smith found it necessary, as Mr. Mundella complained, to adopt a very "apologetic" and "persuasive" tone. The fact seems to indicate that a good many members of the House of Commons do not even yet realize that an adequate system of technical instruction is absolutely necessary to enable this country to hold its own in the industrial and commercial warfare of the present age.

IN a memorandum on the Scotch Technical Schools Bill, which has been introduced by the Lord Advocate, it is stated that, "as there is a School Board in every parish and burgh in Scotland, it is unnecessary to extend the powers of the Bill to any other local authority." The Bill is not to take effect in any parish or burgh until after the triennial election of a new School Board next year; and the resolution of a Board to establish a technical school requires confirmation at a second meeting of the Board, and also by the Scotch Education Department. While the subjects to be taught in the technical schools will be determined by the Department of Science and Art, the schools will in other respects be under the Scotch Education Department. No scholar will be admitted into a technical school until he has passed the fifth standard, which in Scotland frees from the obligation to attend an elementary school. The proposal that adults above the age of twenty-one shall not be eligible for admission to technical schools maintained out of the rates ought to be rejected. If adults desire to attend these institutions, there seems to be no good reason why their wish should not be gratified.

ON Wednesday, the 3rd inst., the Local General Committee appointed to make arrangements for the Manchester meeting of the British Association assembled in the Town Hall, Manchester, to receive the report of the Executive Committee. Mr. Alderman Goldschmidt presided, and there was a numerous attendance. In the report, which was adopted, the Executive Committee gave a most satisfactory account of the efforts which had been made to secure the success of the meeting. Attention was especially called to the number of eminent foreign visitors who are expected to be present, and it was definitely announced that among these visitors will be the Emperor of Brazil, who has been a member since 1871. Of the members of the Association more than a thousand have already expressed their intention of attending the meeting, and many ladies and gentlemen have sent in their names as new members or associates. The Executive Committee pointed out that at previous meetings of the Association a large proportion of the visitors had received offers of hospitality, and they expressed a confident hope that Manchester would not fail in this respect. Numerous excursions have been arranged for Saturday, September 3, and Thursday, September 8; and offers of hospitable entertainment have been received and accepted in connexion with several of these. The Duke of Devonshire has invited a party to Bolton Abbey; and invitations have been received from the Duke of Westminster to visit Eaton Hall; from W. H. Foster, Esq., and Sir Thomas Storey, to visit Hornby Castle and Lancaster; from W. Morrison, Esq., M.P., to visit Malham and Gordale; from the Rev. M. Farrer, to visit Ingleborough; and from the Directors of the London and North-Western and Lancashire and Yorkshire Railway Companies to visit their Locomotive Works at Crewe and Horwich. Hospitable offers have also been received in connexion with excursions to Northwich, Buxton, Stonyhurst, Tatton, Macclesfield, Gawsworth, Clitheroe, the Liverpool Docks, the Longdendale Reservoirs, and Worsley. The Liverpool Marine Biological Committee have arranged for a day's dredging expedition; an invitation has been received for a visit to the Isle of Man at the close of the meeting; and several other excursions have been organized. Many of the principal works and mills will be open for inspection during the meeting.

THE following is the programme of the Manchester meeting of the British Association:—Wednesday, August 31, President's Address, in the Free Trade Hall, at 8 p.m. Thursday, September 1, Sectional Meetings, 11 a.m. to 3 p.m.; *conversazione* at the Royal Jubilee Exhibition, by invitation of the Executive Committee of the Exhibition, 7.30 to 11 p.m. Friday, September 2, Sectional Meetings, 11 a.m. to 3 p.m.; lecture by Prof. H. B. Dixon, F.R.S., on "The Rate of Explosions in Gases," in the Free Trade Hall, at 8.30 p.m. Saturday, September 3, Sectional Meetings, 11 a.m. to 1 p.m.; excursions; lecture to working men by Prof. George Forbes, F.R.S., on "Electric Lighting," in the Free Trade Hall, at 8 p.m. Monday, September 5, Sectional Meetings, 11 a.m. to 3 p.m.; lecture by Colonel Sir Francis de Winton, K.C.M.G., R.A., on "Explorations in Central Africa," in the Free Trade Hall, at 8.30 p.m. Tuesday, September 6, Sectional Meetings, 11 a.m. to 3 p.m.; *conversazione* at the Town Hall, by invitation of the Right Worshipful the Mayor of Manchester. Wednesday, September 7, General Meeting in the Chemistry Lecture Theatre of Owens College, at 2.30 p.m. Thursday, September 8, excursions.

THE Royal Archæological Institute has had a very successful series of meetings in Salisbury and the neighbourhood. On Tuesday, the last day of the Congress, the members were entertained at luncheon at Rushmore Park by General Pitt-Rivers, the President. He conducted the party to Woodcutts, where he has lately discovered the remains of a Romano-British village. The skeletons dug up show that the people, whoever they were, that inhabited this village were very inferior in stature, the males being on an average only 5 feet 2 inches in height, and the women only 4 feet 10 inches. General Pitt-Rivers has in his museum a very large collection of articles that must have been in daily use among them, including coins, both British and Roman, brazen, silver, and gilt fibulæ, knife-handles, chains, tweezers, bracelets, locks, padlocks, flint arrow-heads, fish-hooks, and horse-shoes, to say nothing of a bowl of Samian ware and the bricks of a hypocaust. The members, having seen all that General Pitt-Rivers had to show them, agreed that he "had kept the most interesting of all the days and the best of his treasures for the last."

Science announces the death of Dr. Charles Rau, Curator of the Archæological Department of the National Museum at Washington. America owes to him the excellent arrangement of the large prehistoric collections at Washington. His writings on American archæology, contained in the annual reports of the Smithsonian Institution and in various journals, and his recent work, "Prehistoric Fishing in Europe and North America," secured for him a high place among American archæologists.

THE subscription made by some friends of the late Dr. Walter Flight, F.R.S., has resulted in a sum of £317. This amount has been handed over to Mr. Basil Martineau, of Hampstead, and Mr. Henry Basset, F.C.S., of Barnsbury, who have kindly consented to act as trustees on behalf of Mrs. Flight. The Committee of the Fund, anxious to avoid expense, trust that the subscribers will excuse the printing and circulating of individual notices to the above effect.

WE have more than once referred to the scheme promoted from Kew for the establishment of minor Botanical Gardens in the several West Indian Islands. The gardens of the Windward Islands are to be in correspondence, as far as relates to the supply of useful plants, and information concerning them, with the chief Botanical Department in Jamaica. The Island of Grenada has been the first to take advantage of the new scheme. Its newly established Botanic Garden was opened to the public on July 18. Barbadoes has recently recorded its adhesion. We learn with much regret that the members of the group of Leeward Islands decline at present to take any part in the scheme.

THE *Annalen der Hydrographie und maritimen Meteorologie* of the German Hydrographic Office for July contains the first part of the discussion of the daily synoptic weather charts of the North Atlantic Ocean and adjacent parts of the continents for the autumn of 1883, viz. for the months September to November (see NATURE, June 16, p. 159), thus commencing from the period undertaken by the Meteorological Council. The discussion is accompanied by nine charts, showing clearly (1) the paths of the barometric minima, (2) the position and changes of the barometric maxima, and (3) the mean position of the isobar of 765 mm. (30·119 inches) for fifteen periods of three to nine days each. The same number also contains a comprehensive discussion of the rainfall of Mauritius and neighbouring portions of the Indian Ocean, compiled from the observations published by Dr. Meldrum and all other available sources, by Dr. W. Köppen.

THE volume of "Hourly Readings" of the self-recording instruments at the Observatories in connexion with the Meteorological Office for the year 1884, the last part of which is just published, contains two elaborate appendixes:—(1) The harmoni analysis of the diurnal range of air-temperature at seven Observatories for each month of the twelve years 1871-82. The numerical results have been obtained directly from the continuous photographic records by means of Sir William Thomson's harmonic analyzer. A comparison of the monthly means obtained from the machine with those got by calculation shows that the results obtained by the former are as accurate as those obtained very much greater labour by the latter method. (2) Tables and formulæ, by Lieut.-General R. Strachey, R.E., C.S.I., to facilitate the computation of harmonic coefficients in the form $p_1 \cos n\, 15°$, &c., and in the form $P \sin (n\, 15° + \tau°)$. Tables are calculated for the coefficients of p and q from hourly values, harmonic coefficients from five-day means, non-periodic corrections, and multiples of the usual sines. Tables of multiples of the natural and logarithmic sines, &c., have been previously published, but we know of nothing which at all compares in detail and usefulness with the tables now in question, for the calculations which they are intended to simplify.

DR. VON LENDENFELD's account of his investigations in the Australian Alps, published in Ergänzungsheft No. 87 of *Petermann's Mitteilungen* (see NATURE, July 21, p. 283), contains some interesting observations on the meteorology of that district, especially with respect to rainfall. He found that the mountainous part of the continent has much more rain than any other part of temperate Australia south of the zone of tropical rains. At Hiandra, to the north of the Kosciusko group, it amounts to 61 inches; while between the mountains and the coast the amount is small, being only 18 inches at Cooma. Some places to the west of the mountains, and still in sight of them, suffer much from want of water. Generally speaking there appears to be no connexion between the weather on the Alps and that on the coast. On the latter most rain falls in autumn, while on the mountains the spring is especially wet. In the middle of summer (January and February) rainfall is least both on the mountains and on the coast. In the lowlands precipitation always falls as rain, while on the mountains snow falls at all times of the year, and it never rains in winter. The amount of dew is exceedingly great, but as this is only taken into account in the total amount of the rainfall, the climate of the mountains appears drier than it really is. There are not sufficient observations to determine the temperature and wind conditions accurately, and these can only be estimated from the behaviour of the snow. At heights exceeding 1000 metres (3280 feet) the snow lies for a month or two, and above 2000 metres it is met with in places, even in the height of summer. Snowdrifts are found exclusively on the eastern slopes, which clearly proves the prevalence of westerly winds in winter.

IT has been arranged at the Hong Kong Observatory that Mr. Knipping will, as heretofore, investigate typhoons within the area of the Japanese weather-maps, as well as north and east of that area. Father Faura will investigate the typhoons in their passage across the Philippine Archipelago, and those that approach very near the coast of Luzon. Dr. Doberck will investigate typhoons at sea south and west of Mr. Knipping's district, from information collected from men-of-war and merchant vessels, and typhoons in China from the facts recorded in the returns of the Imperial Chinese Maritime Customs.

A NOVEL series of voltaic combinations, in which solutions of alterable compounds are substituted for the attackable metals, has lately been investigated by Dr. Alder Wright and Mr. C. Thompson (Journ. Chem. Soc., August 1887). The chief feature of the new cells consists in the replacement of the zinc or its equivalent by a plate of carbon, platinum, or other conducting but unchanged substance, immersed in a solution of some easily oxidized or chlorinated compound, and opposed to a similar plate in contact with the solution of a substance capable of being readily deoxidized or dechlorinated. The plate in contact with the oxidizable fluid acquires the lower potential or becomes the negative pole, while the other plate takes the higher potential and forms the positive pole with regard to the outer circuit. An almost endless variety of new combinations may thus be employed, some of which may be expected to develop considerable energy. A convenient cell, of electromotive force 1·5 volt, consists of a U-tube, into one limb of which is poured a solution of sodium sulphite, while a solution of "chromic liquor," that is, a mixture of sulphuric acid and potassium bichromate solution, is run into the other, a little moderately concentrated sulphuric acid being previously placed in the bend to prevent too rapid diffusion of the two. On placing the two platinum plates in their respective solutions and completing the external circuit by a wire, a constant current is maintained, owing to oxidation of the sulphite to sulphate, and reduction of the chromic acid to chromium sulphate. In all the cases examined the currents were remarkably steady, and capable of performing measurable amounts of electrolytical work.

