Letters to the Editor.

PHENOMENA OF CURRENTS OF HIGH FREQUENCY.

I cannot pass without comment the note of Prof. Thomson in your issue of April 1, although I dislike very much to engage in a prolonged controversy. I would gladly let Prof. Thomson have the last word, were it not that some of his statements render a reply from me necessary.

I did not mean to imply that, whatever work Prof. Thomson has done in alternating currents of very high frequency, he had done subsequent to his letter published in the *Electrician*. I thought it possible, and even probable, that he had made his experiments some time before, and my statement in regard to this was meant in this general way. It is more than probable that quite a number of experimenters have built such machines and observed effects similar to those described by Prof. Thomson. It is doubtful, however, whether, in the absence of any publication on this subject, the luminous phenomena described by me have been observed by others, the more so, as very few would be likely to go to the trouble I did, and I would myself not have done so had I not had beforehand the firm conviction, gained from the study of the works of the most advanced thinkers, that I would obtain the results sought for. Now, that I have indicated the direction, many will probably follow, and for this very purpose I have shown some of the results I have reached.

Prof. Thomson states decisively in regard to experiments with the incandescent lamp bulb and the filament mounted on a single wire, that he cannot agree with me at all that conduction through the glass has anything to do with the phenomenon observed. He mentions the well-known fact that an incandescent lamp acts as a Leyden jar and says that "if conduction through the glass were a possibility this action could not occur." I think I may confidently assert that very few electricians will share this view. For the possibility of the condenser effect taking place it is only necessary that the rate at which the charges can equalize through the glass by conduction should be somewhat below the rate at which they are stored.

Prof. Thomson seems to think that conduction through the glass is an impossibility. Has he then never measured insulation resistance, and has he then not measured it by means of a conduction current? Does he think that there *is* such a thing as a perfect non-conductor among the bodies we are able to perceive? Does he *not* think that as regards conductivity there can be question only of degree? If glass were a perfect non-conductor, how could we account for the leakage of a glass condenser when subjected to steady differences of potential?

While not directly connected with the present controversy, I would here point out that there exists a popular error in regard to the properties of dielectric bodies. Many electricians frequently confound the theoretical dielectric of Maxwell with the dielectric bodies in use. They do not stop to think that the only perfect dielectric is ether, and that all other bodies, the existence of which is known to us, must be conductors, judging from their physical properties.

My statement that conduction is concerned to some, although perhaps negligible, extent in the experiment above described was, however, made not only on account of the fact that all bodies conduct more or less, but principally on account of the heating of the glass during the experiment. Prof. Thomson seems to overlook the fact that the insulating power of glass diminishes enormously with the increase in temperature, so much so, that melted glass is comparatively an excellent conductor. I have, moreover, stated in my first reply to Prof. Thomson in your issue of March 18, that the same experiment can be performed by means of an unvarying difference of potential. In this case it must be assumed that some such process as conduction through the glass takes place, and all the more as it is possible to show by experiment, that with a sufficiently high steady difference of potential, enough current can be passed through the glass of a condenser with mercury coating to light up a Geissler tube joined in series with the condenser. When the potential is alternating, the condenser action comes in and conduction becomes insignificant, and the more so, the greater the rate of alternation or change per unit of time. Nevertheless, in my opinion, conduction must always exist, especially if the glass is hot, though it may be negligible with very high frequencies.

Prof. Thomson states, further, that from his point of view I have misunderstood his statement about the limit of audition. He says that 10,000 to 20,000 alternations correspond to 5,000 to 10,000 complete waves of sound. In my first reply to Prof. Thomson's remarks (in your issue of March 18,) I avoided pointing out directly that Prof. Thomson was mistaken, but now I see no way out of it. Prof. Thomson will pardon me if I call his attention to the fact he seems to disregard, namely, that 10,000 to 20,000 alternations of current in an arc—which was the subject under discussion—do not mean 5,000 to 10,000, but 10,000 to 20,000 *complete waves of sound.*

He says that I have adopted or suggested as the limit of audition 10,000 waves per second, but I have neither adopted nor suggested it. Prof. Thomson states that I have been working with 5,000 to 10,000 complete waves, while I have nowhere made any such statement. He says that this would be working below the limit of audition, and cites as an argument that at the Central High School, in Philadelphia, he has heard 20,000 waves per second; but he wholly overlooks a point on which I have dwelt at some length, namely, that the limit of audition of an arc is something entirely different from the limit of audition in general.

