again, losing much time, and being very unhappy if he was unable to get home to make himself neat, and to go with his parents to their place of worship."

In after life the remembrance of his earliest occupation was often brought to his mind: One of his nieces says that he rarely saw a newspaper boy without making some kind remark about him. Another niece recalls his words on one occasion: "I always feel a tenderness for those boys because I once carried newspapers myself."

Faraday's indentures as an apprentice are dated October 7, 1805: one line in them is worthy to be kept—"In consideration of his faithful service no premium is given." . . .

Faraday himself says, [in speaking of his early efforts to obtain knowledge]: "Whilst an apprentice I loved to read the scientific books which were under my hands, and, amongst them, delighted in Marcet's *'Conversations in Chemistry,'* and the electrical treatise in the *'Encyclopædia Britannica.'* I made such simple experiments in chemistry as could be defrayed in their expense by a few pence per week, and also constructed an electrical machine, first with a glass phial, and afterwards with a real cylinder, as well as other electrical apparatus of a corresponding kind." He told a friend that Watts *"On the Mind"* first made him think, and that his attention was turned to science by the article *"Electricity"* in an encyclopædia he was employed to bind.

"My master," he says, "allowed me to go occasionally of an evening to hear the lectures delivered by Mr. Tatum on natural philosophy at his house, 53 Dorset Street, Fleet Street. I obtained a knowledge of these lectures by

bills in the streets and shop-windows near his house. The hour was eight o'clock in the evening. The charge was one shilling per lecture, and my brother Robert (who was three years older and followed his father's business) made me a present of the money for several. I attended twelve or thirteen lectures between February 19, 1810, and September 26, 1811. It was at these lectures I first became acquainted with Magrath, Newton, Nicol, and others."—DR. BENCE JONES, *in "The Life and Letters of Faraday."*

FARADAY'S EARLY THOUGHTFULNESS

In his earliest note-book Faraday wrote down the names of the books and subjects that interested him: this he called *"The Philosophical Miscellany,"* being a collection of notices, occurrences, events, etc., relating to the arts and sciences, collected from the public papers, reviews, magazines, and other miscellaneous works; intended," he says, "to promote both amusement and instruction, and also to corroborate or invalidate those theories which are continually starting into the world of science. Collected by M. Faraday, 1809-10."—DR. BENCE JONES.

A DAY WITH FARADAY IN THE ROYAL INSTITUTION

Let us watch him on an ordinary day. After eight hours' sleep, he rises in time to breakfast at eight o'clock, goes round the Institution to see that all is in order, and descends into the laboratory, puts on a large white apron full of holes, and is busy among his pieces of apparatus. The faithful Anderson, an old soldier, who always did exactly what he was told, and nothing more, is waiting

have ever since been most zealous in using it to the best advantage."

The peculiarity of his mind was indeed well known to himself. In a letter to Dr. Becker he says: "I was never able to make a fact my own without seeing it; and the descriptions of the best works altogether failed to convey to my mind such a knowledge of things as to allow myself to form a judgment upon them. It was so with *new things*. If Grove, or Wheatstone, or Gassiot, or any other told me a new fact, and wanted my opinion either of its value, or the cause, or the evidence it could give on any subject, I never could say anything until I had seen the fact. For the same reason I never could work, as some professors do most extensively, by students or pupils. All the work had to be my own."—Dr. J. H. Gladstone.

FARADAY'S WONDERFUL ACCURACY AS A PHYSICIST

"The thing I am proudest of, is that I have never been found to be wrong." This Faraday could say in the early part of his scientific history without fear of contradiction. After his death, Professor Auguste de la Rive wrote, "I do not think that Faraday has once been caught in a mistake; so precise and conscientious was his mode of experimenting and observing." This is not absolutely true; but the extreme rarity of Faraday's mistakes, notwithstanding the immense amount of his published researches, is one of those marvels which can be appreciated only by those who are in the habit of describing what they have seen in the mist land that lies beyond the boundaries of previous knowledge.—Dr. J. H. Gladstone.

FARADAY'S INTEREST IN THE PHYSICAL UNKNOWN

Into this unknown region [the region beyond ascertained knowledge] Faraday's mental vision was ever stretched. "I well remember one day," writes Mr. Barrett, a former assistant at the Royal Institution, "when as Mr. Faraday was by my side, I happened to be steadying, by means of a magnet, the motion of a magnetic needle under a glass shade. Mr. Faraday suddenly looked most impressively and earnestly as he said, 'How wonderful and mysterious is that power you have there! the more I think over it, the less I seem to know:'"—and yet he who said this knew more of it than any living man. —Dr. J. H. Gladstone.