SIR PHILIP MAGNUS has presented his Report on the technological examination held in 1887, under the direction of the City and Guilds of London Institute for the Advancement of Technical Education. A special feature of this year's examination is that forty-eight candidates were examined in nine subjects, under the direction of the Institute, in New South Wales. Examinations were held in Sydney, Bathurst, and Newcastle. The question papers were sent out to Sydney, and the answers of these colonial condidates were forwarded to London, where they were examined together with those of other candidates, the date of the examination having been so timed as to render this arrangement possible. Sir Philip Magnus considers that the increase in the total number of candidates examined and of those who have passed is satisfactory. In 1886, 4764 candidates were examined, of whom 2627 passed; in 1887, 5508 were examined, of whom 3090 passed. The increase in the number of candidates in 1887 is 744 as against 796 in 1886. During the past session 365 classes were held in 121 different towns. Manchester heads the list of provincial centres from which the largest number of candidates have passed, the number being 183 as against 169 in the previous year. Next in order comes Glasgow with 169 as against 163, Leeds with 114 as against 81, Blackburn with 73 as against 10, Huddersfield with 69 as against 70, Belfast with 66 as against 74, Bradford with 63 as against 80.

THE results of the survey and last census of India are that the area of the peninsula of Hindostan is 1,382,624 square miles, and the population 253,891,821. Although immense tracts of country are annually cultivated, according to the most recent survey ten million acres of land suitable for cultivation have not as yet been ploughed. At the same time, 120 millions of acres are returned as waste lands.

ON July 21 the people of Nancy were astonished by the sudden appearance of an immense number of common ants, which were brought by a very strong wind. Most of the insects were wingless.

ACCORDING to the *Free Press* of Singapore, a work which has occupied much of the recent attention of those Government officials connected with the Land and Survey Departments of the Straits Settlements has been completed, and has been sent to England. This is a map of the Malay Peninsula, based upon one produced in 1879 under the direction of the Straits Branch of the Royal Asiatic Society, but altered and improved by subsequent exploration.

IN a recent number of the *Revue Scientifique*, M. Arnaudeau develops the idea of a double postal tube between Dover and Calais, to be suspended in air. Each tube should be

1 metre in diameter, and of thin metal, allowing the supports to be far apart, say 800 metres. In the tube, a train of ten to fifteen small waggons should run on rails on a floor, the motive power compressed and rarefied air actuating a piston. The lower part of one tube should hold telegraphic, and that of the other telephonic wires. The metallic foundation-piers, some of which should be as much as 70 metres high, should be of truncated-pyramid shape, and capable of floating at first, but gradually filled with masonry and water, and sunk to the bottom. These should support tall pillars having suspension-cables at the top. By the pumping out of the water, these piers could be raised and shifted if necessary.

IN the Exhibition recently opened at Havre there is an interesting collection of specimens of poisonous fishes. Some are poisonous when eaten; others are merely venomous. Among the first are many Sparoids, a Tetrodon, and many *Clupea*, which are abundant near the Cape of Good Hope. In the Japan Sea is found a very peculiar Tetrodon, which is sometimes used as a means of suicide. It brings on sensations like those produced by morphia, and then death. Another interesting collection in the Exhibition is that of a number of Bacteria, and pathogenetic microbes. This collection was formed by Prof. Cornil, of Paris.

AT the annual meeting of the Seismological Society of Japan, on May 27, Prof. S. Sekiya exhibited an interesting model of his own design, showing the motion of the ground at the time of an earthquake. The actual motion was magnified fifty times. At the same meeting, Prof. Milne read a paper on the effects produced by earthquakes upon the lower animals. Animals often show signs of alarm not only while an earthquake is going on, but before the shock is felt. Prof. Milne's friend, Mr. James Bissett, of Yokohama, testifies that thirty seconds before the first shock on the 15th of last January one of his ponies suddenly got up on its feet and pranced about in the stall, evidently terrified at the coming shake. A pony at Tokio was observed to act in a similar manner. Prof. Milne has had many opportunities, just before earthquakes, of confirming the fact that pheasants scream; and several observers have assured him that in like circumstances frogs suddenly cease croaking. Of all animals, geese, swine, and dogs are said to give the clearest indications of an approaching earthquake. It is said, too, that many birds show uneasiness, hiding their heads beneath their wings, and behaving in an unusual manner. Prof. Milne suggests that some of the lower animals may be sensitive to small motions which we do not notice. The terror manifested by intelligent animals like dogs and horses may be, he thinks, the result of their own experience, which has taught them that slight tremors are premonitory of movements more alarming. In the case of pheasants, frogs, and geese, alarm may be due solely to the tremors. Strange behaviour on the part of animals several hours or days before an earthquake Prof. Milne attributes for the most part to accidental causes. In volcanic districts, however, as he shows, it has sometimes happened that before an earthquake certain gases have emanated from the earth; and where this has occurred the smaller animals have not only been alarmed, but sometimes killed.

A VIOLENT shock of earthquake was felt on August 26 at Laghouat. It caused much consternation, these phenomena being very rare in the vicinity.

EARLY in December, an Exhibition of winter flowers, plants, and fruit will be opened at Mayence.

THE locust plague has done much damage this year in Algiers. All the efforts of the authorities to cope with it have proved fruitless, and it is feared that the evil will be not less formidable next year, the eggs deposited being numberless.

THE annual meeting of the North of England Institute of Mining and Mechanical Engineers was held on Saturday last in the building of the Newcastle Exhibition. Sir Lowthian Bell delivered his presidential address. Dealing with the progress of railroads and navigation, he pointed out that fifty years ago the tonnage sailing under the British flag might be taken at 750,000, of which a little above 50,000 consisted of steamers. By the end of 1885 this country possessed 3,456,562 tons of sailing ships, and 3,973,483 tons of steam vessels, making a total of 7,430,045 tons. Referring to compound engines, he said they all knew how the dangers attending the use of steam at a high pre sure had been met by the introduction of the compound system, in which, by the use of three cylinders, a great addition to the expansive force of the steam was now extensively employed. To such an extent had this been carried that 350 tons of coal were now doing the work which formerly required 750. Mr. T. W. Bunning read a paper in which he advocated the federation of the different mining and mechanical associations in the kingdom on the lines of the Society of Chemical Industry. Sir Lowthian Bell was re-elected President.

THE additions to the Zoological Society's Gardens during the past week include a Malbrouck Monkey (*Cercopithecus cynosurus* ♂) from West Africa, presented by Mr. T. Sutton Flack; a Blue and Yellow Macaw (*Ara ararauna*) and a Red and Yellow Macaw (*Ara chloroptera*) from South America, presented by Mr. W. Reid Revell; a Green Turtle (*Chelone viridis*) from the West Indies, presented by Mr. James McGregor; two Griffon Vultures (*Gyps fulvus*), European, a Dark-green Snake (*Zamenis atrovirens*), European, deposited; a One-streaked Hawk (*Melierax monogrammicus*) from West Africa, an Elegant-grass Parakeet (*Euphema elegans* ♀) from South Australia, purchased.

ASTRONOMICAL PHENOMENA FOR THE WEEK 1887 *AUGUST* 14–20.

(FOR the reckoning of time the civil day, commencing at Greenwich mean midnight, counting the hours on to 24, is here employed.)

At Greenwich on August 14

Sun rises, 4h. 45m.; souths, 12h. 4m. 30·3s.; sets, 19h. 24m.; decl. on meridian, 14° 24′ N.: Sidereal Time at Sunset, 16h. 56m.

Moon (New, August 19, 6h.) rises, 23h. 52m.*; souths, 7h. 40m.; sets, 15h. 35m.; decl. on meridian, 18° 18′ N.

Planet.	Rises. h. m.	Souths. h. m.	Sets. h. m.	Decl. on meridia ° ′
Mercury ...	3 9 ...	10 49 ...	18 29 ...	17 58 N.
Venus	8 45 ...	14 28 ...	20 11 ...	3 57 S.
Mars	1 55 ...	10 5 ...	18 15 ...	22 32 N.
Jupiter... ...	11 11 ...	16 21 ...	21 31 ...	10 24 S.
Saturn... ...	2 40 ...	10 36 ...	18 32 ...	20 27 N.

* Indicates that the rising is that of the preceding evening.

August.	h.	
16 ...	— ...	Venus at her point of greatest evening brilliancy.
16 ...	20 ...	Mercury at greatest elongation from the Sun, 19° west.
1 ...	21 ...	Mercury in conjunction with and 0° 33′ nort of the Moon.
19 ...	— ...	Total eclipse of the Sun. The central line of totality passes from south of the Baltic across Europe, Asia, and Japan. At Greenwich and in England and Scotland generally the sun will rise partially eclipsed a few minutes only before termination of the eclipse. In Ireland the eclipse ends before sunrise.

Variable Stars.

Star.	R.A. h. m.	Decl. ° ′		h. m.	
U Cephei	0 52·3	81 16 N.	Aug. 16,	20 28	*m*
R Arietis	2 9·7	24 32 N.	,, 20,		*M*
Algol	3 0·8	40 31 N.	,, 19,	3 48	*m*
R Comæ Berenices	11 58·5	19 25 N.	,, 15,		*M*
T Ursæ Majoris	12 31·3	60 7 N.	,, 16,		*M*
δ Libræ	14 54·9	8 4 S.	,, 19,	21 32	*m*
U Coronæ	15 13·6	32 4 N.	,, 16,	0 53	*m*
U Ophiuchi	17 10·8	1 20 N.	,, 16,	2 28	*m*
			,,	22 36	*m*
X Sagittarii	17 40·5	27 47 S.	,, 17,	21 0	*m*
U Sagittarii	18 25·2	19 12 S.	,, 18,	1 0	*m*
β Lyræ	18 45·9	33 14 N.	,, 14,	4 0	*M*
R Lyræ	18 51·9	43 48 N.	,, 16,		*m*
η Aquilæ	19 46·7	0 43 N.	,, 14,	2 0	*m*
δ Cephei	22 25·0	57 50 N.	,, 20,	0 0	*m*

M signifies maximum ; *m* minimum.

Meteor-Showers.

	R.A. °	Decl. °	
Near γ Andromedæ	25	42 N.	Swift ; streaks.
,, μ Persei	61	49 N.	Very swift ; streaks.
,, δ Draconis	291	70 N.	Swift ; short.

NEW GUINEA EXPLORATION.

ON March 15 last a private exploring Expedition, commanded by Mr. Theodore Bevan, left Thursday Island for New Guinea in the steamer *Victory*, which had been placed for six weeks at Mr. Bevan's disposal by Mr. Robert Philp, the owner. Mr. Bevan's object in undertaking this expedition was to ascertain whether it was possible to reach the mountains in the interior of New Guinea by means of the Aird or other large rivers flowing into the Gulf of Papua, and to establish, if possible, friendly relations with the natives in the neighbourhood of the gulf, with the view of paving the way for future explorations.

