Agenia, Aporus, Miscophus, Ammophila, Crabro, Cerceris, Philanthus, and some others, all of which stupefy the caterpillars, spiders, or bees, which they store up for the nourishment of their brood, and it would be desirable to have it pointed out to what genera the insects really belong. The species seen by Mr. Cecil, in a collection at Athens, which is described as "a thin-bodied variety," is, I think, a species of the genus Ammophila, or of Pompilus; that observed by Mr. Armit, of Queensland, is probably a species of Pelopæus. Some further definition of the insects I consider highly desirable, as the general term wasp must, I believe, lead to a very false conclusion.

British Museum, November 2 FREDK. SMITH

The Expected Meteor Shower

THE meteor shower of Biela's comet, referred to in your "Astronomical Notes" as likely to occur on the 27th inst., should also be looked for on several evenings preceding that date. Last year there were more of these slow-moving *Andromedes* on the 25th than on the 27th of November. On the former night, from 5h. 30m. to 7h., I saw sixteen shooting stars, seven of which belonged to this stream, for they showed a good radiant at R.A. 24° Dec. 45° N. Yet on the 27th only two others were noted out of a total of 10 recorded during a watch from 9h. to 10h. 30m. An occasional look out is therefore advisable on several nights about the 27th, when, if meteors are seen in more than ordinary profusion, it will be important to record their numbers and paths. W. F. DENNING

Ashleydown, Bristol, November 7

Geological Climate and Geological Time

IN considering the climatic changes which have evidently taken place on various parts of the earth's surface, it seems to me that what may have been a very important factor has been rather strangely left out of calculation by physicists, never having been noticed hitherto, as far as I am aware. It is that of the heat which must at one period or other have been transmitted from the moon. There can be scarcely a doubt that this must at one time have influenced the earth's climate to a very powerful degree, producing the effects of a second or additional sun. In the absence of any perceptible marks of atmospheric or aqueous erosive action on the moon it is at present impossible to arrive at any idea of its relative age or at what period its heat may have been most abundantly radiated; but if the much hotter climate which once prevailed in northern latitudes could be referred to this cause it might give us some clue to the difficulty. Something also might be done in comparing the various changes of climate which have taken place in certain parts of the earth's surface, as indicated by geological evidence, with the actual course of the moon. The subject is at least worth entertaining, and may be recommended to the consideration of physicists. WILLIAM DAVIES

10, Guildford Street, Russell Square, November 4

A "New Galvanometer"

THE galvanometer (with its coil moving about a horizontal axis) described by Dr. Obach in NATURE, vol. xviii. p. 707, is not new. Prof. Pickering has fully described it, under the name of *Cosine* galvanometer, in his "Elements of Physical Manipulation," Part 2 (1876), p. 260. When this instrument was first used I do not know. R. E. BAYNES

Christchurch, Oxford, November 9

COMMERCIAL CRISES AND SUN-SPOTS[1]

"Thou Sun, of this great world both eye and soul."

IT is curious to notice the variety of the explanations offered by commercial writers concerning the cause of the present state of trade. Foreign competition, beer-drinking, over-production, trades-unionism, war, peace, want of gold, superabundance of silver, Lord Beaconsfield, Sir Stafford Northcote, their extravagant expenditure, the Government policy, the wretched Glasgow Bank directors, Mr. Edison and the electric light, are a few of the happy and consistent suggestions continually made to explain the present disastrous collapse of industry and credit.

