Overturning a Few of Our Most Confirmed Notions

The Illusion of the Axial Rotation of the Moon

THESE are amazing theories brought forward by Nikola Tesla in "The Electrical Experimenter" for February. The first of them smashes our venerable conception about the moon's rotation. Tesla declares:

"It is well known since the discovery of Galileo that the moon, in travelling through space, always turns the same face toward the earth. This is explained by stating that while passing once around its mother-planet the lunar globe performs just one revolution on its axis. The spinning motion of a heavenly body must necessarily undergo modifications in the course of time, being either retarded by resistances internal or external, or accelerated owing to shrinkage and other causes. An unalterable rotational velocity through all phases of planetary evolution is manifestly impossible. What wonder, then, that at this very instant of its long existence our satellite should revolve exactly so, and not faster or slower. But many astronomers have accepted as a physical fact that such rotation takes place. It does not, but only appears so; it is an illusion, a most surprising one, too.

"I will endeavor to make this clear by reference to Figure 1, in which E represents the earth and M the moon. The movement through space is such that the arrow, firmly attached to the latter, always occupies the position indicated with reference to the earth. If one imagines himself as looking down on the orbital plane and follows the motion he will become convinced that the moon does turn on its axis as it travels around. But in this very act the observer will have deceived himself. To make the delusion complete let him take a washer similarly marked and supporting it rotatably in the centre, carry it around a stationary object, constantly keeping the arrow pointing toward the latter. Though to his bodily vision the disk will revolve on its axis, such movement does not exist. He can dispel the illusion at once by holding the washer fixedly while going around. He will now readily see that the supposed axial rotation is only apparent, the impression being produced by successive changes of position in space.

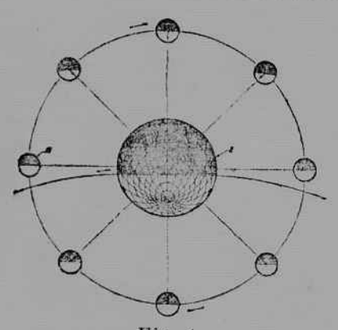


Fig. 1

It is well known that the Moon, M, always turns the same face toward the Earth, E, as the black arrows indicate. The parallel rays from the Sun illuminate the Moon in its successive orbital positions as the unshaded semicircles indicate. Bearing this in mind, do you believe that the Moon rotates on its own axis?

"But more convincing proofs can be given that the moon does not, and cannot revolve on its axis. With this object in view attention is called to Figure 2, in which both the satellite, M, and earth, E, are shown imbedded, in a solid mass, M' (indicated by stippling) and supposed to rotate so as to impart to the moon its normal translatory velocity. Evidently, if the lunar globe could rotate as commonly believed, this would be equally true of any other portion of mass M', as the sphere M², shown in dotted lines, and then the part common to both bodies would have to turn simultaneously in opposite directions. This can be experimentally illustrated in the manner suggested by using, instead of one, two overlapping rotatable washers, as may be conveniently represented by circles M and M², and carrying them around a centre as E, so that the plain and dotted arrows are always pointing toward the same centre. No further argument is needed to demonstrate that the two gyrations cannot coexist or even be pictured in the imagination and reconciled in a purely abstract sense.

"The truth is the so-called 'axial rotation' of the moon is a phenomenon deceptive alike to the eye and mind and devoid of physical meaning. It has nothing in common with real mass revolution characterized by effects positive and unmistakable. Volumes have been written on the subject and many erroneous arguments advanced in support of the notion. Thus, it is reasoned that if the planet did not turn on its axis it would expose the whole surface to terrestrial view; as only one-half is visible, it must revolve. The first statement is true, but the logic of the second is defective, for it admits of only one alternative. The conclusion is not justified, as the same appearance can also be produced in another way. The moon does rotate, not on its own, but about an axis passing through the centre of the earth, the true and only one.

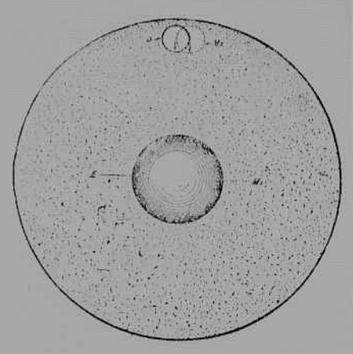


Fig. 2. Tesla's conception of the rotation of the Moon, M, around the Earth, E; the Moon, in this demonstration hypothesis, being considered as embedded in a solid mass, M'. If, as commonly believed, the Moon rotates, this would be equally true for a portion of the mass, M², and the part common to both bodies would turn simultaneously in "opposite" directions.

"The unfailing test of the spinning of a mass is, however, the existence of energy of motion. The moon is not possessed of such vis viva. If it were the case then a revolving body as M' would contain mechanical energy other than that of which we have experimental evidence. Irrespective of this so exact a coincidence between the axial and orbital periods is, in itself, immensely improbable, for this is not the permanent condtion toward which the system is tending. Any axial rotation of a mass left to itself, retarded by forces external or internal, must cease. Even admitting its perfect control by tides the coincidence would still be miraculous. But when we remember that most of the satellites exhibit this peculiarity, the probability becomes infinitesimal.