We reprint from the *Sydney Morning Herald* of May 23 the following account of the expedition :—

The expedition has proved the existence of spacious waterways leading far into the interior of the island, the two most important—and magnificent rivers they seem to be—having been named the Douglas and the Jubilee. These discoveries may be destined to be of considerable importance to Australia, for a flourishing industrial European community may in the not very remote future settle on the banks of these waterways. Northern Queensland, from its situation, may naturally be expected to reap the greatest advantages from the opening up of New Guinea, but, directly or indirectly, the habitation of its fertile plains and valleys with pioneer settlers must prove beneficial to the metropolis of New South Wales. A comprehensive account of the expedition will be published in due course, illustrated by a chart showing the new discoveries, and by photographic views of new mountain ranges and previously unknown tribes of natives, but a brief description of some of the principal discoveries made will probably be read with interest.

Of the country in the vicinity of the Aird, very little up to the present is known, and at Thursday Island old experienced hands looked upon it as little short of madness, having regard to the supposed treacherous channels existing, and the hostility of the natives, to attempt to enter the rivers which discharge their waters into the gulf. Mr. Bevan, however, paid little regard to the grim forebodings, and the Expedition was fortunate in reaching Cape Blackwood in the month of April, at a time when the waters are invariably smooth, and when there is little reason to fear tempestuous weather. The exploring party soon set to work. Several minor streams were discovered, particulars concerning which will be given in due course, but, as already indicated, two new fresh-water rivers of magnitude were found, disemboguing their waters through various mouths into the Gulf of Papua. Both these pursue a devious course amidst ranges of hills, washing the base at times of lofty mountains. The rivers are longitudinally about 60 miles distant from each other. The first one—the Douglas—is reached by the Aird, up which the *Victory* steamed, and it became manifest that the Aird was only one of several mouths of the main stream, which was navigated for a distance of 130 miles, but which, however, in reality took the party inland only about 80 miles, by latitude, northward of Cape Blackwood. The explorers left this river through a channel marked upon the Admiralty chart as dry land, and this brought them into Deception Bay. The existence of this passage, in which there is from four to eight fathoms of water, proves Cape Blackwood to be an island. It may here be stated that for the first 30 miles up the Aird the country was found to be of deltaic formation, with alluvial islands scattered here and there ; but beyond that the main stream of the Douglas becomes a compact watercourse, flowing between rising ground on either side. The country about the delta is flat, covered with scrub, and the banks are well defined. On the higher waters of the Douglas there is a practically uninhabited forest country, which in parts could be easily cleared. Two important fresh-water tributaries to the Douglas were discovered, one of which has been named the Burns and the other the Philp. A new range of mountains observed in this vicinity was named by the leader after his uncle, Mr. Thomas Bevan, an ex-Sheriff of London.

The Gulf of Papua has been explored up to Orokolo, and to the westward of that village are what appear to be fine rivers, but these were reported by the natives to be separate mouths of one river, and the natives' report has been confirmed by Mr. Bevan, who, proceeding up a sixth large channel to the west of Bald Head, came upon the main river, which fed the delta and cut inland at right angles into the five other rivers. There was a heavy break on each bar of the first five openings, probably due to south-east weather on the Queensland coast, but a smooth-water passage was found into the sixth opening. The time at the disposal of the party was too limited to enable them to survey each opening of the river, so a westerly course was pursued, and the *Victory* steamed up a large channel running in a northerly direction from Bald Head to the point of its confluence with other waters. A week was spent in examining the rivers coming in from the north-west, but although high land was seen it could not be reached by any branch in that direction. The easterly passages were next tried, and a channel was found running easterly and north-easterly, almost at right angles, into two other streams. Taking the branch running inland, they proceeded a few miles further, and found it led into two other streams, one going inland and the other with a current towards the sea as before. Yet again did they meet two other streams, and still steaming up the one leading inland, they, on going 5 miles further, came upon another, and this time the last arm leading seaward. Here they found themselves on a fresh-water river nearly half a mile wide, with a steady current flowing towards the sea. A magnificent panorama of rising country was now opened up. Range over range of hills stretched into the distance, capped by some towering blue mountain peaks, and so clear was the atmosphere that even the high mountains, which must have been leagues away, seemed close at hand. They were all clad with trees, and upon the face of them could easily be distinguished the water-gullies, brightly illuminated by the glistening rays of the sun. The river was navigated 110 miles from Bald Head, or about 50 miles in latitude from Orokolo, its chief trend being in an easterly and north-easterly direction, although the course was unusually serpentine. In honour of Her Majesty's having completed the fiftieth year of her reign, this river, probably the finest in British New Guinea, has been named the Jubilee. The ranges into which the waters carried the little steamer, drawing 9 feet of water, were named the Albert Victor.

Very little trouble was experienced with the natives during the expedition. Only once was the party attacked, and that was when going up the Aird—about 20 miles from its mouth—probably by the same tribe that attacked Capt. Blackwood forty-two years ago. The hostile blacks fired several flights of arrows, some of which fell harmlessly by the vessel's side, but they dispersed at the sound of the steamer's whistle, and after a few shots had been fired wide ; neither the attacking nor attacked sustaining the slightest hurt. Through this untoward circumstance Mr. Bevan was unable to obtain the name of the tribe. Another tribe, who evinced their peaceful intentions by carrying green bows in their canoes, were found inhabiting the country behind Aird's Hill. A third tribe was met with 48 miles inland, as the crow flies, from Cape Blackwood, and these called themselves the Tumu. At the confluence of the Douglas River with Deception Bay, a fourth, the Moko tribe, was found. The Kiwa Pori tribe, the fifth met with, were ascertained to be the inhabitants of the country close to Bald Head, in the Papuan Gulf. The Birumu tribe were seen about 16 miles north-west of Bald Head, and the Evorra, the seventh and last tribe, were found about the same distance north-east from Bald Head. With all, except of course the first, friendly relations were established. Mr. Bevan's previous experience of New Guinea natives and knowledge of some of their habits and dialects were exceedingly serviceable to him; and with the exercise of a little patience he was enabled to inspire them with the fullest confidence. Several natives were induced to go on board the steamer, and were photographed. Only three of the tribes could be spoken of as large, the one possessing the greatest numerical strength being the Kiwa Pori, which numbered from 400 to 500 men. The result of Mr. Bevan's observations is that the country is practically uninhabited except along the coast. No natives were seen on the Jubilee River beyond 25 miles from the coast-line.

The best of the land—and fine rich soil it is—appeared to lie between the head of the deltas of both rivers and the foot of the hills, where it looked exceedingly fertile, and covered in places with a palm scrub which could be readily cleared. Sago, tobacco, bananas, bread-fruit, and sugar-cane were found to be indigenous. As already stated, the country about the deltas is alluvial and flat, and then in turn come sandstone, limestone, and ironstone, as well as the stratified rocks which mark the earlier geological periods. Mr. Bevan hopes, at no distant date, to be able to complete the work of which this preliminary expedition he has now made is but the precursor. In the animal, vegetable, and mineral kingdoms, there is a splendid field for men of science. About eighty ornithological specimens have been obtained by the party, and a few snakes, lizards, and fishes, which will be examined at the Australian Museum. A large and varied ethnological collection has also been obtained by Mr. Bevan in exchange for trade from the tribes with whom he established friendly intercourse. Some of the prominent features in the landscape have been named after Mr. Richard Wynne, Mr. F. E. Joseph, Dr. Ramsay, Messrs. Harrie Wood, C. S. Wilkinson, E. Fosbery, and other well-known Sydney citizens.

A word is necessary with regard to the climate, which is described as by no means unhealthy. The temperature varied from 72° F. at daybreak to about 86° in the shade at noon. The party returned to Thursday Island within the time stipulated by the owners of the *Victory*, in excellent health, and with unimpaired physique. The cost of the expedition was from £500 to £600, but from this a considerable sum, represented by the value of the collections, must be deducted. In response to Mr. Bevan's application, the Government have placed at his disposal a competent draftsman to aid him in making up his plottings.

THE INSTITUTION OF MECHANICAL ENGINEERS.

THE Institution of Mechanical Engineers held their summer meeting last week, at Edinburgh, under the presidency of Mr. E. H. Carbutt. The meetings were held in the Library Hall of the University, the members being received by the Marquis of Tweeddale, the chairman, Sir William Muir, Principal of the University, and other members of the Reception Committee. The two papers first read on Tuesday related to the Forth Bridge and the machinery employed in its construction. Both papers we reprint to-day. The discussion on the first of them referred mainly to the subjects of expansion and contraction under variations of temperature and to wind-pressure, and in reply the author of the paper, Mr. E. M. Wood, explained that 1½ inches per 100 feet was allowed for expansion, or double the amount usually thought sufficient; whilst, as regards the wind-pressure, the highest registered had been 35¼ lbs. per square foot, whilst 56 lbs. was allowed for. All the speakers who discussed the paper of Mr. Arrol, the contractor for the bridge, referred in high terms to the skill and ingenuity exhibited throughout. Later on in the day the members made an excursion to the Forth Bridge, Mr. Arrol and the heads of the various departments at the works acting as guides. A striking feature was the comparative noiselessness with which the work was carried on, owing to the successful use of hydraulic power in riveting.

We regret to learn that on the day of the visit to the bridge two men had lost their lives owing, it is believed, to the staging on which they were employed giving way; this raises the number that have been killed at the Forth Bridge works to six during the last two months, the number of men employed averaging between 3000 and 4000.

The third paper read was by Mr. F. J. Rowan, on electro-magnetic machine tools, which were invented by him to overcome the difficulties of riveting by hand; they perform their work in a very complete way. The conditions of the work itself involve the separation of the riveting portion of the apparatus from the bolster or holder-up, whilst the riveting process requires that the two portions of the machine should be rigidly held together. This is effected by magnets so arranged on opposite sides of the plating with their poles of unlike denomination facing each other, that they are drawn towards each other, thus pressing the plates together, and insuring the proper condition for riveting. The riveting itself is effected by an electric motor, which by means of gearing and a cam, lifts the hammer against a spring, the amount of compression imparted to the spring in lifting being regulated by hand.

The first paper read on Wednesday was descriptive of the electric light on the Isle of May, by Mr. D. A. Stevenson. The machinery, boilers, and engines, are placed near the base of the island, and close to the water-supply, as it was found that the saving which would be effected by not having to convey fuel to the top of the island, or to pump up water, would compensate for the loss of energy due to the resistance of extra length of the electric conductor. The electric generators are two De Meritens alternate-current machines, each weighing 4½ tons. The induction arrangement of each machine consists of five sets of twelve permanent magnets, sixty in all, each magnet being made up of eight steel plates. The armature, 2 feet 6 inches in diameter, is composed of five rings with twenty-four bobbins on each, arranged in groups of four in tension and six in quantity, and makes 600 revolutions per minute. With the circuit open, each machine develops an electromotive force of 80 volts, with the circuit closed through an arc 40 volts. An average current of 220 amperes is developed, thus yielding 8800 watts of electrical energy, or 11·7 horse-power in the external circuit. In the dioptric arrangement constructed by Messrs. Chance to the author's design, the condensing principle has been carried further than in any apparatus previously constructed. The principle consists in darkening certain sectors by diverting the light from them and throwing it into the adjoining sectors so as to reinforce their light. The author agreed with the conclusion arrived at by the Trinity House that taking first cost and annual maintenance into account, electricity should only be used for important landfall-lights; where, however, the most powerful light was desired, independently of cost, the electric arc had no rival. Some interesting observations have been carried on for the last five months which prove the electric light to be the most penetrating of all lights in all states of weather. Every night at twelve o'clock the light-keepers at St. Abbs Head, twenty-two miles distant, where there is a first-order flashing light, and one of the most powerful oil-lights in the service, observe the Isle of May light; whilst the keepers there observe the St. Abbs Light. The result of these observations has been that the Isle of May light has been seen one-third more frequently than the other. The paper was discussed by Sir James Douglas and several other speakers. A paper was read on the construction of the Tay Viaduct, by Mr. F. S. Kelsey, the resident engineer. This bridge is two miles long, and has taken five years to construct, having been opened for traffic on June 20 last. A paper on the dredging of the lower estuary of the Clyde, by Mr. C. A. Stevenson, was read. Both these papers, which were fully discussed, are of technical rather than scientific interest.