It occurs to but few people to remember that what is happening now is but a mild repetition of what has previously happened time after time. October, 1878, is comparable with May, 1866, with November, 1857, with October, 1847, and, going yet further back, with a somewhat similar condition of things, in 1837, in 1825-26, and even in 1815-16. The incidental circumstances of these commercial collapses have indeed been infinitely diversified. At one time the cause seemed to be the misconduct of the great firm of Overends; in 1857 there was the mutiny in India, the peace with Russia, and a commercial collapse in the United States; in 1847 occurred the Irish famine and a failure of European harvests generally, following upon the great railway mania; the crisis of 1837 succeeded an immense expansion of home trade, the establishment of joint stock banks, and the building of multitudes of factories and other permanent works; 1825 was preceded by extravagant foreign speculations and foreign loans; 1815 was the year of the general peace. All kinds of distinct reasons can thus be given why trade should be now inflated and again depressed and collapsed. But, so long as these causes are various and disconnected, nothing emerges to explain the remarkable appearance of regularity and periodicity which characterises these events.

The periodicity of the earlier portion of the series is so remarkable that, even without the corroboration since received, it convinced scientific inquirers that there was some deep cause in action. Dr. Hyde Clarke, for instance, wrote, more than thirty years ago, a paper entitled "Physical Economy—a preliminary inquiry into the physical laws governing the periods of famines and panics." This paper was published in the *Railway Register* for 1847, and is well worth reading. In the commencement he remarks: "We have just gone through a time of busy industry, and are come upon sorrow and ill-fortune; but the same things have befallen us often within the knowledge of those now living. Of 1837, of 1827, of 1817, of 1806, of 1796, there are men among us who can remember the same things as we now see in 1847. A period of bustle, or of gambling, cut short in a trice and turned into a period of suffering and loss, is a phenomenon so often recorded, that what is most to be noticed is that it should excite any wonder." Dr. Hyde Clarke then proceeds to argue in a highly scientific spirit that events so regularly recurring cannot be attributed to accidental causes; there must, he thinks, be some physical groundwork, and he proposed to search this out by means of a science to be called Physical Economy. In the third page of his paper he tells us that he had previously written a paper on the laws of periodical or cyclical action, printed in Herapath's *Railway Magazine* for 1838. "At this time," he says, "it was my impression that the period of speculation was a period of ten years, but I was led also to look for a period of thirteen or fourteen years. . . . In the course of these inquiries I looked at the astronomical periods and the meteorological theories without finding anything at all available for my purposes." A little below Dr. Hyde Clarke continues:—"Still thinking that the interval was an interval of about ten years, I was, during the present famine, led to look for a larger period, which would contain the smaller periods, and as the present famine and distress seemed particularly severe, my attention was directed to the famine so strongly felt during the French Revolution. This gave a period of about fifty-four years, with five intervals of about ten or eleven years each, which I took thus:—

"1793 1804 1815 1826 1837 1847."

Dr. Hyde Clarke was by no means the only statist who

[1] This article, although treating the same subject, and partially containing the same facts as a paper by the same writer, read at the recent meeting of the British Association, is a distinct composition. The paper in question will probably be published elsewhere.

adopted a theory of periodicity thirty or forty years ago. In February, 1848, Mr. J. T. Danson read a paper to the Statistical Society of London, attempting to trace a connection between periodic changes in the condition of the people and the variations occurring in the same period in the prices of the most necessary articles of food. Mr. James Wilson had published, in 1840, a separate work or large pamphlet upon "Fluctuations of Currency, Commerce, and Manufactures," in which he speaks of the frequent recurrence of periods of excitement and depression. In later years Mr. Wm. Langton, the esteemed banker of Manchester, independently remarked the existence of the decennial cycle, saying: "These disturbances are the accompaniment of another wave, which appears to have a decennial period, and in the generation of which moral causes have no doubt an important share." The paper in which this remark occurs is contained in the *Transactions* of the Manchester Statistical Society for 1857, and is one of the most luminous inquiries concerning commercial fluctuations anywhere to be found.[1] In still later years Mr. John Mills of the Manchester Statistical Society has almost made this subject his own, insisting, however, mainly upon the mental origin of what he has aptly called the Credit Cycle.