"Three theories have been advanced for the origin of the moon. According to the oldest, suggested by the great German philosopher Kant and developed by Laplace in his monumental treatise 'Mécanique Céleste,' the planets have been thrown off from larger central masses by centrifugal force. Nearly forty years ago Prof. George H. Darwin in a masterful essay on tidal friction furnished mathematical proofs, deemed unrefutable, that the moon had separated from the earth. Recently this established theory has been attacked by Prof. T. J. J. See in a remarkable work on the 'Evolution of the Stellar Systems,' in which he propounds the view that centrifugal force was altogether inadequate to bring about the separation and that all planets, including the moon, have come from the depths of space and have been captured. Still a third hypothesis of unknown origin exists which has been examined and commented upon by Prof. W. H. Pickering in 'Popular Astronomy of 1907,' and according to which the moon was torn from the earth when the latter was partially solidified, this accounting for the continents, which might not have been formed otherwise.

"Undoubtedly planets and satellites have originated in both ways, and, in my opinion, it is not difficult to ascertain the character of their birth. The following conclusions can be safely drawn:

1. A heavenly body thrown off from a larger one cannot rotate on its axis. The mass, rendered fluid by the combined action of heat and pressure, upon the reduction of the latter immediately stiffens, being at the same time deformed by gravitational pull. The shape becomes permanent upon cooling and solidification and the smaller mass continues to move about the larger one as though it were rigidly connected to it except for pendular swings or librations due to varying orbital velocity. Such motion precludes the possibility of axial rotation in the strictly physical sense. The moon has never spun around, as is well demonstrated by the fact that the most precise measurements have failed to show any measurable flattening in form.

2. If a planetary body in its orbital movement turns the same side toward the central mass this is a positive proof that it has been separated from the latter and is a true satellite.

3. A planet revolving on its axis in its passage around another cannot have been thrown off from the same, but must have been captured."

What?

Is it possible the moon doesn't turn on its own axis? That the theory of the lightning rod is half baked? That wireless messages don't travel through the air at all? According to Nikola Tesla, writing in "The Electrical Experimenter," these conditions exist, right here in our midst, despite our blissful ignorance.

How We've Misunderstood Wireless!

AND finally the scientist, having settled the fate of the moon and the lightning, turns to the marvellous modern achievement, the wireless. He writes:

"To the popular mind this sensational advance conveys the impression of a single invention, but in reality it is an art, the successful practice of which involves the employment of a great many discoveries and improvements. I viewed it as such when I undertook to solve wireless problems and it is due to this fact that my insight into its underlying principles was clear from their very inception.

"In the course of development of my induction motors it became desirable to operate them at high speeds and for this purpose I constructed alternators of relatively high frequencies. The striking behavior of the currents soon captivated my attention and in 1889 I started a systematic investigation of their properties and the possibilities of practical application. The first gratifying result of my efforts in this direction was the transmission of electrical energy through one wire without return, of which I gave demonstrations in my lectures and addresses before several scientific bodies here and abroad in 1891 and 1892. During that period, while working with my oscillation transformers and dynamos of frequencies up to 200,000 cycles per second, the idea gradually took hold of me that the earth might be used in place of the wire, thus dispensing with artificial conductors altogether.

"The immensity of the globe seemed an unsurmountable obstacle, but after a prolonged study of the subject I became satisfied that the undertaking was rational, and in my lectures before the Franklin Institute and National Electric Light Association early in 1893 I gave the outline of the system I had conceived. In the latter part of that year, at the Chicago World's Fair, I had the good fortune of meeting Prof. Helmholtz, to whom I explained my plan, illustrating it with experiments. On that occasion I asked the celebrated physicist for an expression of opinion on the feasibility of the scheme. He stated unhesitatingly that it was practicable, provided I could perfect apparatus capable of putting it into effect, but this, he anticipated, would be extremely difficult to accomplish.

"I resumed the work very much encouraged and from that date to 1896 advanced slowly but steadily, making a number of improvements, the chief of which was my system of concatenated tuned circuits and method of regulation, now universally adopted. . . .

"Imagine the earth to be a bag of rubber filled with water, a small quantity of which is periodically forced in and out of the same by means of a reciprocating pump. . . . If the strokes of the latter are effected in intervals of more than one hour and forty-eight minutes, sufficient for the transmission of the impulse through the whole mass, the entire bag will expand and contract and corresponding movements will be imparted to pressure gauges or movable pistons with the same intensity, irrespective of distance. By working the pump faster, shorter waves will be produced which, on reaching the opposite end of the bag, may be reflected and give rise to stationary nodes and loops, but in any case, the fluid being incompressible, its inclosure perfectly elastic, and the frequency of oscillations not very high, the energy will be economically transmitted and very little power consumed so long as no work is done in the receivers. This is a crude but correct representation of my wireless system in which, however, I resort to various refinements. Thus, for instance, the pump is made part of a resonant system of great inertia, enormously magnifying the force of the impressed impulses. The receiving devices are similarly conditioned and in this manner the amount of energy collected in them vastly increased.