In the evening a *conversazione* was given by the Lord Provost, magistrates, and Council of the city in the Museum of Science and Art. Sir William Thomson gave a very exhaustive lecture on waves, concluding with an important suggestion. It seemed to him that inasmuch as wave resistance depends almost entirely on surface action, it might be diminished relatively very much by giving a great deal of body below the water-line. High speeds of 18 or 20 knots might thus be obtained. By making ships like the old French ships, swelling out below the water-line, there would be a large additional displacement and carrying power, and little addition to wave disturbance.

THE STRUCTURE AND PROGRESS OF THE FORTH BRIDGE.[1]

As a visit to the works of the Forth Bridge is included in the programme of the present meeting of this Institution, the author trusts that a short sketch of the preliminary proceedings, with a description of the structure and progress, from one engaged on the work from its outset, will prove of interest in explaining the reasons and means adopted for connecting the railways on opposite shores of the Firth of Forth, at the site of the historic ferry and still existing Hawes Inn, whose time-table for the departures of the ferry-boat is so quaintly alluded to in "The Antiquary."

Previous Proposal.—For many years, suggestions for establishing direct communication between the southern railways running into Edinburgh and the Fifeshire lines, with the object of more direct access to Perth and the north, had been frequently considered by the companies interested in that route; but until an Act of Parliament was obtained in 1873 for the construction of a suspension bridge, designed by the late Sir Thomas Bouch, for crossing the Forth at the site of the present works, no proposal gave prospect of successful issue. Although the type of bridge then proposed was not one generally considered applicable for the passage of railway trains, yet no positive objection seems to have been taken to it, inasmuch as a contract was entered into for its construction, workshops were erected at the site, and foundations were started. But after the severe gale at the close of the year 1879, so destructive to a viaduct in an equally exposed position, it was deemed prudent to suspend operations; and the directors of the North-Eastern, Midland, and Great Northern Railway Companies, which each have an interest in obtaining direct access to the eastern and northern districts of Scotland, requested their respective consulting engineers, Mr. T. E. Harrison, Mr. W. H. Barlow, and Mr. (now Sir John) Fowler, to confer together and report upon the possibility of some other plan for making through communication between the existing lines at the point already selected. Tunnelling was out of the question on account of the depth of the water; the proposals therefore took the form of bridges.

Present Plan.—On May 4, 1881, the engineers submitted their joint report, unanimously agreeing that the steel bridge on the cantilever and central-girder system, designed by Sir John Fowler and Mr. Benjamin Baker, was not only the least expensive, but the best suited for the situation. The soundness of this decision has since received confirmation in the fact that seven long-span bridges have been or are now under construction in different parts of the world, and many more are proposed on the principle adopted for the Forth Bridge. For the substitution of this design in place of the suspension bridge contemplated in 1873, the Forth Bridge Railway Company appointed Sir John Fowler and Mr. Baker their engineers, and obtained an Act of Parliament in July 1882. The financial obligations for the construction of the bridge having been undertaken by the railway companies interested in the through route—namely, the North-Eastern, Midland, Great Northern, and North British—tenders were invited for the work, and from the applications received two offers were selected; and with the combined firm of Messrs. Tancred Arrol and Co. a contract was made in December 1882 for the entire execution of the work.

General Dimensions.—The total length of the bridge will be 8300 feet, or 380 feet over one mile and a half. There are two main spans of 1700 feet each, two side spans of 675 feet each, with the ends counterbalanced and anchored to the masonry, and three intervening piers; these together make up about a mile of the total length, and the remainder is composed of fifteen approach spans of 168 feet each, and of masonry arches and abutments. For a length of 500 feet in the centre of each of the two 1700-feet spans there is a clear headway for navigation of 150 feet above high water; the rails being placed at a level 6 feet higher. From the base of the deepest pier to the top of the cantilevers the total height is 450 feet, or only 10 feet less than the Great Pyramid of Egypt.

The cross sections of the main spans are of trapezoidal form, 330 feet in height from centre to centre of the members over the piers, and 33 and 120 feet in width across top and bottom respectively, and tapering towards the ends of the cantilevers, thus giving a form which is eminently suitable for withstanding lateral pressure. The girders carrying the railway are supported at intervals inside the cantilevers, &c., by trestles or cross frames, and a continuous lattice-work parapet 4½ feet above the rails extends the whole length of the bridge.

Load, and Wind Pressure.—In addition to its own weight the bridge is being constructed to support, without exceeding in any member the unit stresses permitted by the Board of Trade, a load equivalent to trains of unlimited length equal to 1 ton per foot run on each line of railway, or passing trains consisting each of two engines and tenders at the head of sixty coal trucks weighing 15 tons each; and also to withstand a lateral wind pressure of 56 lbs. per square foot of exposed surface of train and structure. The magnitude of the lateral pressure may be judged from the fact that over the mile length of main spans the estimated surface exposed to a point blank wind at right angles to the bridge amounts to a little more than 7½ acres; the pressure of 56 lbs. per square foot on this surface would therefore be equivalent to a total of more than 8000 tons. In addition to lateral winds, the direction from any point of the compass has been provided for, even including the imaginary condition of each group of main piers becoming the centre of a whirlwind. Effects of temperature will be provided for in the rails, and at the junctions of the central girders with the cantilevers; and the bearings on both the main piers and under the weighted ends of the cantilevers have provision made for allowing movements due to changes of temperature and to the elasticity of the cantilevers under lateral pressure. The lateral play allowed is limited, so that the whole of the piers may act in concert to resist combined actions of all forces tending to disturb the normal state of rest of the 50,000 tons of permanent load. As a further provision 48 steel bolts of 2½ inches diameter, secured 24 feet down in the masonry by anchor plates, hold down the bed plates with an initial tension of 2000 tons; the nuts and saddle-plates are so arranged as to allow freedom of lateral movement to the skew backs; but any lifting would at once be prevented by the anchorage coming into action, which however could only happen under the assumed circumstances of a wind pressure more than double that already mentioned, acting over the whole estimated surfaces. The maximum pressure on the base of the piers will be a little over 6 tons per square foot.

Forms of Parts.—The enormous forces to be resisted have been met by adopting the most suitable forms of parts for withstanding the stresses. Tubular members are used for compression, and open-braced box-forms for tension. These parts vary in size as required. Though the tubular form has scarcely been used in this country for bridge members since its employment by the late Mr. Brunel, no difficulty has arisen in connexion with its use; even the junctions are dealt with as readily as the generality of the work.

Masonry.—The masonry for the main piers, above the whinstone concrete filling of the caissons, consists of a casing of Aberdeen granite, inclosing and bonded into a hearting of Arbroath stone set in cement, and strengthened by three massive wrought-iron belts built into the stone-work. The deepest pier weighs about 20,000 tons. The remainder of the masonry of the piers and abutments is of a similar class, whinstone being largely used in the interiors.

Steel.—For the principal members of the superstructure subject exclusively to compression, the steel used has a tensile strength of from 34 to 37 tons per square inch, with at least 17 per cent. of elongation in a length of 8 inches; for the other parts 20 per cent. of elongation, with 30 to 33 tons tensile strength. The rivet steel has 25 per cent. elongation, and 26 to 28 tons tensile strength per square inch. The whole of the steel is manufactured by the Siemens process. No sheared edges or punched holes are permitted.

Work started.—No time was lost by the contractors in starting the work. The land was at once entered on; the old workshops were put in order, and the extensive range of offices, stores, workshops, and yards was commenced, which now cover fifty acres. Meanwhile the centre line of the bridge was fixed, and the position of the piers determined. The foundations of those on land were begun simultaneously with the building of temporary jetties for gaining access to the piers that had to be sunk below water-level. These jetties, which are still used for conveying the material, are in themselves no small work; the southern or Queensferry jetty extends 2200 feet from the shore, and is connected with the workshops by an incline worked by a rope driven by a stationary engine. In order that the operations might be carried on continuously day and night when needful, electric light installations, supplemented by lucigens, were laid

[1] Paper read by Mr. E. Malcolm Wood before the Institution of Mechanical Engineers, on Tuesday, August 2.

over the works and piers; and telephonic communication was established between the offices and all the centres of operations. The workshops and yards were rapidly completed, and furnished with tools, of which many are of a special and novel description. Ever since the commencement the work has progressed without interruption, and has gradually assumed the gigantic proportions of the present time. Over 3000 hands have been employed continuously for the last year; and during the present summer months the number has been increased to 3600. The majority find lodgings in the neighbourhood of the bridge; and the remainder make use of a special train service to and from Edinburgh, and a steamer to and from Leith, put on for their use night and morning.

Materials.—The materials for the permanent work have been obtained throughout from producers of repute: Aberdeen granite from Messrs. Fyfe; Portland cement from Messrs. Hilton and Anderson and Bazley White; Siemens steel from the Steel Company of Scotland and the Landore Steel Works. All the steel has been subjected to rigid examination, and has passed the ordeal of specified tests before leaving the makers' works; a few specimens showing its high quality are exhibited. The materials delivered up to the present time have included—

Granite	550,000 cubic feet.
Portland cement	21,000 tons.

The amount thus far erected has been—

Masonry in piers and abutments ...	129,500 cubic yards.
Steel in approaches and main spans	19,000 tons.
Steel for main spans, prepared ready for erection, about	20,000 tons.

By the time the first consignment of steel arrived, the shops were ready for the preparatory operations, and the whole establishment was rapidly organized to deal in the most complete manner with the work to be executed. Hydraulic power is freely used, from the extremely neat form of shop crane to the 2000-ton press for curving the tube-plates. With the exception of the main-pier caissons, made by Messrs. Arrol Brothers of Glasgow, and the superstructure of the approach spans by Messrs. P. and W. Maclellan of Glasgow, the whole of the work has been turned out of the shops at the bridge, their present capacity being an output of 1300 tons of finished work per month.