The peculiar interest of Dr. Hyde Clarke's speculations consists in the fact that he not only remarked the cycle of ten or eleven years, but sought to explain it as due to physical causes, although he had not succeeded in discovering any similar astronomical or meteorological variation with which to connect it. Writing as he did in 1838 and 1847, this failure is not to be wondered at. His supposed period of fifty-four years is perhaps deserving of further investigation, but it is with his period of ten or eleven years that we are now concerned.

My own inquiries into this interesting subject naturally fall much posterior to those of Dr. Clarke; but, about the year 1862, I prepared two elaborate statistical diagrams, one of which exhibited in a single sheet all the accounts of the Bank of England since 1844, while the other embraced all the monthly statements I could procure of the price of corn, state of the funds, rate of discount, and number of bankruptcies in England from the year 1731 onwards. Subsequent study of these diagrams produced upon my mind a deep conviction that the events of 1815, 1825, 1836-39, 1847, and 1857, exhibited a true but mysterious periodicity. There was no appearance, indeed, of like periodicity in the earlier parts of my second diagram. In the first fifteen years of this century statistical numbers were thrown into confusion by the great wars, the suspension of specie payments, and the frequent extremely high prices of corn. It must be allowed, moreover, that the statistical diagram, so far as concerns the eighteenth century, presents no appreciable trace of decennial periodicity. The recent continual discussions concerning the solar or sun-spot period much increased the interest of this matter, and in 1875 I made a laborious reduction of the data contained in Prof. Thorold Rogers' admirable "History of Agriculture and Prices in England from the Year 1259." I then believed that I had discovered the solar period in the prices of corn and various agricultural commodities, and I accordingly read a paper to that effect at the British Association at Bristol. Subsequent inquiry, however, seemed to show that periods of three, five, seven, nine, or even thirteen years would agree with Prof. Rogers' data just as well as a period of eleven years; in disgust at this result I withdrew the paper from further publication. I should like, however, to be now allowed to quote the following passage from the MS. of the paper in question:—

"Before concluding I will throw out a surmise, which, though it is a mere surmise, seems worth making. It is now pretty generally allowed that the fluctuations of the money market, though often apparently due to exceptional and accidental events, such as wars, great commercial failures, unfounded panics, and so forth, yet do exhibit a remarkable tendency to recur at intervals approximating to ten or eleven years. Thus the principal commmercial crises have happened in the years 1825, 1836-9, 1847, 1857, 1866, and I was almost adding 1879, so convinced do I feel that there will, within the next few years, be another great crisis. Now if there should be in or about the year 1879, a great collapse comparable with those of the years mentioned, there will have been five such occurrences in fifty-four years, giving almost exactly eleven years (10·8) as the average interval, which sufficiently approximates to 11·1, the supposed exact length of the sun-spot period, to warrant speculations as to their possible connection."

I was led to assign the then coming (that is, the now present) crisis to the year 1879, because 11·1 years added twice over to 1857, the date of the last perfectly normal crisis, or to 1847, the date of the previous one, brings the calculator to 1879. If I could have employed instead Mr. J. A. Broun's since published estimate of the sun-spot period, to be presently mentioned, namely, 10·45 years, I should have come exactly to the present year 1878. My mistake of one year was due to the meteorologists' mistake of eight months, which, as crises usually happen in October and November, was sufficient to throw the estimate of the event into the next twelvemonths.