Prof. Thomson further states, in reply to some of my views expressed in regard to the constant current machines that five or six years ago it occurred to him to try the construction of a dynamo for constant current, in which "the armature coils were of a highly efficient type, that is, of comparatively short wire length for the voltage and moving in a dense magnetic field." Exteriorly to the coils and to the field he had placed in the circuit of each coil an impedance coil which consisted of an iron core wound with a considerable length of wire and connected directly in circuit with the armature coil. He thus obtained, he thought, "the property of considerable self-induction along with efficient current generation." Prof. Thomson says he expected "that possibly the effects would be very much the same as those obtainable from the regularly constructed apparatus." But he was disappointed, he adds. With all the consideration due to Prof. Thomson, I would say that, to expect a good result from such a combination, was rather sanguine. Earth is not farther from Heaven than this arrangement is from one, in which there would be a length of wire, sufficient to give the same self-induction, wound on the armature and utilized to produce useful E. M. F., instead of doing just the opposite, let alone the loss in the iron cores. But it is, of course, only fair to remember that this experiment was performed five or six years ago, when even the foremost electricians lacked the necessary information in these and other matters.

Prof. Thomson seems to think that self-induction wipes out the periodical undulations of current. Now self-induction does not produce any such effect, but, *if* anything, it renders the undulation more pronounced. This is self-evident. Let us insert a self-induction coil in a circuit traversed by an undulating current and see what happens. During the period of the greatest rate of change, when the current has a small value, the self-induction opposes more than during the time of the small rate of change when the current is at, or near, its maximum value. The consequence is, that with the same frequency the maximum value of the current becomes the greater, the greater the self-induction. As the sound in a telephone depends only on the maximum value, it is clear that self-induction is the very thing required in a telephone circuit. The larger the self-induction, the louder and clearer the speech, provided the same current is passed through the circuit. I have had ample opportunity to study this subject during my telephone experience of several years. As regard the fact that a self-induction coil in series with a telephone diminishes the loudness of the sound, Prof. Thomson seems to overlook the fact that this effect is wholly due to the impedance of the coil, *i. e.*, to its property of diminishing the *current strength.* But while the current strength is diminished the undulation is rendered only more pronounced. Obviously, when comparisons are made they must be made with the same current.

In an arc machine, such as that of Prof. Thomson's, the effect is different. There, one has to deal with a make and break. There are then two induced currents, one in the opposite, the other in the same direction with the main current. If the function of the mechanism be the same whether a self-induction coil be present or not, the undulations could not possibly be wiped out. But Prof. Thomson seems, likewise, to forget that the effect is wholly due to the defect of the commutator; namely, the induced current of the break, which is of the same direction with the main current and of great intensity, when large self-induction is present, simply bridges the adjacent commutator segments, or, if not entirely so, at least shortens the interval during which the circuit is open and thus reduces the undulation.

In regard to the improvement in the feeding of the lamps by vibrations or undulations, Prof. Thomson expresses a decisive opinion. He now says that the vibrations *must* improve the feeding of a clock-work lamp. He says that I "contented myself by simply saying," that I cannot agree with him on that point.

Now, *saying it*, is not the only thing I did. I have passed many a night watching a lamp feed, and I leave it to any skilled experimenter to investigate whether my statements are correct. My opinion is, that a clock-work lamp, that is, a lamp in which the descent of the carbon is regulated not by a clutch or friction mechanism, but by an escapement, cannot feed any more perfectly than tooth by tooth, which may be a movement of, say, $\frac{1}{16}$ of an inch or less. Such a lamp will feed in nearly the same manner whether the current be perfectly smooth or undulating, providing the conditions of the circuit are otherwise stable. If there is any advantage, I think it would be in the use of a smooth current, for, with an undulating current, the lamp is likely to miss some time and feed by more than one tooth. But in a lamp in which the descent of the carbon is regulated by friction mechanism, an indulating current of the proper number of undulations per second will always give a better result. Of course, to realize fully the benefits of the undulating current the release ought to be effected independently of the up-and-down movement I have pointed out before.