Shop Practice.—The procedure in the shops may be described as follows. The flat plates and bars are first straightened. The plates to be curved are heated to a uniform red heat in a gas furnace, and while red-hot are moulded in dies under hydraulic pressure to the required form, stacked and coated with ashes, and allowed to cool slowly and equally; any subsequent warping is taken out by placing them again in the press when cold, and giving them a final squeeze into the correct shape. The butts of the bars are cold sawn, and the edges and butts of the flat plates are planed in the usual manner. The ends of the curved plates are planed in a novel form of machine, in which the tool travels in a circular path readily adjusted to the radius of the curved plate. On completion of the planing, the plates are taken to the tube yard, and are built up round the longitudinal ribs and internal stiffening frames, which have previously been fitted together in moulds to the exact diameter required: so that the plating of the framing at once gives the tube its proper form. The plates are in 16-feet lengths, and break joint alternately over the stiffeners at 8-feet intervals. Means are adopted to keep the tubes in line while the rivet holes are pierced by a travelling annular drilling frame, which is mounted on wheels and carries a boiler and engine driving ten drills by cotton ropes. A pair of drills are attached to each bed; and as the beds can traverse the circumference of the tubes, while the drills can traverse the length of the beds, the whole outside of the tube is commanded, and the holes are completed with accuracy to insure their precise coincidence when the parts are rebuilt at the site. As fast as each section of 8 feet length is finished, the machines are propelled along the rails to take up a new position; they thus travel gradually in successive stages over the whole length laid down. The tee and trough-shaped parts are built together in the shops, and the holes are drilled by adjustable vertical and horizontal drills, fitted to a travelling carriage; the power is transmitted to the machines by ropes from the shop shafting. Numerous radial machines are also in use for the secondary parts. For dealing with special parts, many ingenious and somewhat novel workshop appliances have from time to time been brought into use, beyond those here mentioned. All the parts of the junctions are carefully fitted together in the yard in the exact positions they will relatively occupy in the bridge. After each member has been prepared, the pieces are painted, marked, and stored until required for erection.

Founding Piers.—With the founding of the piers below water commenced the more difficult part of the undertaking; but without any sensible delay the whole of the piers have been successfully sunk and completed. The foundations for piers in shallow water were put in either by tidal work or by open cofferdams, and the excavation was carried down to boulder clay or rock. Though these were of individual interest themselves, from the size and difficulties met with, they are dwarfed by the magnitude of the operations connected with the deep-water piers, of which those in the south group are embedded in the boulder clay in one case at 90 feet below mean water-level, while at Inchgarvie they rest on a level bench cut out of the sloping whinstone rock at a depth of 72 feet.

Caissons.—The caissons for all the deep piers are 70 feet in diameter at base; the cutting edges and shoe are of steel, and the upper parts of wrought-iron. They were first built on ways on the south shore, and were launched with sufficient ballast on board in the form of concrete to insure their stability while towed out to their berths at the end of the jetties, where guide piles and dolphins were used to place them in correct position. Temporary wrought-iron cofferdams were built upon the top of the caissons, timber working decks constructed, cranes and concrete mixers fixed, air-pressure connexions made good, and sinking operations commenced with a pressure in the excavating chamber sufficient to drive out the water; the air-compressing machinery was placed on the jetty alongside. The Inchgarvie caissons had to be equipped with all these fittings while moored to the south jetty, so as to be ready for work on arrival over their rocky bed.

The working chamber was illuminated by electric lights; and communication was effected with it through three shafts with air locks on the level of the upper deck. The two shafts for the skips bringing up the excavated material were constructed with horizontal sliding shutters, worked by hydraulic rams, in place of the usual swing doors. The winding drum for bringing up the skip from the working chamber was not in the lock itself, but driven by an engine outside. On arrival of the skip in the lock, the lower slide was shut to, and the blow-off cock opened for releasing the pressure, the top slide drawn back, and the hook of the discharging crane was coupled to the skip by hand. This direct and rapid method of transit for the excavated materials greatly facilitated the sinking; the whole operation from arrival of the skip in the lock to its removal lasted only about three-quarters of a minute in ordinary working, the sequence of the movements being automatically controlled by interlocking gear. The air locks in the third shaft for the men were constructed with a view of rapidly changing shifts, and had double chambers, each capable of holding seven men.

The silt overlying the harder deposit was expeditiously expelled from the working chamber by means of ejection pipes passing into water outside, the air-pressure being sufficient to blow out charges of silt and water mixed in a box which communicated by a valve with the ejection pipes. On reaching the boulder clay, portable steel diggers, actuated by hydraulic cylinders placed between the roof and the implements, were brought into use to break up this hard material.

At Inchgarvie a modification of this system was required for sinking the deep piers into the hard whinstone rock, which had a natural slope of 1 in 4½. Bags of sand and concrete were deposited in two piles on the deeper side of the site to be occupied by the caisson, which had been launched with massive timber blocks in the chamber, to rest upon this artificial bed; these blocks and the edge of the caisson touching the rock on the shallower side were the first bearings it took when lowered at the site. The whole of these primary operations required extreme care to provide for differences of weight on the base, due to the depth of water at different states of the tide. Then by means of rock drills and ordinary quarrying operations inside the air-chamber the rock was excavated until the caisson was sunk to a level bench cut out of the sloping rock. In these caissons the full pressure of air due to the head of water was maintained during the sinking, and it was found advisable to change the gangs every four hours; the maximum pressure reached at high tide was 33 pounds per square inch above the atmosphere. The last of these caissons was got down to its final depth in October 1885.

In sinking the southern group of caissons, the air-pressure hardly ever exceeded 22 pounds per square inch, the silt and clay acting as a lute; and the working shifts were of six hours' duration, about twenty-seven men being down at a time.

Recovery of Canted Caisson.—With the exception of the north-west pier in the southern group, the whole of the piers were completed with regularity. But the caisson for that particular pier, weighing with concrete some 3000 tons, while ready at the site for placing in its final position, by some means became waterlogged on New Year's Day, 1885, and on the tide falling slid forwards on the mud about 15 feet, and canted over through 25°. After an ineffectual attempt to right it by pumping, regular siege was laid to it; but not until the autumn following, after nine months of incessant work, was a timber jacket or cofferdam completed, which enabled the pumps at last to obtain command over the leaks. The caisson then floated again, and after repair was sunk in position in the ordinary manner, arriving at its final depth in 1886. After the excavation had been completed, the chambers were rammed with concrete and grouted up, the concrete and anchorage and masonry were completed, and the temporary cofferdam was ready for removal.

Men Employed.—No difficulty arose in obtaining a sufficient number of men inured to work under air-pressure, as M. Coisseau, of the firm of MM. Couvreux and Hersent, of Paris, brought his staff of trained excavators from the Antwerp harbour improvement works, and contracted for the work to be executed under air-pressure.

Raising Viaduct Girders.—After the masonry of the approach viaduct piers had been carried up to a convenient height, a temporary stage was built, upon which the girders were erected and riveted up. Steel cross-beams with pairs of hydraulic jacks were placed under the ends of the girders over the piers; and a stage surrounding the piers was suspended from the main girders. From this platform the men in charge of the rams conducted the operations of lifting and blocking up the girders; and the masons afterwards completed the stonework in the vacant spaces. By this plan the girders were raised to their final height in July of the present year. The whole of the ten spans on the south side were lifted simultaneously as soon as they were all riveted up. The materials for the piers were first raised in trucks, by a steam hoist on the jetty, to a tramway laid on beams between the bottom members of the girders, and afterwards lowered into position by winches over each pier, these winches being driven by running ropes from engines on the girders at alternate piers. These approach spans now require only the parapet and a few other details for completing them in all respects, ready for the permanent way.

Erecting Steel Work over Main Piers.—On the completion of the masonry, the operation of erecting the steel work was commenced on the northern piers early in 1885 by riveting up the bed plates, and lowering them into position over the heads of the foundation bolts. Their surfaces were afterwards smoothed by emery wheels, and coated with crude petroleum, to prepare them for receiving the bearing plates of the cantilever bases or skewbacks. These, as already mentioned, have freedom for a limited amount of sliding, and the gauges at present attached show that the sliding movements follow the changes of temperature as anticipated.

The skewbacks, forming the junction of five tubular and five rectangular members over the piers, were then erected, and were connected with the horizontal members at the same level, which had been built together on a stage. After the connexions had been riveted up, a commencement was made upon the upper parts over the piers; these parts have since been erected without any form of fixed scaffolding, and the operation is still in progress over the Inchgarvie piers.

The lifting gear for raising the erecting platforms consists of a pair of plate frames, one below the other, fixed inside each 12-feet pier-column, by pins passing through the wings of the frames and the ribs of the column. The lower frame supports a hydraulic lifting press; and upon the ram rests a through box-girder cross-beam, at right angles to the length of the bridge, passing through voids in the columns, where plates are temporarily left out for this purpose. These cross-beams support lattice-girders in pairs, one on each side of the column, which extend a little more than the full length of the side of the quadrangle formed by the piers. Upon the top of all comes the main deck, furnished with gantries, cranes, oil-heated rivet-furnaces, &c., complete in all respects for carrying on the chief operations of erection. On the bottom level of the girders is a lower deck, with the ends housed in to form temporary shelters for the men. The box and other girders are built up of parts which will eventually be used in the permanent structure. Communication between the level of the jetty and the platforms is made by hoists, drawn up between wire-rope guides by the winding engine on the level of the jetty, which lifts the material by wire ropes to the platform; safety clutches are attached to each cage, for seizing the guide ropes in case the hauling gear were to give way. During lifting operations, access to the platforms is gained by ladders laid up the cross-bracing between the main columns over the piers.

The process of raising the platforms is as follows. Water-pressure at about 30 cwts. per square inch is conveyed from pumps on the jetty to the lifting presses by wrought-iron piping taken up the inside of the columns, and is turned into a cyinder, lifting the load off the series of pins in the top frame. The pins are then withdrawn, and the ram lifts the box-girder, carrying with it the loose frame, until opposite the next series of holes in the ribs of the columns, into which the pins are then inserted; the pressure is released, and the box-girder again rests upon the upper frame. In the return stroke the ram, hanging by its shoulders from the upper frame, by means of its piston form now hauls up the lower frame, from which the pins have been withdrawn; and when this has been repinned, it is ready to support the press for another upward stroke. By this means the platforms have been gradually raised, generally through lifts of 16 feet at a time, until arrived at the summit. On their way up they have been utilized for building the tubular cross-braces and other work; and at the present time those at the southern and northern piers form the stage for erecting the top members between the heads of the main columns. The platforms at Inchgarvie are now only 40 feet below the height to which they will have ultimately to be raised.

In building the pieces together, they are connected by service bolts, until the hydraulic riveters are brought into action. For the open work the riveters are of the gap type; but for the closed tubular work, a special adaptation was devised by Mr. Arrol, by which the rivets are closed in any part of the built tubes. When these machines arrive at the top of the columns, after having completed the riveting on the way up, they are taken apart ready for application elsewhere.

Erecting Cantilevers.—The building out of the first projecting bays of the cantilevers is being conducted on the system just described, with such modification as to suit the altered circumstances. The bottom members are first erected, and have been built by means of overhanging frames in panels, resting upon the completed portions of the tube, and so constructed that, as fast as the work is riveted up by the annular riveting machines, and the forward portions of the cage-like framing are brought into bearing, the back frames can be unshipped and taken forwards to the working face. Upon the top of this framework a movable hydraulic crane is placed for lifting the pieces into position, which are brought alongside from the pier by carriers suspended from a single rail of angle bar. As soon as the limit is reached at which these members can support the projecting work, inclined supporting stays are introduced, which connect the bottom member at this part with a temporary horizontal tie stretching between the main columns at about the level of the cross-bracing; thence the inclined stays slope down again, and are attached to the bottom member on the other side of the pier. After this has been done, platform girders with decks are built at a convenient level to rest on cross-beams carried by rising frames, which are introduced between the corners of the first vertical member of the bridge: this member having been pierced beforehand with a series of pin-holes, in readiness for a lifting action similar to that used in the main columns. The ends of the platforms nearest the piers are raised by suspension bars, by the action of hydraulic rams attached to the main columns at a higher level. From these platforms, as in the previous cases, the erection of all parts commanded by them is carried on as they rise.