While writing my 1875 paper for the British Association, I was much embarrassed by the fact that the commercial fluctuations could with difficulty be reconciled with a period of 11·1 years. If, indeed, we start from 1825, and add 11·1 years time after time, we get 1836·1, 1847·2, 1858·3, 1869·4, 1880·5, which show a gradually increasing discrepancy from 1837, 1847, 1857, 1866 (and now 1878), the true dates of the crises. To explain this discrepancy I went so far as to form the rather fanciful hypothesis that the commercial world might be a body so mentally constituted, as Mr. John Mills must hold, as to be capable of vibrating in a period of ten years, so that it would every now and then be thrown into oscillation by physical causes having a period of eleven years. The subsequent publication, however, of Mr. J. A. Broun's inquiries, tending to show that the solar period is 10·45 years, not 11·1,[1] placed the matter in a very different light, and removed the difficulties. Thus, if we take Mr. John Mills' "Synopsis of Commercial Panics in the Present Century," and, rejecting 1866 as an instance of a premature panic, count from 1815 to 1857, we find that four credit cycles occupy forty-two years, giving an average duration of 10·5 years, which is a remarkably close approximation to Mr. Broun's solar period. Thus encouraged, it at last occurred to me to look back into the previous century, where facts of a strongly confirmatory character at once presented themselves. Not only was there a great panic in 1793, as Dr. Hyde Clarke remarked, but there were very distinct events of a similar nature in the years 1783, 1772–3, and 1763. About these dates there can be no question, for they may all be found clearly stated on pp. 627 and 628 of the first volume of Mr. Macleod's unfinished "Dictionary of Political Economy." Mr. Macleod gives a concise, but, I believe, correct account of these events, and as he seems to entertain no theory of periodicity, his evidence is perfectly unbiased. Yet, in the space of a few lines, he unconsciously states this periodicity, saying:—"Ten years after the preceding crisis of 1763 another of a very severe nature took place in 1772 and the beginning of 1773. It extended over all the trading nations of Europe." A few lines below he goes on to state that in May, 1783, a rapid drain of bullion to the Continent set in, which greatly alarmed the Bank directors and embarrassed the merchants. The

[1] It is reprinted in the *Transactions* of the same Society for 1875-76.

[1] NATURE, vol. xvi. p. 63.

paragraph in which this occurs is headed "The Crisis of 1783," and on turning the page we at once come on another paragraph headed "The Crisis of 1793." Here then we have, in a few lines of a good authority concerning the history of finance, a statement of four crises occurring at almost exactly decennial intervals. It is wonderful that no writer has, so far as I know, previously pointed out the strictly periodic nature of these events; and I may add that I have several times lectured to my college classes about these crises without remarking their periodicity. It is true that we cannot, by any management of the figures, bring them into co-ordination with later crises so long as we adhere to the former estimate of the solar period. If, starting from 1857, we count back nine intervals of 11·1 years each, we get to 1757 instead of 1763; we are landed in the middle of a cycle instead of in the beginning or end; and there can be no possible doubt about the crises of 1763 and 1857. But, if we are once allowed to substitute the new estimate of Broun, which is the same as the old one of Lamont, the difficulty disappears; for the average interval is 10·44 . . . years!

This beautiful coincidence led me to look still further backwards, and to form the apparently wild notion that the great crisis generally known as that of the South Sea Bubble might not be an isolated and casual event, but only an early and remarkable manifestation of the commercial cycle. The South Sea Bubble is generally set down to the year 1720, and the speculations in the shares of that company did attain their climax and commence their collapse in that year. But it is perfectly well known to the historians of commerce that the general collapse of trade which profoundly affected all the more advanced European nations, especially the Dutch, French, and English, occurred in 1721. Now, if we assume that there have been since 1721, up to 1857, thirteen commercial cycles, the average interval comes out 10·46 years; or if we consider that we are in this very month (November, 1878) passing through a normal crisis, then the interval of 157 years from 1721 to 1878 gives an average cycle of 10·466 years.

It would be impossible, however, to enlist the South-Sea Bubble in our series unless there were some links to connect it with subsequent events. I have, therefore, spent much labour during the past summer in a most tedious and discouraging search among the pamphlets, magazines, and newspapers of the period, with a view to discover other decennial crises. I am free to confess that in this search I have been thoroughly biased in favour of a theory, and that the evidence which I have so far found would have no weight if standing by itself. It is impossible in this place to state properly the facts which I possess; I can only briefly mention what I hope to establish by future more thorough inquiry.