FARADAY AND THE MATHEMATICIANS

The work of Michael Faraday introduced a new era in the history of physical science. Unencumbered by pre-existing theories, and untrammeled by the methods of the mathematician, he set forth on a line of his own; and, while engaged in the highest branches of experimental research, he sought to explain his results by reference to the most elementary mechanical principles only. Hence it was that those conclusions which had been obtained by mathematicians only by the help of advanced analytical methods, and which were expressed by them only in the language of the integral calculus, Faraday achieved without any such artificial aids to thought, and expressed in simple language, having reference to the mechanism which he conceived to be the means by which such results

were brought about. For a long time Faraday's methods were regarded by mathematicians with something more than suspicion; and, while they could not but admire his experimental skill, and were compelled to admit the accuracy of his conclusions, his mode of thought differed too widely from that to which they were accustomed, to command their assent. In Sir William Thomson, and in Clerk Maxwell, Faraday at length found interpreters between him and the mathematical world; and to the mathematician perhaps the greatest monument of the genius of Faraday is the *"Electricity and Magnetism"* of Clerk Maxwell.—WILLIAM GARNETT, M. A., D. C. L., *in "Heroes of Science—Physicists."*

FARADAY'S SENSE OF ORDER AND TENACITY OF PURPOSE

A family tradition exists that the Faradays came originally from Ireland. Faraday himself has more than once expressed to me his belief that his blood was in part Celtic, but how much of it was so, or when the infusion took place, he was unable to say. He could imitate the Irish brogue, and his wonderful vivacity may have been in part due to his extraction. But there were other qualities which we should hardly think of deriving from Ireland. The most prominent of these was his sense of order, which ran like a luminous beam through all the transactions of his life. The most entangled and complicated matters fell into harmony in his hands. His mode of keeping accounts excited the admiration of the managing board of this Institution [the Royal]. And his science was similarly ordered. In his *"Experimental Researches,"* he numbered every paragraph, and welded their various parts

together by incessant reference. His private notes of the *"Experimental Researches,"* which are happily preserved, are similarly numbered: their last paragraph bears the figure 16,041. His working qualities, moreover, showed the tenacity of the Teuton. His nature was impulsive, but there was a force behind the impulse which did not permit it to retreat. If in his warm moments he formed a resolution, in his cool ones he made that resolution good. Thus his fire was that of a solid combustible, not that of a gas, which blazes suddenly, and dies as suddenly away.—PROFESSOR TYNDALL.

FARADAY'S APPRECIATION OF LOVE AND SYMPATHY

Faraday prized the love and sympathy of men—prized it almost more than the renown which his science brought him. Nearly a dozen years ago it fell to my lot to write a review of his *"Experimental Researches"* for the *"Philosophical Magazine."* After he had read it, he took me by the hand, and said, "Tyndall, the sweetest reward of my work is the sympathy and good will which it has caused to flow in upon me from all quarters of the world." Among his letters I find little sparks of kindness, precious to no one but myself, but more precious to me than all. He would peep into the laboratory when he thought me weary, and take me up stairs with him to rest. And if I happened to be absent he would leave a little note for me, couched in this or some other similar form:—"Dear Tyndall—I was looking for you, because we were at tea—we have not yet done—will you come up?" I frequently shared his early dinner; almost always, in fact, while my lectures were going on. There was no trace

of asceticism in his nature. He preferred the meat and wine of life to its locusts and wild honey. Never once during an intimacy of fifteen years did he mention religion to me, save when I drew him on to the subject. He then spoke to me without hesitation or reluctance; not with any apparent desire to "improve the occasion," but to give me such information as I sought. He believed the human heart to be swayed by a power to which science or logic opened no approach; and right or wrong, this faith, held in perfect tolerance of the faiths of others, strengthened and beautified his life.—PROFESSOR TYNDALL.

FARADAY'S OVERWORK AND ITS CONSEQUENCES

Faraday was now [about 1840] feeling the effects of the mental strain to which he had been subjected for so many years. During these years he repeatedly broke down. His wife alone witnessed the extent of his prostration, and to her loving care we, and the world, are indebted for the enjoyment of his presence here so long. He found occasional relief in a theater. He frequently quitted London and went to Brighton and elsewhere, always choosing a situation which commanded a view of the sea, or of some other pleasant horizon, where he could sit and gaze and feel the gradual revival of the faith that

"Nature never did betray
The heart that loved her."

But very often for some days after his removal to the country, he would be unable to do more than sit at a window and look out upon the sea and sky.—PROFESSOR TYNDALL.