The erection of the secondary parts proceeds simultaneously with that of the main members, the railway girders being built by corbelling out from the supports, and the other parts by light stages when the parts themselves cannot serve as a means of support to extend the work. As will readily be understood, the erection of these sections calls for greater nerve and judgment on the part of the men employed than does that of the portions previously described.

In conclusion, the author desires to express his indebtedness to Sir John Fowler and Mr. Benjamin Baker, through whose kindness he has been enabled to place before the Institution the foregoing particulars respecting an undertaking which, as shown by the magnitude of the works now being carried on, constitutes one of the greatest engineering feats ever attempted.

THE MACHINERY EMPLOYED AT THE FORTH BRIDGE WORKS.[1]

THE greater part of the machinery at the Forth Bridge works is original in design and novel in construction, chiefly because of the unusual nature of the work to be carried out. It may be roughly classed under the following heads: hydraulic bending and setting, planing, drilling, erecting, and riveting. In designing the machinery and tools to accomplish these different kinds of work, there had ever to be kept in view rapidity of production, with a very high quality of work in the finished structure. An idea of the quantity of machinery provided to deal with the material passing through the shops may be partly formed from the fact that it is capable of finishing 1500 tons in a single month.

Hydraulic Bending and Setting Machinery.—To bend and twist the large steel plates required in the construction of the tubes and their connexions, a great variety of hydraulic presses had to be provided. The largest of these is capable of exerting a pressure of 1600 tons between the dies. It consists of four 24-inch cylinders, resting on two longitudinal girders bedded in concrete. From each cylinder rise two iron colums, which carry a fixed table overhead. On the top of the rams another table is placed, which can be raised or lowered at will. Between these two tables are placed the blocks which stamp the plates to the desired shape. In most cases this shape is the arc of a circle, but in others the form is very varying, while in some instances the plates are flanged as well as bent or twisted. In nearly every case, after a plate has been set while heated, it requires to be finally adjusted when cooled. To dispense with the heating of the plates gives unsatisfactory work, and is in many cases impossible. In no instance is this plan of bending adopted to any extent without annealing the plates both before and after the work has been put upon them. Much of the final adjusting of the plates is done by presses consisting of a simple ram fixed to the upper of two girders, which are bound together at the ends, the lower girder serving as the seat for the block on which the plate is placed. Numerous other forms of presses are employed for lighter work.

Planing Machinery.—A special class of machinery is employed to plane the edges of the plates. In the case of most of the plates this requires to be done very carefully, because in the structure of the bridge a certain percentage of the stress in compression is taken up by the plates butting, instead of wholly by the rivets as in the tension joints. This statement applies to all plates in the tubes.

The sides are first of all planed on what may be looked upon as an ordinary planing machine. It is provided however with special double side-cheeks, between which are two fixed swivelling tool-boxes, one on each side of the machine. These tool-boxes can when desired be transferred to a special cross-slide, as it is sometimes more convenient to work with one box in the cross-slide rather than with both between the side-cheeks. Both tools act together and cut continuously—that is, during the backward as well as the forward travel of the table. The plate to be cut is fixed upon a curved block, which in turn is securely bolted to the table.

For planing the ends of the curved plates a special machine had to be designed and built, in which the plates are secured to a fixed table, while the tool is made to travel backwards and forwards in a swinging pendulum that receives its motion through a connecting-rod from a travelling saddle. The tool cuts both ways in this instance also, and is fed to its work by hand.

The planing machines employed to finish the rectangular plates for girder work are of the usual pattern for plate-edge planing, but with the addition of an end slide provided with a separate tool for planing one end of the plate at the same time that one of its sides is being similarly treated. This machine finishes a plate at two settings, with the certainty that the ends are at right angles to the sides.

In some machines two saddles are upon the main slide, and in others two tools are in one saddle; both devices have their advantages. The facing of the tees, angles, and other sections is done as a rule by cold steel saws, in order to secure good butting.

Drilling Machinery.—As will be inferred from the varying character of the work, the drilling is performed by various classes of machines. The principle kept in view is that, wherever possible, girders, tubes, &c., should be drilled only while their various parts are temporarily built and held together by bolts in the position they will finally occupy in the finished structure; in this way the highest class of work is obtained.

For drilling the tubes, the machines, each complete in itself, are made large enough to embrace the entire circumference of the tube. They consist of a wrought-iron under-frame or carriage, on which are placed the engine and boiler. On it are also fixed two large cast-iron annular rings or headstocks, embracing the tube, round which ten drilling slides and heads travel circumferentially. The slides are moved around the rings and consequently around the tubes by a worm at each end, gearing into a worm-wheel that forms part of the rings. The motion of the drill-heads on the slides is longitudinal, or parallel to the tubes. These two motions easily permit of the ten drills working at any part of the circumference of the tube comprised between the two annular rings, which embrace a length of 8 feet. When this length is finished, the whole machine is travelled forwards, and is again ready to drill a new length of 8 feet. The tube rests on timber blocks, which are removed from the front and placed behind as the machine travels forwards. In the case of the lighter tubes, the rate of drilling is as high as 12 lineal feet of tube per shift of ten hours; this represents about 800 holes drilled

The booms of all girders are drilled separately on blocks, thus leaving the bracings to be drilled to template, which is done by radial drills at another time. The machines employed to drill the booms are of a wholly different kind from those used for the tubes. They are moved along rails, running on each side of the blocks upon which the booms are built, and parallel with them. They consist of a double carriage with upright columns, connected together by means of a cross-beam and sundry other framing for carrying the shafts, pulleys, &c. To the columns and cross-beam are secured slides, to which the fixed drill-heads are bolted on the front of the machine; while to the back are attached radiating arms, each carrying a single drill. In this way there are both fixed and swinging drills on the two sides of the machine, capable of drilling holes in either a horizontal or a vertical plane. The fixed drills serve for all holes in the regular pitch, while the movable drills take what may be called odd holes, such as those where the struts and ties are to be secured to the booms. All the fixed drills are self-feeding, but the movable ones are fed by hand. The number of drills simultaneously at work varies greatly; at times as many as thirteen have been employed together on a single boom.

Other machines having radials with only single drills are used for a special class of drilling, and are found to work to great advantage. With the exception of a few special tools, all the remaining drilling is done by radials capable of making a complete circle round the column on which they are supported. Tables are placed on each side of these machines, and the work is fixed on one of the tables; and as the drills are placed at a convenient distance from one another, all the drilling required is easily accomplished without a second shifting of the work.

Erecting and Riveting Machinery.—To erect and rivet such large quantities of material at the immense height at which much of it requires to be done demands a large quantity of special plant for riveting and other purposes. The ordinary class of riveting is accomplished by means of small portable riveters, consisting of two arms held apart by links and stays; one arm acts as the holder-on, while the other carries the hydraulic cylinder for supplying the power, the cylinder and arm together forming one casting. For some of the more difficult work, where neither could this form of riveter be employed nor could the work be done by hand, small direct-acting hydraulic cylinders were used; the die for forming the rivet-head was here fixed into the piston. Two 4-inch cylinders were usually employed, held

[1] Paper read by Mr. William Arrol before the Institution of Mechanical Engineers on Tuesday, August 2.

to their work either by hard wood packing placed against the permanent structure, or by temporary girders brought into proper position. In these machines the pressure employed was 3 tons per square inch. A large amount of excellent work was performed by these machines in positions where it was practically impossible to do it otherwise.

The riveting of the vertical columns of the piers is done by riveting machines attached to the under sides of the lifting platforms. They are lifted with the platforms, and do their wo k while the platform is at rest. They consist of two longitudinal girders or uprights, one on the outside and the other on the inside of the column. Along the face of each girder a riveting cylinder is raised or lowered by hydraulic power. The inside girder has a trunnion at top and bottom, fitting into a step in two temporary diaphragms for supporting the thrust of the rams in riveting. It is turned round on the trunnions at will, so as to rivet up an entire length of 16 feet of the tube both circumferentially and longitudinally. The outside girder and riveting cylinder when at work always face the inside. The outside girder is attached at top and bottom to two wrought-iron rings, which encircle the column, and not only furnish the necessary support but also permit of the machine being moved round the column by hydraulic power as required. Over 800 rivets have been closed in a day by one of these machines.

In the erection of the large piers of the bridge, hydraulic power is utilized to a great extent. The principle adopted is to build the piers from off a platform raised by hydraulic pressure as the work of erection proceeds, utilizing the piers themselves in process of building as the support of the rising platform.

THE CHEMISTRY OF THE RARE EARTHS.

It is now nearly twelve months since the chemical world was agitated by the memorable departure made by Mr. Crookes, in his address to the Chemical Section of the British Association, in attempting to translate into language thoughts which had been irresistibly forced home to the minds of many men of science as to the insufficiency of the theories of our modern chemical philosophy to account for the presence in our midst of those objects of ever-increasing interest, the chemical elements. It will be remembered that, both in the address referred to and in his lecture at the Royal Institution on the "Genesis of the Elements," Mr. Crookes based a large portion of his arguments upon the remarkable experiences which he himself had met with in endeavouring to separate the constituents of the rare earths contained in several sparsely distributed minerals. It may be of interest just to recall the main conclusions drawn by the lecturer from his experiments upon the substances yielded by the laborious but fruitful process of fractionation. Yttrium, which only two years ago was supposed to be a simple substance, fell under that *nil desperandum* sorting influence into five components, each of which presented a distinct phosphorescent spectrum; samarium, one of the constituents of old didymium, was found to consist of two and possibly of three ingredients; and finally, the two components of didymium itself, into which it had been separated by Dr. Auer von Welsbach, were shown by Mr. Crookes, M. de Boisbaudran, and M. Demarçay to consist themselves of several.

Contemporaneously with the work which has been carried on by these and other experimenters, Drs. Krüss and Nilson, who have at their disposal tolerably large quantities of Scandinavian minerals containing rare earths, have been engaged upon work of a similar nature, and have lately published in the *Berichte* of the German Chemical Society results of the highest interest, not only confirming the conclusions above referred to, but announcing that, "in place of the rare metals erbium, holmium, thulium, didymium, and samarium, we must now accept the existence of more than twenty elements."

Considering the interest which Mr. Crookes's addresses have called forth, and the important bearing of this contemporaneous work upon a subject of such paramount importance to the first principles of chemistry, it may be of advantage to give a short description of the experiments which have led to results of such magnitude.

The minerals examined were specimens of thorite from Brevig and Arendal, in the province of Christiansand, of wöhlerite from Brevig, cerite from Bastnäs, fergusonite from Arendal and Ytterby, and of euxenite from Hitterö and Arendal. The nitrates of the earths contained in these minerals gave very beautiful absorption-spectra, and a precise measurement of the positions of the lines and bands in these spectra resulted in the surprising observation that in certain minerals only a particular few of the absorption-bands of the nitrates of some of the rare earths were visible; thus, only one line out of all the lines considered to belong to the nitrate of holmium, the metal which Soret called X, was visible in any intensity in the spectrum of the nitrates from thorite of Brevig; moreover, this particular line is but insignificant, among many much more intense, in the usual spectrum of the nitrate of holmium. The more intense lines were either not at all or only faintly visible in the spectrum of thorite of Brevig; hence it is concluded that Soret's X must consist of at least two ingredients, of which one is found free in thorite of Brevig, and gives this one line of wave-length 428·7.