It is remarkable to notice that the South Sea Company, which came to grief in 1720-21, was founded in 1711, just ten years before, and that on the very page (312) of Mr. Fox Bourne's "Romance of Trade,"[1] which mentions this fact, the year 1701 also occurs in connection with speculation and *stock-jobbing*, as the promotion of companies was then called. The occurrence of a crisis in the years 1710-11-12, is indeed almost established by the lists of bubble insurance companies formed in those years, as collected by Mr. Cornelius Walford, and obligingly shown to me by him.[2]

Again, it is quite plain that about ten years after stock-jobbing had been crushed by the crisis of 1721, it reared its head again. A significant passage in the *Gentleman's Magazine* of 1732 (vol. ii. p. 561) remarks that "Stock-jobbing is grown almost epidemical. Fraud, corruption, and iniquity in great companies as much require speedy and effectual remedies now as in 1720. The scarcity of money and stagnation of trade in all the distant parts of England, is a proof that too much of our current coin is got into the hands of a few persons." This "getting the current coins into the hands of a few people" was the favourite theory at that time to explain any slackness of trade, just as now over-production is the theme of every short-sighted politician. But the legislature of that day thought they could remedy these things in a drastic manner, so they passed in 1734 "An Act to prevent the infamous practice of stock-jobbing." Mr. Walford, who has inquired into the commercial history of this time far more minutely than any other writer, remarks[1] that "gambling in stocks and funds had broken out with considerable fervour again during the few years preceding 1734. It was the first symptom of recovery from the events of 1720."

I may add that there was in 1732 a great collapse of a society called the "Charitable Corporation for Relief of the Industrious Poor." A great many people were ruined by the unexpected deficit discovered in the funds of this kind of bank, and Parliament and the public were asked to assist the sufferers, just as they might now be asked to aid the shareholders of the City of Glasgow Bank. Thus does history repeat itself!

Whether it was that the act of 1734 really did diminish the infamous practice of stock-jobbing, or, whether the sun-spots manifested less variation than usual, it is clear that between 1732 and 1763 it is very difficult to discover anything approaching a mania or crisis. My learned and obliging correspondents at Amsterdam and Leiden, Drs. S. and W. Vissering, disclaim any knowledge of such events in the trade of Holland at that time, and my own diagram, showing the monthly bankruptcies throughout the interval, displays a flatness of a thoroughly discouraging character. Nevertheless, inquiry leads me to believe that although there really was nothing to call a crisis, mania, or panic, yet there were remarkable variations in the activity of trade and the prices of some staple commodities, such as wool and tin, sufficient to connect the earlier with the later periods. It is a matter of much regret that I have hitherto been quite unable to discover a connected series of price-lists of commodities of the early part of last century. The accounts of prices of goods at Greenwich Hospital, to be found in several statistical works, are not only incomplete, but probably misleading. Any reader of this article who can point out to me series of prices of metals or other commodities, not merely agricultural, before 1782, will confer a very great obligation upon me by doing so.

Deferring, however, for the present, any minuter inquiry, I permit myself to assume that there were about the years 1742 and 1752 fluctuations of trade which connect the undoubted decennial series of 1711, 1721, and 1732, with that commencing again in the most unquestionable manner in 1763. Thus the whole series of decennial crises may be stated as follows: (1701?), 1711, 1721, 1731-32, (1742? 1752?), 1763, 1772-73, 1783, 1793, (1804-5?), 1815, 1825, 1836-39 (1837 in the United States), 1847, 1857, 1866, 1878. A series of this sort is not, like a chain, as weak as its weakest part; on the contrary, the strong parts add strength to the weak parts. In spite, therefore, of the doubtful existence of some of the crises, as marked in the list, I can entertain no doubt whatever that the principal commercial crises do fall into a series having the average period of about 10·466 years. Moreover, the almost perfect coincidence of this period with Broun's estimate of the sun-spot period (10·45) is by itself strong evidence that the phenomena are causally connected. The exact nature of the connection cannot at present be established. As we have seen, Hyde Clarke, Wilson, and Danson all argued, some thirty or forty years ago, that commercial fluctuations must be

[1] This book contains an interesting account of some of these early manias and panics.

