little instruction; but if one has some knowledge of electrical matters, he can easily determine how a rod ought to be put up. The most important points to be attended to are tight joints and a good earth connection at the bottom of the rod. The parts of the rod should be screwed together with couplings, as in water and steam pipes. A small iron water pipe would make a good lightning rod; so would a flat strip of iron one inch wide and 1-16 inch thick. There is no need to go to the expense of a copper rod. Iron is by many considered really better than copper. The grounding of the rod must be attended to with great care. The lower end of the rod *must* be in water or in moist earth. A plate of iron or a coil of the rod itself should be connected to the end of the rod to insure good contact between the rod and the earth. Rods should be carried up at all the corners of the building, and go to the peaks of the gables and along the ridges of the roof, up chimneys, pinnacles and towers, to all the highest points of the building, but there should not be high rods above the roof and chimneys, such as are very often seen in the older practice of putting up lightning rods. Lightning rods are not put up to invite the lightning to come down that way, but to take care of it, if it insists upon coming. Rods should be fastened to the metal of roofs, gutters, and leaders, and should not be insulated from the house by glass insulators as was formerly the universal method. Such insulation is useless, since a quarter inch of glass cannot hold back a discharge which has already jumped through perhaps a mile of air. Short points may be put upon the rod at all the higher parts of the building, not more than a foot above the building, but these are not necessary. The idea that a tall rod protects a certain area around its base is no longer considered true. The rod if solid should not be more than a half inch thick. If it is a tube it may weigh about as much per foot as if it were solid. Heavy telegraph wire if put up plentifully would be as serviceable as a rod. A building well netted over with such wire, better galvanized for durability, would be as thoroughly protected as with the most expensive rod. Remember that surface of metal is what is wanted in a rod rather than weight. In many respects a heavy rod is inferior to a light one of greater surface. Continuity of the metal is the most important feature. There must be no air gaps, no loose joints. It will thus be seen that a blacksmith with a little gumption is just as well able to do the work of making and putting up a rod as the best engineer. Much valuable information upon this subject has been printed each year in these columns. You should also have SUPPLEMENTS, Nos. 249, 348, and 998, price ten cents each. We append the rules given by Prof. S. P. Thompson as a summary of the modern views upon this subject. It will be noted that our advice given above differs slightly in some unimportant particulars from these rules. 1. All parts of a lightning conductor should be of one and the same metal, avoiding joints as far as possible, and with as few sharp bends and corners as may be. 2. The use of copper for lightning rods is a needless extravagance. Iron is far better. Ribbon is slightly better than round rod; but ordinary galvanized iron telegraph wire is good enough. 3. The conductor should terminate not merely at the highest point of a building, but be carried to all high points. It is unwise to erect very tall pointed rods projecting several feet above the roof. 4. A good deep *wet* earth should be provided, independent of gas or water pipes, to which the conductor should be led down. 5. If in any part the conductor goes near a gas or water pipe it is better to connect them metallically than to leave them apart. 6. In ordinary buildings the conductor should be insulated away from the walls, so as to lessen liability of lateral discharge to metal stoves and things inside the house. 7. Connect all external metal work, zinc spouts, iron crest ornaments and the like, to each other and to the earth, but not to the lightning conductor. 8. The cheapest way of protecting an ordinary house is to run common galvanized iron telegraph wire up all the corners, along all the ridges and eaves, and over all the chimneys, taking them down to the earth in several places to a moist stratum, and at each place burying a load of coke. 9. Over the tops of tall chimneys it is well to place a loop or arch of the lightning conductor made of any stout and durable metal. Any man of intelligence can put up a lightning rod or wire from these simple rules, and may then feel assured that he has done all that can be done to protect his home from a stroke of lightning.