In these observations a single 60° prism of dispersion $A - H_2 = 4° 18'$ was preferred, inasmuch as weak lines or bands cannot be distinctly seen with more dispersion, and the position of maximum darkness becomes more difficult to fix; the spectroscope was fitted with the most refined micrometer arrangement for the accurate determination of the wave-lengths, so that the whole of the work may be checked by future observers. Before passing to the discussion of the main results of the experiments, a brief description of the procedure in case of one of the minerals examined may not be without interest. Thorite of Brevig is a typical specimen of the Scandinavian rare earth minerals, and its treatment was as follows. After removal of the thoria, which was required for the purpose of determining the atomic weight of thorium, the solution in ice-cold water of the sulphates of the mixed earths was precipitated by oxalic acid, leaving the iron, manganese, and uranium in solution. The oxalates were then ignited and the residual earths again converted to sulphates; the sulphates were converted to hydrates by precipitation with ammonia, and the hydrates dissolved in nitric acid, by which a lovely pink solution of the nitrates was obtained. As small quantitities of thorium and cerium were still contained in the mixture, the nitrate solution was evaporated to dryness, and the residue ignited, whereby the thorium and cerium nitrates were converted into insoluble basic salts. The filtered solution of the residue then contained the nitrates of the didymium and yttrium metals, and gave the following absorption-spectrum:—

Thorite of Brevig.

Observed position of max. darkness.		Previously observed wave-length.	For	Intensity of the absorption-bands.
Reading of micro-meter.	Observed wave-length.			
2354	728·3	728·3	Di	Tolerably strong.
2381	708·2	708·2	Di	Very faint.
2411	686·0	684·0	Tm	Extremely faint.
2420	679·3	679·4	Di	Faint.
2457	654·1	654·7	Er	Faint.
2480	640·6	640·4	X	Very faint.
2505	626·1	626·1	Di	Faint.
2568	591·5	591·5	Di	Faint.
2596	579·2	579·2	Di	Tolerably faint.
2605	575·4	575·4	Di	Faint.
2689	539·6	...	?	Very faint.
2713	531·3	531·3	Di	Faint.
2721	529·2	530·0	Di	Extremely faint.
2740	523·6	523·1	Er	Strong.
2747	521·6	521·5	Di	Very faint.
2781	512·2	512·2	Di	Faint, broad.
2872	485·9	485·5	X	Very faint.
2888	482·3	482·0	Di	Very faint, but sharp.
2913	476·5	477·7	Sm	Faint.
2944	469·2	469·0	Di	Strong.
2974	462·3	463·2	Sm	Faint.
3068	445·6	445·1	Di	Very strong.
3076	444·2	444·7	Di	Very strong.
3164	428·7	428·5	X	Strong.
3240	417·3	416·7	Sm	Strong.

Similar observations were made upon the nitrates derived from the other minerals above mentioned, the actual wave-lengths being in every case determined so that the position of the lines can be open to no doubt whatever.

Ten years ago the erbium earths were considered as the oxide of a single element, but we now know that they consist of the oxides of scandium, ytterbium, thulium, erbium, terbium, holmium, and yttrium. Out of the rich data furnished by the present observations the observers believe they can prove that all those erbium-earths whose nitrates give absorption-spectra are not oxides of simple bodies, but mixtures of the oxides of various new elements. Yttrium, as before mentioned, has already been shown by Mr. Crookes to consist of five constituents, and it will be interesting to see what light the workers in Stockholm have thrown upon the nature of some of the remainder.

M. Lecoq de Boisbaudran showed that by fractionation of Soret's X two new substances were arrived at, which he named holmium and dysprosium, but these are now shown to be themselves compound, for one part of dysprosium is not present in thorite of Brevig or cerite of Bastnäs, although present in the mixture called X; in fact, de Boisbaudran's dysprosium lines Dyα, Dyβ, and Dyδ are found to belong to three different elements; and the other constituent, the holmium of de Boisbaudran, is probably made up of no less than four distinct components.

As the introduction of fresh names is rapidly increasing the difficulty of work in this direction, Krüss and Nilson prefer to simply label the components by affixing the letters of the Greek alphabet to already accepted symbols. The metal called by Soret X is therefore constituted as follows:—

	Wave-length of characteristic line in absorption-spectrum of nitrate.
Xα	640·4
Xβ	542·6
Xγ	536·3
Xδ	485·5
Xε	474·5
Xζ	451·5
Xη	428·5

of which

Thorite of Brevig contains...	Xα, Xδ, Xη.
,, Arendal ,, ...	Xβ, Xγ, Xε, Xζ, Xη.
Wöhlerite of Brevig ,, ...	Xγ, Xζ, Xη.
Cerite of Bastnäs ,, ...	Xα, Xη.
Fergusonite of Arendal ,, ...	Xβ, Xγ, Xδ, Xε, Xζ, Xη.
Fergusonite of Ytterby and euxenite of Arendal and Hitterö contain	Xα, Xβ, Xγ, Xδ, Xε, Xζ, Xη.

We are now accustomed to distinguish as erbium that body whose nitrate solution exhibits, in addition to a large number of lines in the violet and ultra-violet, two principal lines of wave-lengths 523·1 and 654·7 respectively, of which the former is the most intense. But in euxenite of Hitterö much greater difference is shown, one being extremely strong, while the other is barely visible; therefore here again the observers consider themselves in face of at least two elements, Erα and Erβ, one giving 523·1 and the other 654·7. Moreover, they have succeeded in separating the two almost completely by a method of fractionation similar to that employed by Mr. Crookes.

Cleve, in 1879, gave the name of thulium to the metal whose oxide formed the strongest base present in the mixture of erbium earths; and its salts, according to Thalèn, exhibit two absorption-bands, 684·0 and 465·0, of which the former is the most intense. Again, the variations are found to be too great for the supposition of a single earth to be tenable, one line being entirely absent in fergusonite and thorite of Arendal, while the other is strong; hence thulium must also consist of two ingredients, Tmα and Tmβ.

The observations with regard to didymium are all the more interesting as entirely confirming Mr. Crookes's statements, and Drs. Krüss and Nilson even go further in proving either that our interpretations of the indications of spectrum analysis are grossly wrong or that didymium is composed of not less than nine distinct elements. Dr. Auer von Welsbach's symbols for praseodymium and neodymium, the two constituents of didymium which he actually separated, are discarded, and the same nomenclature adopted as in the case of holmium.

	Characteristic line in absorption-spectrum of nitrate solution.
Diα	728·3
Diβ	679·6
Diγ	579·2 and 575·4
Diδ	521·5
Diε	512·2
Diζ	482·0
Diη	469·0
Diθ	445·1
Diι	444·7

The name samarium was given by M. de Boisbaudran to an element identical with Marignac's Yβ, an ingredient of the old didymium. The nitrate of this metal gives seven absorption-bands according to Thalèn, but it is surprising that in thorite and euxenite of Arendal the line 416·7 is tolerably strong, and even very strong, without another samarium line to be seen in the spectrum; the conclusion is inevitable that there must be in this substance a constituent whose nitrate gives the line 416·7, and to this the name Smα is given, all other samarium lines being provisionally supposed to belong to Smβ.

The main result of this splendid work, therefore, appears to be that, instead of holmium, erbium, thulium, didymium, and samarium, we must, if we follow Krüss and Nilson, recognize the existence of at least twenty-two new elements, the fate of some of which may be, in the near future, to be subjected to still further subdivision. If we add to these the results previously obtained by Mr. Crookes with respect to yttrium, the astounding revelation is presented to us that instead of six we find ourselves in face of twenty-seven, or a clear gain of at least twenty-one new elements.

But now comes the vital question—Are these really new elements, or are they only different molecular aggregations of the atoms of a few, as suggested by Mr. Crookes? It certainly seems very remarkable that so large a number of elements should be crowded together about the central series of the periodic system, and we appear to have a repetition of the same phenomenon, in a much intensified degree, as obtains in the cases of nickel and cobalt, rhodium, ruthenium, and palladium, and of iridium, osmium, and platinum. It may, however, be interestin this connexion to remember that this precise state of things was predicted by Mendelejeff himself (*Ann. Chem. Pharm.* Suppl. 8, p. 158), and in no way militates against the new element theory. Krüss and Nilson, rather than be obliged to have recourse to the introduction of new or auxiliary theories of spectrum analysis, prefer to rest upon the simpler and apparently more straightforward assumption that these substances, whose nitrate spectra show such marked differences, are indeed *bonâ fide* new elements. The accuracy of this view will doubtless be strongly contested, but in any case the result appears likely to be equally striking; for, if future work shows its want of accordance with facts, then an entirely new field of research has been opened, and the generally accepted ideas of the structure of matter must of necessity undergo a complete metamorphosis.

A. E. TUTTON.

SOCIETIES AND ACADEMIES.

LONDON.

Royal Society, June 16.—"On Figures of Equilibrium of Rotating Masses of Fluid." By G. H. Darwin, M.A., LL.D., F.R.S., Fellow of Trinity College and Plumian Professor in the University of Cambridge.

The intention of this paper is, first, to investigate the forms which two masses of fluid assume when they revolve in close proximity about one another, without relative motion of their parts; and secondly, to obtain a representation of the single form of equilibrium which must exist when the two masses approach so near to one another as just to coalesce into a single mass.

When the two masses are far apart the solution of the problem is simply that of the equilibrium theory of the tides. Each mass may, as far as the action on the other is concerned, be treated as spherical. When they are brought nearer to one another this approximation ceases to be sufficient, and the departure from sphericity of each mass begins to exercise a sensible deforming influence on the other.

The actual figure assumed by either mass may be regarded as a deformation due to the influence of the other considered as a sphere, on which is superposed the sum of an infinite series of deformations of each due to the deformation of the other and of itself.

But each mass is deformed, not only by the tidal action of the other, but also by its own rotation about an axis perpendicular to its orbit. The departure from sphericity of either body due to rotation also exercises an influence on the other and on itself, and thus there arises another infinite series of deformations.

It is shown in the paper how the summations of these two kinds of reflected influences are to be made, by means of the solution of certain linear equations for finding three sets of coefficients.

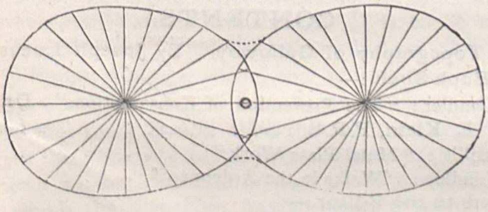
The first set of coefficients are augmenting factors, by which the tide of each order of harmonics is to be raised above the value which it would have if the perturbing mass were spherical. The second set correspond to one part of the rotational effect, and belong to terms of exactly the same form as the tidal terms, with which they ultimately fuse. The third set correspond to the rest of the rotational effect, and appertain to a different class of deformation, which are in fact sectorial harmonics of different orders. The term of the second order represents the ellipticity of the mass due to rotation, augmented, however, by mutual influence. All the terms of this class, except the second, are very small; their existence is, however, interesting.

From the consideration that the repulsion due to centrifugal force shall exactly balance the attraction between the two masses, the angular velocity of the system is found. It is greater than would be the case if the masses were spherical.

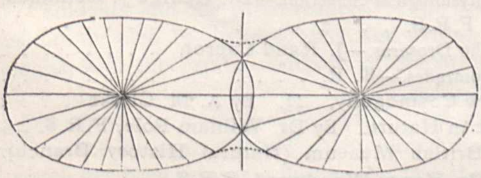
The theory here sketched is applied in the paper numerically, and illustrated graphically in several cases.