[2] These lists are partly published in Mr. Walford's "Insurance Cyclopædia," article Gambling.

[1] "Insurance Cyclopædia," art. Gambling.

governed by physical causes. But here we are embarrassed by the fact that no inquirer has been able to discover a clear periodic variation in the price of corn. This is what Sir William Herschel attempted to do, at the beginning of this century, in his truly prophetic inquiry about the economic effects of the sun-spots; but his facts are evidently too few to justify any sure inference. Carrington also compared the sun-spot curve with that of the price of corn, without detecting any coincidence; and my own repeated inquiries have been equally without result as to this point. The fact is, I believe, that cereal crops, as grown and gathered in Europe, depend for their success upon very complicated conditions, so that the solar influence is disguised. But it does not follow that other crops in other latitudes may not manifest the decennial period. Dr. Schuster[1] has pointed out a coincidence between good vintages and minima of sun-spots which can hardly be due to accident, and the whole controversy about the connection of Indian famines with the sun-spot period is of course familiar to all readers of NATURE. Now if we may assume Dr. Hunter's famine theory to be true there is little difficulty in explaining the remarkable series of periodic crises which I have pointed out.

The trade of Western Europe has always been strongly affected by communication with the Indies. Several of the crises are distinctly traceable to this cause, especially those at the beginning of the eighteenth century. That was a time of wild enterprise in the tropical regions, as the very names of the South Sea Company, the Mississippi scheme, the Darien project, &c., show. The Dutch, English, and French East India Companies were then potent bodies, the constant subject of legislation and controversy. Thus it is my present belief that to trade with India, China, and probably other parts of the tropical and semi-tropical regions, we must attribute the principal fluctuations in European commerce. Surely there is nothing absurd in such a theory when we remember that the present crisis is at least partly due to the involvement of the City of Glasgow Bank in the India trade, through the medium of some of their chief debtors. Thus the crisis of 1878 is clearly connected with the recent famines in India and China, and these famines are confidently attributed to solar disturbance.

To establish this view of the matter in a satisfactory manner, it would be desirable to show that there has been a decennial variation of trade with India during the 170 years under review. The complications and disturbances produced in the statistics of such a trade by various events are so considerable that I have not yet attempted to disentangle them properly. Yet the accounts of the merchandise (not including bullion) exported by the English East India Company between the years 1708–9 and 1733–34 display such a wonderful tendency to decennial variation, that I cannot refrain from quoting them. As stated by Milburn in vol. i. p. xlviii. of his "Oriental Commerce," they are as given in the following table, except that I have struck off three places of figures useless for our purposes :—

Values of Merchandise Exported to India

Years.	£1000	Years.	£1000
1708–9	162	1721–22	148
1709–10	161	1722–23	135
1710–11	201	1723–24	118
1711–12	162	1724–25	97
1712–13	109	1725–26	80
1713–14	85	1726–27	77
1714–15	79	1727–28	101
1715–16	61	1728–29	102
1716–17	69	1729–30	135
1717–18	88	1730–31	137
1718–19	107	1731–32	150
1719–20	134	1732–33	105
1720–21	122	1733–34	140

[1] NATURE, vol. xvi., p. 45.

In the above table there are three well-marked maxima in 1710–11, 1721–22, and 1731–32 at intervals closely approximating to that of the sun-spot curve. I believe that there are some traces of the same decennial variation in subsequent portions of the same tables. The fact that this variation is difficult to trace may possibly explain the absence of any serious crises in 1742 and 1752.