(8301) F. R. M. asks: 1. When light rays cross each other or reflect back upon themselves as they are made to do in diagrams of images formed by lenses and mirrors, why do they not become mixed up and produce interference? A. They do not become mixed up, but do interfere when the reflection is at a suitable angle. It is in this way that the fact that light is due to a wave motion was demonstrated by Fresnel. These interferences cannot be seen in the open, but require a dark room and special arrangements. They can be seen by placing the hand over the eye so that you can look at a bright light, such as an open window will furnish in a clear day. You will then see innumerable dark lines in the space between two fingers, parallel to the fingers. These are interference lines. The waves do not become mixed up, because any number of sets of waves can pass at once through the same space as if no other wave were there. This is the case with water waves on a lake or the ocean. It is the case with sound waves. Two persons can talk at the same time in the same room and be heard by others. A whole orchestra can play at the same time and no jumble or mixture of the sound result. Perfect harmony will result. We see no reason why light waves which are not vibrations of ordinary matter, as these other vibrations are, should be mixed or confused by existing in the same space together. 2. When two moving shadows approach each other, why do they rush together just before they meet? A. We would try to explain this if we thought the question stated a fact. We do not think two shadows move any faster as they come near each other than they did when further apart. 3. Is it a fact that food will sour more quickly if put into a refrigerator while still quite warm? If so, please explain. A. We do not think so. The reason a hot dish should not be put into a refrigerator is that it heats the air and destroys the work the ice has already done. In the hot refrigerator food will then spoil. This is because the air of the refrigerator has been heated, and not because hot food was put in. 4. Why is it that milk sours in a thunderstorm? A. We do not know.

(8302) C. W. R. asks: Will you please refer me to some book describing fully transformers made to transform a two-phase to a three-phase current or *vice versa?* A. We presume you wish to find the plans from which you can make the transformer you require. We do not know any published plans of this sort. There are good books upon the theory of the transformer. Such is Kapp's, price $1.75 by mail; Adams's "Transformer Design," price $1.50 by mail. By the aid of these you might work out what you need.

(8303) F. W. writes: I have a small motor which runs a fair speed when using 4 volts and ¼ ampere. I would like to run the motor on a 110-volt light circuit. What size wire must I use on the field and armature? A. There is probably not room for the wire to rewind the motor for 110 volts. The better way is to put the motor in series with two 16-candle lamps. It will then get ¼ ampere and a few volts.

(8304) G. O. S. writes: During a thunder shower here it was said that some of the stitchers using sewing machines run by an electric motor connected to the shafting by a 10 or 15 foot leather belt experienced a sensation like that of one's feet going to sleep. Is it possible that they felt a slight shock? It is not dangerous to run the motor during a thunder shower, is it? The power is furnished by the Edison Company. A. Anything is possible with the lightning, but it is not apparent from your description that anything happened. The sensation may have been from electricity, and again it may have been from nervousness. No one can tell. A quiet mind would eliminate one cause of unpleasant sensation at such a time. No electric disturbance is likely to have passed from the Edison wires through a leather belt to the sewing machine. If the Edison wires are underground they are not likely to receive a lightning discharge. Aerial wires are very often struck by lightning, but when suitable lightning arresters are used there is little likelihood of the electricity of the lightning entering a building. If your installation is properly made there should not be any special risk at the sewing machines during a thunderstorm.

(8305) W. S. P. asks: 1. What are the modern works upon the telephone? I don't mean the working of an individual telephone, but the methods for connecting and working them. A. The best work upon this subject is Miller's "American Telephone Practice," price $3 by mail. It is very full and complete. Another important work is Hopkins's "Telephone Lines and Their Properties," price $1.50 by mail. With these two you have a very complete presentation of the whole subject. Of smaller books there are Webb's "Telephone Handbook," price $1, and Poole's "Practical Telephone Handbook," price $1.50 by mail. 2. What are the strengths of the several currents used in telephone work, say inside of New York city? (Not long-distance.) What strength suffices for ordinary speaking current? A. The current strength, of course, varies with the different transmitters. It is very minute with all. Prof. Cross, of Boston, by employing very delicate instruments and great refinement of method, reached the following results: The current in the secondary wire of the induction coil of the Edison transmitter, 0.072 milliampere; of the Blake transmitter, 0.132 milliampere; of the Hunnings transmitter, 0.556 milliampere. 3. What for the magneto-electric that rings the local call bell? A. Magneto call bells are wound to 300 to 500 ohms for local work; for bridged work much higher, to 10,000 ohms even. The E. M. F. of the magneto when run as ordinarily by hand is from 65 to 75 volts. As the current is alternating, the amperes are less than the quotient of the volts by the ohms; but at any rate the current strength is very small. We have no exact data upon the point.