In regard to the physiological effects, Prof. Thomson says, that in such a comparatively poor conductive material as animal tissue the distribution of current cannot be governed by self-induction to any appreciable extent, but he does not consider the two-fold effect of the large cross-section, pointed out by Sir William Thomson. As the resistance of the body to such currents is low, we must assume either condenser action or induction of currents in the body.

NIKOLA TESLA.

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Literature.

The Elements of Dynamic Electricity and Magnetism: By Philip Atkinson, A. M., Ph. D. New York: *D. Van Nostrand Co.*, 1891. 5x8 inches; 405 pages. Price, $2.

While there is no lack of books on the elements of electricity and magnetism, there has of late arisen a demand for a class of works which shall be adapted not only to the learner who desires to continue his studies with special reference to their future application in actual work, but also for that large class which has come to take a lively interest in electrical work, because it has been so forcibly brought to public attention during the last few years. A book to interest these learners and general readers, therefore, must present the subjects in their plainest dress, and must convey the facts through the medium of conclusive inductive reasoning rather than by the aid of formulæ. It is from this standpoint that the author has treated the subject matter contained in the book, which forms a companion work to that previously published, entitled "Elements of Static Electricity." In the present work the author has taken up the subject of dynamo electricity and magnetism, and very properly begins with definitions and a description of the voltaic battery. He describes the principal single and double fluid cells now in common use, and their method of operation. Two chapters on magnetism and electro-magnetism discuss the wide range of these phenomena. The author leads up from the natural magnet to the mariner's and surveyor's compass and gives one of the most complete short exposés of terrestrial magnetism that has come under our observation. He also discusses the form of magnets, and their polar attraction and repulsion. Passing on to electro-magnetism, we find a treatment of the laws governing the relation between currents carried in neighboring conductors and the effects of currents upon magnets and upon masses of iron. The author explains very clearly the simple rules by which all these phenomena may be remembered, and shows their application to the construction of the Ruhmkorff coil, which is described very fully.

Chapter VI is devoted to electric measurement. In it are described the various electrical units employed in practical electrical work, and this is followed by a description of the most generally employed testing instruments, among them the Thomson galvanometer, the Weston voltmeter, the Wirt voltmeter, the Cardew and others. The dynamo and motor are then taken up, and after a few short introductory paragraphs on the history of the dynamo, the author at once brings us to the types employed at the present time and their construction. This survey includes not only those of the well-known continuous current machines, but also the best known alternating current dynamos and motors. Thermo-magnetic motors are also touched upon here. Electrolysis and electric storage form the subject matter of the two following chapters, introduced by the theory of Grotthuss, which still seems to be the favorite one for text book purposes, and perhaps justly so. The application of the laws of electrolysis to electric storage is also pointed out, and the construction of the most recent types of secondary batteries is described and illustrated. The relations of electricity to heat form a chapter which will attract considerable interest as we find in it, besides the laws governing the generation of heat in conductors, a simple statement of electro-thermic phenomena and a description of the latest forms of the Thomson welding machine, and the results which have been obtained with it. The relation of electricity to light forms the subject matter of Chapter XI, in which the various phenomena of the effects of light on selenium are described, together with the magneto-optic polarization effects, and the various other photo-electric phenomena discovered by Becquerel, Kerr and others. The author then takes up the arc light and discusses its nature, and the most general types of lamps employed. This is followed by similar treatment of the incandescent lamp, in which connection the two and three wire systems of distribution are described. The telegraph and the telephone, to each of which a chapter is devoted, end the volume.

While we are not prepared to agree entirely with all the views expressed by the author, especially on points of theory, the present unsettled state of the latter might be easily made to account for divergences. If we may also be allowed to suggest, we think that the work in further editions, which will undoubtedly be called for, might be improved by a more rigid adherence to the classification of the subjects treated. The book has the undoubted merit of giving the latest information on the practical advances made, and does not burden the reader with a long and profitless review of what has been done during the last fifty years. The book is admirably printed and illustrated, and the author has evidently availed himself of the latest and best sources of information. We trust that the publishers will find their enterprise fully rewarded.

THE SWINBURNE TRANSFORMERS.