Probably, however, we ought not to attribute the decennial fluctuation wholly to Indian trade. It is quite possible that tropical Africa, America, the West Indies, and even the Levant are affected by the same meteorological influences which occasion the famines in India. Thus it is the nations which trade most largely to those parts of the world, *and which give long credits to their customers*, which suffer most from these crises. Holland was most easily affected a century ago; England is most deeply affected now; France usually participates, together with some of the German trading towns. But I am not aware that these decennial crises extend in equal severity to such countries as Austria, Hungary, Switzerland, Italy, and Russia, which have comparatively little foreign trade. Even when they are affected, it may be indirectly through sympathy with the great commercial nations.

There is nothing in this theory inconsistent with the fact that crises and panics arise from other than meteorological causes. There was a great political crisis in 1798, a great commercial collapse in 1810-11 (which will not fall into the decennial series); there was a Stock Exchange panic in 1859; and the great American collapse of 1873-75. There have also been several minor disturbances in the money market, such as those of February, 1861, May and September, 1864, August, 1870, November, 1873; but they are probably due to exceptional and disconnected reasons. Moreover, they have seldom, if ever, the intensity, profundity, and wide extension of the true decennial crises.

If it were permitted to draw any immediate conclusion from these speculations, I should point to the necessity of at once undertaking direct observations upon the varying power and character of the sun's rays. There are hundreds of meteorological observatories registering, at every hour of the day and night, the most minute facts about the atmosphere; but that very influence, upon which all atmospheric changes ultimately depend, *the solar radiation*, is not, I believe, measured in any one of them, at least in the proper manner.[1] Pouillet showed long ago (1838) how the absolute heating power of the sun's rays might be accurately determined by his Pyrheliometer. This instrument, and the results which he drew from its use, are fully described in his "Éléments de Physique Expérimentale et de Météorologie" (livre 8me, chap. i., section 285). But I have never heard that his experiments have been repeated, except so far as this may have been done by Sir John Herschel, with his so-called Actinometer, as described by him in the Admiralty Manual of Scientific Inquiry. I fancy that physicists still depend upon Pouillet's observations in 1837 and 1838 for one of the most important constants of the solar system, if constant it can be called. While astronomers agitate themselves and spend infinite labour about the two-hundredth planetoid, or some imperceptible satellite, the very fountain of heat and light and life is left unmeasured. Pouillet indeed assumed that the heating power of the sun's rays is a constant quantity, which accounts for his not continuing the solar observations. But, if there is any truth in all these sun-spot speculations, there must be a periodic variation in the sun's rays, of which the sun-spots are a mere sign, and perhaps an unsatisfactory one. It is possible that the real variations are more regular than the sun-spot indications, and thus perhaps may be explained the curious fact that the decennial crises recur more regu-

[1] Of course there have been abundance of black-bulb thermometer observations made in various parts of the world, but I doubt whether they are of much value.

larly on the whole than the maxima and minima of sun-spots.

But why do we beat about the bush when all that is needed is half-a-dozen of Pouillet's pyrheliometers with skilled observers, who will seize every clear day to determine directly the heating power of the sun? Why do we not go direct to the Great Luminary himself, and ask him plainly whether he varies or not? If he answers No! then some of us must reconsider our theories, and perhaps endure a little ridicule. But if, as is much more probable, he should answer Yes! then the time will come when the most important news in the *Times* will be the usual cablegram of the solar power. Solar observatories ought to be established on the table-lands of Quito or Cuzco, in Cashmere, in Piazzi Smyth's observatory on the Peak of Teneriffe, in Central Australia, or wherever else the sun can be observed most free from atmospheric opacity. An empire on which the sun never sets, and whose commerce pervades every port and creek of the sunny south, cannot wisely neglect to keep a watch on the great fountain of energy. From that sun, which is truly "of this great world both eye and soul," we derive our strength and our weakness, our success and our failure, our elation in commercial mania, and our despondency and ruin in commercial collapse.

W. STANLEY JEVONS

THE WERDERMANN ELECTRIC LIGHT

WE are able this week to give some further details concerning Mr. Werdermann's method of dividing the electric light.