(8306) L. A. F. asks: Is there an escape or loss of electric fluid if the electric light bulb or lamp is removed from its holder when the current is on? Will the meter register it? A. If a socket is in good condition there ought not to be any leakage when the lamp is removed. If, however, there is leakage the meter will register the current which is lost.

(8307) J. M. asks: 1. If a stone is dropped into the ocean at a very deep part, will the stone sink to the bottom or will it remain above the bottom and float in the water? I heard some people say that the pressure was so great that the stone could not sink. A. Anything which begins to sink in the water of the ocean will continue to sink till it reaches the bottom underneath it. The pressure is very great. At 24,000 feet it is four tons per square inch, and at the greatest depths of the ocean it is about five tons per square inch. This will compress any article which sinks to that depth very greatly and render it much heavier relatively to the water; but the water is not compressed to any degree by even that great pressure. So that the article which is sinking and being compressed is all the time growing heavier relatively to the water and will sink faster the farther it sinks. 2. Has a cannon on board of a man-of-war a device to make it rebound, or is the cannon fastened to the ship? A. The old method was to allow the gun to run back by its recoil so as to load it again. All modern guns are breechloaders and do not run back by their recoil. The force of the recoil is taken up by a liquid pressure, some liquid such as glycerine being used.

(8308) Farmer asks: Will you kindly tell me through your paper whether lightning rods secured to buildings with malleable iron brackets are a protection against lightning? It would appear to me that the rods should be insulated at all points where they come in contact or are secured to the building or they must be more dangerous than otherwise. A. Opinions differ upon this point. Equally good authorities are to be found upon both sides of the question. We are personally inclined to the opinion that a lightning rod may just as well be connected to the house directly as to use a glass insulator. Our reasons for this opinion are that the glass will be wet as soon as rain falls and its insulating value will be greatly reduced; and the electric discharge, which has already leaped through thousands of feet of air between the cloud and the earth, will not mind the few inches of air through which it must pass in going from the rod to the iron support of the rod around the insulator.

(8309) A. S. asks: How many units of heat for a stated weight of the metals sodium and potassium are evolved in passing to the condition of KOH and NaOH respectively? A. When one gramme of potassium combines with oxygen there are 1,745 units of heat produced. When one gramme of sodium combines with oxygen 3,293 units of heat are produced. We have no separate data for the change from the oxide to the hydrate.

(8310) J. C. M. writes: I have a son 15 years old who wants to learn all about electricity and electric instruments. You no doubt have such books on sale. I would like to have catalogues of them, with your recommendation of such as you think most suitable for him. He wants a *descriptive* and *practical* work— one that will give him complete instructions for making and repairing any *part* of any *kind* of electric or magnetic appliance. A. There is no work or set of books which can supply what is asked in this request. We presume the intention is to ask for books by means of which the lad can make a beginning of learning electricity. We can furnish Sloane's "Electrical Library" for $5 by mail. There are also separate books to be had upon making telephones, putting in electrical bells, etc. After these might come the building of a small dynamo or motor, the making of a galvanometer and induction coil. These can be found in Bottone's "Electrical Instrument Making for Amateurs," price 50 cents.

(8311) W. I. P. asks: Where can I get information on the subject of wave motion and the attempts to use it as a power? A. See SUPPLEMENTS, Nos. 536, 825, 861, price ten cents each, for articles describing various devices which have been employed to utilize the force of waves to do work.

(8312) H. R. asks: As to the electric motor described in "Experimental Science." Do you sell it or its parts? A. We do not sell any of the apparatus described in "Experimental Science" or the parts of any of it. The object of the book is to stimulate ingenious persons to "make things" by showing them how to proceed. This object it is accomplishing. There is no book so well adapted to help one to build suitable and sufficient apparatus for studying science within its limits as is this book.

(8313) F. R. asks: What book or paper gives information on the Marconi wireless telegraphy. I wish a description of instruments and operation of same. Can such instruments be made in an ordinary machine or model making shop. A. Fahie's "History of Wireless Telegraphy," price $2 by mail, gives descriptions of the various systems which have been invented, Marconi's among the rest. We have published several papers on the subject, but none which gives details of construction such as would enable a man to build a copy of the apparatus. Moreover, Mr. Marconi is changing his apparatus continually as the results of his experiments, and no description is up-to-date upon the subject. There is nothing about the apparatus which could not be built in any ordinary shop.

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