WEALTH VERSUS SCIENCE IN FARADAY'S CAREER

While once conversing with Faraday on science, in its relations to commerce and litigation, he said to me, that at a certain period of his career, he was forced definitely to ask himself, and finally to decide, whether he should make wealth or science the pursuit of his life. He could not serve both masters, and he was therefore compelled to choose between them. After the discovery of magneto-electricity his fame was so noised abroad, that the commercial world would hardly have considered any remuneration too high for the aid of abilities like his. Even before he became so famous, he had done a little "professional business." This was the phrase he applied to his purely commercial work. His friend, Richard Phillips, for example, had induced him to undertake a number of analyses, which produced, in the year 1830, an addition to his income of more than a thousand pounds; and in 1831, a still greater addition. He had only to will it to raise in 1832 his professional business income to £5,000 [$25,000] a year. Indeed, this is a wholly insufficient estimate of what he might, with ease, have realized annually during the last thirty years of his life.

While restudying the *"Experimental Researches"* with reference to the present memoir, the conversation with Faraday here alluded to came to my recollection, and I sought to ascertain the period when the question, "wealth or science," had presented itself with such emphasis to his mind. I fixed upon the year 1831 or 1832, for it seemed beyond the range of human power to pursue science as he had done during the subsequent years, and to pursue

upon him; and as thought flashes after thought through his eager—perhaps impatient—brain, he twists his wires into new shapes, and rearranges his magnets and batteries. Then some conclusion is arrived at which lights up his face with a gleam of satisfaction, but the next minute a doubt comes across that expressive brow,—may the results not be due to something else yet imperfectly conceived?—and a new experiment must be devised to answer that. In the meantime one of his little nieces has been left to his charge. She sits as quiet as a mouse with her needlework; but now and then he gives her a nod, or a kind word, and throwing a little piece of potassium on to a basin of water for her amusement, he shows her the metal bursting into purple flame, floating about in fiery eddies, and the crack of the fused globule of potash at the end. Presently there is handed to him the card of some foreign *savant,* who makes his pilgrimage to the famous Institution and its presiding genius; he puts down his last result on a slate, comes up stairs, and, disregarding the interruption, chats with his visitor with all cordiality and openness. Then to work again till dinner-time, at half-past two. In the afternoon he retires to his study with its plain furniture, and the india-rubber tree in the window, and writes a full letter of affection to some friend, after which he goes off to the council meeting of one of the learned bodies. Then back again to the laboratory, but as evening approaches he goes up stairs to his wife and niece, and then there is a game at bagatelle or acting charades; and afterwards he will read aloud from Shakespeare or Macaulay till it is time for supper and the simple family worship which now is not

liable to the interruptions that generally prevent it in the morning. And so the day closes.

Or, if it be a fine summer evening, he takes a stroll with his wife and the little girl to the Zoological Gardens, and looks at all the new arrivals, but especially the monkeys, laughing at their tricks till the tears run down his cheeks.—J. H. GLADSTONE, PH.D., F. R. S., *in "Michael Faraday."*

FARADAY IN THE PUBLIC LECTURE-ROOM

But suppose it is his night to lecture. The subject has been carefully considered, an outline of his discourse has been written on a sheet of foolscap, with all the experiments marked and numbered, and during the morning everything has been arranged on the table in such order that his memory is assisted by it. The audience now pours in, and soon occupies all the seats, so that late-comers must be content with sitting on the stairs or standing in the gangways, or at the back of the gallery. Faraday enters, and placing himself in the center of the horse-shoe table, perfect master of himself, his apparatus, and his audience, commences a discourse which few that are present will ever forget. Here is a picture by Lady Pollock:— "It was an irresistible eloquence, which compelled attention and insisted upon sympathy. It waked the young from their visions, and the old from their dreams. There was a gleaming in his eyes which no painter could copy, and which no poet could describe. Their radiance seemed to send a strange light into the very heart of his congregation; and when he spoke it was felt that the stir of his voice and the fervor of his

words could belong only to the owner of those kindling eyes. His thought was rapid and made itself a way in new phrases—if it found none ready made—as the mountaineer cuts steps in the most hazardous ascent with his own axe. His enthusiasm sometimes carried him to the point of ecstacy when he expatiated on the beauties of Nature, and when he lifted the veil from her deep mysteries. His body then took motion from his mind; his hair streamed out from his head; his hands were full of nervous action; his light, lithe body seemed to quiver with its eager life. His audience took fire with him, and every face was flushed. Whatever might be the afterthought or the after-pursuit, each hearer for the time shared his zeal and his delight."—Dr. J. H. Gladstone.