The real difficulty was found in devising a form of *light* which *could* be divided into several, and still give enough illuminating power for practical use; and it is in this particular that Mr. Werdermann has apparently succeeded. It may be interesting here to state Mr. Werdermann's reasons for adopting this particular form of lighting.

When in an electric lamp, electrodes having the same sectional area are used, the changes at the points between which the voltaic arc passes, take place in a manner which is well known, viz., a crater or hollow is formed in the positive electrode which emits the light, the crater itself being heated by the current to white heat, and the surrounding part to redness. The negative electrode which assumes the form of a cone, is only heated to redness, and emits scarcely any light.

It was found that an increase in the sectional area of the positive electrode diminishes the light emitted by that electrode, and if the increase is continued gradually, the light on that electrode finally disappears entirely, whereas the heating effect upon the negative electrode in connection therewith increases, until finally light is emitted by the same. Again, by increasing the sectional area of the negative electrode, the heating effect upon the same decreases proportionally to the increase of its area, until the area having been sufficiently increased the heat almost entirely disappears, and consequently the consumption or wearing away of that electrode is scarcely appreciable.

The light given out by the positive electrode in connection therewith, on the contrary, increases in proportion to the difference existing between the sectional area of the two electrodes, and instead of a crater being formed in the positive carbon, the latter assumes the form of a cone as formerly was the case with the negative carbon. The greater the difference between the areas of the two carbons the shorter is the length of the voltaic arc which can be obtained between them, and when the area of the positive is gradually diminished and that of the negative increased, the light is produced by the carbons apparently in contact, and a small deposit of graphite is seen on the negative electrode. The section of this deposit is about $\frac{1}{4}$ that of the positive carbon itself, and it is about $\frac{1}{8}$ of an inch high.

Mr. Werdermann was led to make these experiments by the idea that perhaps by altering the sectional area of the carbons a similar effect might be produced to that which is obtained in electrolysis when a plate is used as one electrode and a small wire at the other, and from the

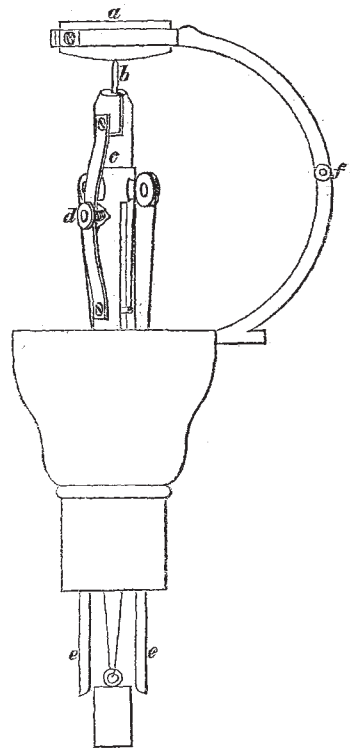

FIG. 1.

results obtained he devised his present system of electric lighting.

His lamp is constructed in the following manner:—

He places the negative carbon which is in the form of a disc 2 inches in diameter, and about 1 inch thick, uppermost. This carbon is clasped all round by a copper band which is prolonged to the terminal to which one of the leading cables is attached. The lower or positive electrode is a small pencil of carbon 3 millimetres in

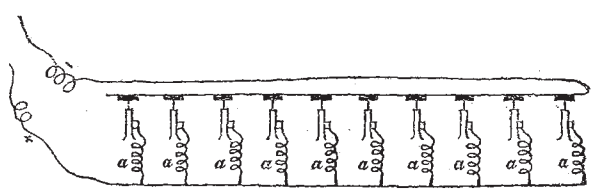

FIG. 2.

diameter, and can be made of any suitable length. This slides up vertically in a tube placed directly underneath the disc. This tube guides the pencil and also forms a contact for it, the top of the tube being solid copper in two pieces, one being rigid and the other pressing against the carbon by means of a regulating spring. The carbon pencil protrudes above the tube about $\frac{3}{4}$ of an inch, and touches the negative disc, and this length when the current passes is made incandescent.