When the masses are equal to one another they are found to be shaped like flattened eggs, and the two small ends face one another. Two figures are given, in one of which the small ends nearly touch, and in the other where they actually cross. In the latter case, as two portions of matter cannot occupy the same space, the reality must consist of a single mass of fluid consisting of two bulbs joined by a neck, somewhat like a dumb-bell. In the figure conjectural lines are inserted to show how the overlapping of the masses must be replaced by the neck of fluid.

FIG. 1



Section perpendicular to axis of rotation.



Section through axis of rotation.

A comparison is also made between the Jacobian ellipsoid of equilibrium with three unequal axes and the dumb-bell. It appears that with the same moment of momentum the angular velocity is nearly the same in the two figures, but the kinetic energy is a little less in the dumb-bell. The intrinsic energy of the dumb-bell is, however, greater than that of the ellipsoid, so that the total energy of the dumb-bell is slightly greater than that of the ellipsoid.

Sir William Thomson has remarked on the "gap between the unstable Jacobian ellipsoid . . . . . and the case of the smallest moment of momentum consistent with stability in two equal detached portions." "The consideration," he says, "of how to fill up this gap with intermediate figures is a most attractive question, towards answering which we at present offer no contribution."[1] This paper is intended to be such a contribution, although an imperfect one.

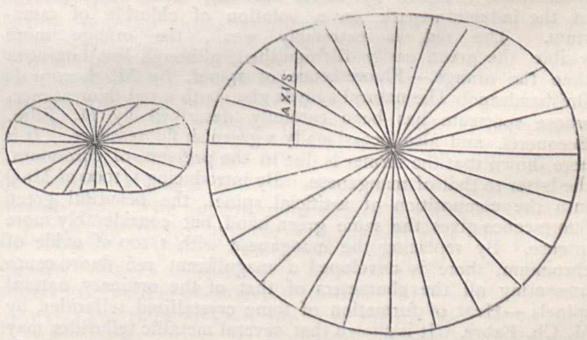
M. Poincaré has made an admirable investigation of the forms of equilibrium of a single rotating mass of fluid, and has specially considered the stability of Jacobi's ellipsoid.[2] He has shown by a difficult analytical process, that when the ellipsoid is moderately elongated, instability sets in by a furrowing of the ellipsoid along a line which lies in a plane perpendicular to the longest axis. It is, however, extremely remarkable that the furrow is not symmetrical with respect to the two ends, and there thus appears to be a tendency to form a dumb-bell with unequal bulbs.

M. Poincaré's work seemed so important that, although the figures above referred to were already drawn a year ago, this paper was kept back in order that an endeavour might be made to apply the principles enounced by him, concerning the stability of such systems. The attempt, which proved abortive on account of the imperfection of approximation of spherical harmonic analysis, is given in the appendix to the paper, because, notwithstanding its failure, it presents features of interest.

The calculations in this paper being made by means of spherical harmonic analysis, it is necessary to consider whether this approximate method has not been pushed too far in the computation of figures of equilibrium which depart considerably from spheres. A rough criterion of the applicability of the analysis is derived from a comparison between the two values of the ellipticity of an isolated revolutional ellipsoid of equilibrium as derived from the rigorous formula and from spherical harmonic analysis. As judged by this criterion, which is necessarily in some respects too severe, the figures drawn appear to present a fair approximation to accuracy.

Since, as above stated, the rigorous method of discussing the stability of the system fails, certain considerations are adduced which bear on the conditions under which there is a form of equilibrium consisting of two fluid masses in close proximity, and it appears that there cannot be such a form, unless the smaller of the two masses exceeds about one-thirtieth of the larger. It seemed therefore worth while to find to what results the analysis would lead when two masses, one of which is twenty-seven times as great as the other, are brought close together. As judged by this criterion the computed result must be very far from the truth, but as the criterion is too severe, it seemed worth while to give the figure. The smaller mass is found to be deeply furrowed in a plane parallel to the axis of

FIG. 2.



Ratio of masses 1 : 27. Upper half of figures section through axis of rotation. Lower half section perpendicular to axis.

rotation, so as to be shaped like a dumb-bell, and although this result can only be taken to represent the truth very roughly, yet it cannot be entirely explained by the imperfection of the analytical method employed. It appears then as if the smaller body were on the point of separating into two masses, in the same sort of way that the Jacobian ellipsoid may be traced through the dumb-bell shape until it becomes two masses.

M. Poincaré has commented in his paper on the possibility of the application of his results, so as to throw light on the genesis of a satellite according to the nebular hypothesis, and this

[1] Thomson and Tait, "Natural Philosophy" (1883), § 778 (i). He also remarks elsewhere that by thinning a Jacobian ellipsoid in the middle, we shall get a figure of the same moment of momentum and less kinetic energy.

[2] *Acta Math.* vii. 3 and 4, 1885.

nvestigation was undertaken with such an expectation. He remarks, however, that the conditions for a separation from a mass which is strongly concentrated at its centre, are necessarily very different from those which he has treated mathematically.

However, both his investigation and the considerations adduced here seem to show that, when a portion of the central body becomes detached through increasing angular velocity, the portion should bear a far larger ratio to the remainder than is observed in our satellites, as compared with their planets ; and it is hardly probable that the heterogeneity of the central body can make so great a difference in the results as would be necessary if we are to make an application of these ideas.

It seems then at present necessary to suppose that after the birth of a satellite, if it takes place at all in this way, a series of changes occur which are still quite unknown.

Paris.

Academy of Sciences, August 1.—M. Janssen in the chair.—On the silicates of thorine, by MM. L. Troost and L. Ouvrard. It was lately shown by the authors that the study of the double phosphates formed by thorine and zircon with phosphoric acid and potassa or soda furnished no argument for associating thorine with zircon. Their further researches on the combinations of thorine and silica have yielded a compound substance, in which this base seems to be still further removed from zircon. The silicates of thorine were prepared by heating a mixture of silica and thorine with the chloride of calcium used as a solvent, and by varying the conditions two silicates were obtained, differing entirely in their composition and crystalline form. The crystals belong to the orthorhombic system, with density 6·82 at 16° C., analysis yielding 18·01 silica and 81·80 thorine. This compound corresponds to the formula $2ThO \cdot SiO_2$ (Th = 58·1), or $Th'O_2 \cdot SiO_2$ (Th' = 116·2). There is no isomorphism between this silicate of thorine and zircon $ZrO_2 \cdot SiO_2$; but here thorine may be regarded as playing the part of a bioxide. This conclusion has been confirmed by the recent experiments of MM. Krüss and Nilson, who, when determining the vapour-density of thorium, obtained numbers approaching, but always inferior to, that corresponding to the formula $Th'Cl_2$.—New fluorescences with well-marked spectral bands, by M. Lecoq de Boisbaudran. The new fluorescences here described are specially remarkable both for the number and the position of their distinct rays. They are often very bright, and are obtained by taking as agents the oxides of Sm, $Z\alpha$, $Z\beta$, and as solid solvents alumina or gallina. Alumina with 1/50 of samarine shows a red, an orange, and a green band, whose positions differ little from those occupied by bands obtained from the inversion of the induction-spark on a solution of chloride of samarium. The red is extremely weak, the orange more visible, the green easily distinguished, although less luminous than the orange.—Fluorescence of spinel, by M. Lecoq de Boisbaudran. The natural spinels give both a red fluorescence, whose spectrum has been carefully described by M. Edm. Becquerel, and also occasionally a greenish fluorescence. It is here shown that the former is due to the presence of chromium, the latter to that of manganese. By introducing 1/1000 of MnO into the composition of artificial spinel, the beautiful green fluorescence gives the same green band, but considerably more intense. By replacing the manganese with 1/100 of oxide of chromium, there is developed a magnificent red fluorescence presenting all the characters of that of the ordinary natural spinels.—Heat of formation of some crystallized tellurides, by M. Ch. Fabre. It is shown that several metallic tellurides may be obtained by heating in nitrogen a mixture of powdered tellurium and filings of the metal. The tellurides of iron, nickel, cobalt, and thallium not hitherto obtained, are crystallized, resisting hydrochloric acid and sulphuric acid at a low temperature, but slowly changing in a moist atmosphere. Reduced to a fine powder they are easily dissolved in bromine and the water of bromine yielding the corresponding bromide, hydrobromic acid, and tellurous acid. A comparison of the heats of formation of the crystallized tellurides and selenides seems to show that in the same group, according as the equivalent weight of the metalloid combined with the metal increases, the quantity of heat liberated by the combination diminishes. But in order to verify this hypothesis, it would be necessary to determine the heat of formation of the corresponding crystallized sulphides.—On the succinimidoacetic and camphorimidoacetic ethers, by MM. Alb. Haller and G. Arth. In order to obtain these ethers, the authors have employed the sodified derivatives of succinimide and camphorimide, the latter behaving like its analogues in the presence of the alkaline metals.—On a new isomere of benzine, by M. G. Griner. Besides the dipropargyle belonging to the fatty series discovered by M. L. Henry, the author has obtained another isomere of benzine, which does not combine with ammoniacal cuprous chloride, and consequently is not acetylenic. Its simplest formula would seem to be $CH_2—C \equiv C—C \equiv C—CH_3$.—Remarks in connexion with the observations of M. Grawitz on the preparation of the chromates of aniline and their applications, by MM. Ch. Girard and L. L'Hote. The authors repeat that they were the first to isolate and study the bichromate of aniline, a crystalline salt, of which they gave the formula and chemical properties, and from which they have succeeded in preparing certain colours such as mauvéine, pheno-safranine, violaniline, &c.—On the effects of salting on pig's flesh affected by charbon, by M. F. Peuch. The experiments here described show that even in thoroughly salted bacon the charbon is not killed, but its virulence is destroyed.—On a new microbe determining indigotic fermentation and the production of blue indigo, by M. E. Alvarez. The author's experiments show that indigo is a product of fermentation determined by a special microbe greatly resembling those of pneumonia and rhinosclerome, which also have the power of setting up indigotic fermentation. The microbe of indigo also possesses pathologic properties determining either a passing local inflammation, or even rapid death with congestions of the visceræ and fibrine exudations.

BOOKS, PAMPHLETS, and SERIALS RECEIVED.

A New Mode of Geometrical Demonstration, with Examples ; D. Maver (Brown, Aberdeen).—Terra : A. A. Anderson (Reeves and Turner).—Annales de l'Observatoire de Nice. tome ii. (Paris).—Food Adulteration and its Detection : J. P. Battershall (Spon).—Electricity : W. Larden (Longmans).—British Dogs, Nos. 9 and 10 : H. Dalziel (Gill).—Bees and Bee-keeping, vol. ii. parts 9, 10, 11 : F. R. Cheshire (Gill).—McGill University Annual Calendar, Faculty of Medicine (Montreal).—On the Education of Engineers : H. Dyer (Munro, Glasgow).—Hints to Meteorological Observers, 2nd edition (W. Marriott (Stanford).—Archives Néerlandaises des Sciences Exactes et Naturelles, xxi. (Harlem).—Brain, part xxxviii. (Macmillan).—Quarterly Journal of the Royal Meteorological Society, April (Stanford).—Meteorological Record, vol. vi. No. 24, vol. vii. No 25 (Stanford).—Annalen der Physik und Chemie, 1887, No. 8*b* (Leipzig).—Beiblätter u den Annalen der Physik und Chemie, 1887, No. 7 (Leipzig).

CONTENTS.