HOW FARADAY CAPTIVATED ALL HEARTS

We have heard much of Faraday's gentleness and sweetness and tenderness. It is all true; but it is very incomplete. You cannot resolve a powerful nature into these elements; and Faraday's character would have been less admirable than it was had it not embraced forces and tendencies to which the silky adjectives "gentle" and "tender" would by no means apply. Underneath his sweetness and gentleness was the heat of a volcano. He was a man of excitable and fiery nature; but through high self-discipline he had converted the fire into a central glow and motive-power of life, instead of permitting it to waste itself in useless passion. "He that is slow to anger," saith the sage, "is greater than the mighty, and he that ruleth his own spirit than he that taketh a city." Faraday was *not* slow to anger, but he completely ruled

his own spirit, and thus though he took no cities, he captivated all hearts.—Professor Tyndall, *in "Faraday as a Discoverer."*

FARADAY'S SIMPLEMINDEDNESS

When, in the course of writing this book, I have spoken to his acquaintances about Faraday, the most frequent comment has been in such words as "Oh! he was a beautiful character, and so simple-minded." I have tried to ascertain the cause of this simple-mindedness, and I believe it was the consciousness that he was meaning to do right himself, and the belief that others whom he addressed meant to do right too, and so he could just let them see everything that was passing through his mind. And while he knew no reason for concealment, there was no trace of self-conceit about him, nor any pretense at being what he was not.—Dr. J. H. Gladstone.

FARADAY'S METHODS OF ORDER AND EXACTNESS

The habit of Faraday was to think out carefully beforehand the subject on which he was working, and to plan his mode of attack. Then, if he saw that some new piece of apparatus was needed, he would describe it fully to the instrument-maker with a drawing, and it rarely happened that there was any need of alteration in executing the order. If, however, the means of experiment existed already, he would give Anderson [his attendant for nearly forty years] a written list of the things he would require, at least a day before—for Anderson was not to be hurried. When all was ready, he would descend

into the laboratory, give a quick glance round to see that all was right, take his apron from the drawer, and rub his hands together as he looked at the preparations made for his work. There must be no tool on the table but such as he required. As he began, his face would be exceedingly grave, and during the progress of an experiment all must be perfectly quiet; but if it was proceeding according to his wish, he would commence to hum a tune, and sometimes to rock himself sideways, balancing alternately on either foot. Then, too, he would often talk to his assistant about the result he was expecting. He would put away each tool in its own place as soon as done with, or at any rate when the day's work was over, and he would not unnecessarily take a thing away from its place: thus if he wanted a perforated cork, he would go to the drawer which contained the corks and cork-borers, make there what he wanted, replace the borers, and shut the drawer. No bottle was allowed to remain without its stopper; no open glass might stand for a night without a paper cover; no rubbish was to be left on the floor; bad smells were to be avoided if possible; and machinery in motion was not permitted to grate. In working, also, he was very careful not to employ more force than was wanted to produce the effect. When his experiments were finished and put away, he would leave the laboratory and think further about them up stairs.

This orderliness, and this economy of means, he not only practiced himself, but he expected them also to be followed by any who worked with him; and it is from conversation with these that I have been able to give this sketch of his manner of working.

This exactness was also apparent in the accounts which

he kept with the Royal Institution and Trinity House [a second great public institution—one that had the care of lighthouses, beacons, etc.—with which Faraday was connected for many years] in which he entered every little item of expenditure with the greatest minuteness of detail. —Dr. J. H. Gladstone.

FARADAY'S PECULIARITY OF MIND

As to the mental process that devised, directed, and interpreted his experiments, it must be borne in mind that Faraday was no mathematician; his power of appreciating an *a priori* reason often appeared comparatively weak. It has been stated on good authority that Faraday boasted on a certain occasion of having only once in the course of his life performed a mathematical calculation: that once being when he turned the handle of Babbage's calculating machine. Though there was more pleasantry than truth in this professed innocence of numbers, probably no one acquainted with his electrical researches will doubt that, had he possessed more mathematical ability, he would have been saved much trouble, and would sometimes have expressed his conclusions with greater ease and precision. Yet, as Sir William Thomson has remarked with reference to certain magnetic phenomena, "Faraday, without mathematics, divined the result of the mathematical investigation; and, what has proved of infinite value to the mathematicians themselves, he has given them an articulate language in which to express their results. Indeed, the whole language of the 'magnetic field,' and 'lines of force' is Faraday's. It must be said for the mathematicians that they greedily accepted it, and