In my letter appearing in your last issue an error was made in the statement beginning: "In the communication from Mr. Swinburne a few days after the publishing of my article, Mr. Swinburne, etc." It should read as follows: "In a communication received from Messrs. Swinburne & Co. a few days after the publishing of my article, etc., they state that the leakage current in their transformers of 40 lights capacity is about 40 per cent.; allowing that this 40 per cent. is correct, the comparative leakage current in the open and closed types of transformers is approximately 10 to 1."

WM. STANLEY, JR.

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WHAT ARE THE LIMITS OF HIGH POTENTIAL TRANSMISSION?

IN another column we describe the tests which have recently been made to demonstrate the possibility of transmitting electrical energy between Lauffen and Frankfort, in which potentials of over 30,000 volts were employed. These experiments appeared to indicate the practical success of the system, but in a letter appearing in the *Elektrotechnische Zeitschrift*, August Schneller, of The Hague, Holland, draws attention to certain points, which, he claims, have not been fully considered. He writes as follows:

"In our technical papers, the power transmission project from Lauffen to Frankfort, on the occasion of the Frankfort Exhibition, has been the frequent object of discussion of late. Although in the carrying out of my experiments in the preparation of ozone, I have already had considerable experience with alternating currents up to 24,000 volts potential, I have up to now avoided taking part in this discussion. Since, however, this project has been seriously taken up and spoken of by his Excellency, Dr. Von Stephan, I have regarded it as my duty to testify to the enormous difficulties of transmitting power with 20,000 volts alternating current, which make its carrying out in practice impossible. The transmitted 300 h. p. may have at the primary transformer 30,000 volts and 6.2 amperes=186,000 watts. To obtain 30,000 volts by transformation in commercially practicable apparatus, so as to be safe, is indeed difficult, but under certain construction not impossible.

"The chief difficulty in the transmission of 30,000 volts lies not, however, in the fourfold transformation and the loss thereby entailed, nor in the transformers themselves, but in the outside conductors. With 6.2 amperes, with a copper wire of 5 mm. diameter, and with 350 kilometres of wire the drop in potential amounts to only 1,830 volts = 6.1 per cent.; but the other losses which the conductors are subject to have been entirely left out of account up to the present. For the overhead conductors telegraph poles are necessary, which ought not to be more than 50 metres apart, so that altogether there will be 3,500 telegraph poles, and 7,000 oil insulators. One insulator, even an oil insulator, has an average resistance of 1,000 megohms when measured with low potential battery current. For 7,000 insulators there may then be a resistance of 150,000 ohms; then there would be, at 30,000 volts, 0.2 ampere loss, which loss of 3.2 per cent., in such an important undertaking, may almost be neglected.

"Now, however, comes the principal point: The 'charging loss,' according to my measurements, for an air dry insulator at 15,000 volts, amount to 2.3 watts; at 20,000 volts to 4.7 watts, and at 30,000 volts might reach about 15 watts. In the 7,000 insulators then, in dry weather, there would be about 100,000 watts loss. The losses in foggy or rainy weather are still left quite out of the calculation. If we assume a distance between the parallel conductors of one metre, there results, at 30,000 volts potential, a loss of 0.15 watt per metre by silent discharge; hence, for 175 kilometres, a loss of 26,000 watts. Allowing an efficiency of 93 per cent. for the primary and secondary machines and 98 per cent. for the transformers at full load, the loss in the line 6.1 per cent., the insulation loss 3.2 per cent., the 'charging loss' on the insulators at 100,000 watts, and the silent discharge in 175 kilometres of parallel conductors at 26,000 watts, then we come to the conclusion that in dry weather, from the Lauffen plant of 300 h. p. we will get in Frankfort about 37 h. p.

"There must be taken into account still further, about 6,000 square metres of condensing surface of the conductors and insulators. I have measured the sparking distance with 20,000 volts alternating current at 100 reversals per second, without any condenser, and found it to be 46 mm.; and when a condenser of 15 sq. mm. surface was included, the sparking distance was more than 80 mm.; but how great the sparking distance is with 6,000 square metres of condensing surface, goes beyond my experience. On the basis of these truths it is easily seen that the whole project is a technical impossibility."