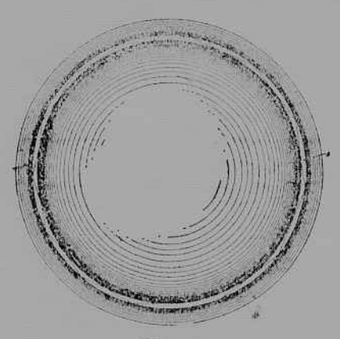


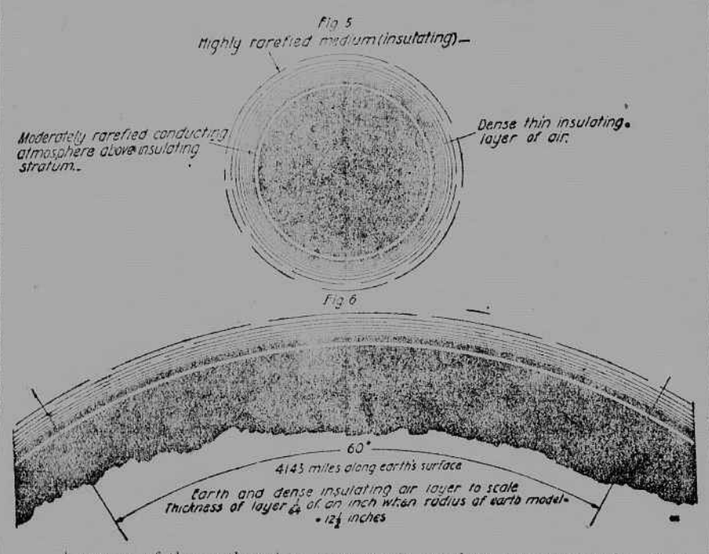
Fig. 7

The theory has been seriously advanced and taught that the radio ether wave oscillations pass around the Earth by successive reflections, as here shown. The efficiency of such a reflector cannot be more than 25 per cent; the amount of energy recoverable in a 12,000-mile transmission being but 115,000,000,000th part of one watt, with 1,000 kilowatts at the transmitter.

"The Hertz wave system is in many respects the very opposite of this. To explain it by analogy, the piston of the pump is assumed to vibrate to and fro at a terrific rate and the orifice through which the fluid passes in and out of the cylinder is reduced to a small hole. There is scarcely any movement of the fluid and almost the whole work performed results in the production of radiant heat, of which an infinitesimal part is recovered in a remote locality. However incredible, it is true that the minds of some of the ablest experts have been from the beginning, and still are, obsessed by this monstrous idea, and so it comes that the true wireless art, to which I laid the foundation in 1893, has been retarded in its development for twenty years. This is the reason why the 'statics' have proved unconquerable, why the wireless shares are of little value and why the government has been compelled to interfere.

"We are living on a planet of well-nigh inconceivable dimensions, surrounded by a layer of insulating air above which is a rarefied and conducting atmosphere (Fig. 5). This is providential, for if all the air were conducting the transmission of electrical energy through the natural media would be impossible. My early experiments have shown that currents of high frequency and great tension readily pass through an atmosphere but moderately rarefied, so that the insulating stratum is reduced to a small thickness as will be evident by inspection of Fig. 6, in which a part of the earth and its gaseous envelope is shown to scale. If the radius of the sphere is 12½", then the non-conducting layer is only 1/64" thick, and it will be obvious that the Hertzian rays cannot traverse so thin a crack between two conducting surfaces for any considerable distance, without being absorbed.

"The theory has been seriously advanced that these radiations pass around the globe, by successive reflections, but to show the absurdity of this suggestion reference is made to Fig. 7 in which this process is diagrammatically indicated. Assuming that there is no refraction, the rays, as shown on the right, would travel along the sides of a polygon drawn around the solid, and inscribed into the conducting gaseous boundary, in which case the length of the side would be about 400 miles. As one-half the circumference of the earth is approximately 12,000 miles long there will be, roughly, thirty deviations. The efficiency of such a reflector cannot be more than 25 per cent, so that if none of the energy of the transmitter were lost in other ways, the part recovered would be measured by the fraction (¼)³⁰. Let the transmitter radiate Hertz waves at the rate of 1,000 kilowatts. Then about one hundred and fifteen billionth part of one watt is all that would be collected in a perfect receiver. In truth, the reflections would be much more numerous, as shown on the left of the figure, and owing to this and other reasons, on which it is unnecessary to dwell the amount recovered would be a vanishing quantity.



A section of the earth and its atmospheric envelope drawn to scale. It is obvious that the Hertzian rays cannot traverse so thin a crack between two conducting surfaces for any considerable distance without being absorbed, says Dr. Tesla, in discussing the ether space wave theory.

"Consider now the process taking place in the transmission by the instrumentalities and methods of my invention. For this purpose attention is called to Fig. 8, which gives an idea of the mode of propagation of the current waves and is largely self-explanatory. The drawing represents a solar eclipse with the shadow of the moon just touching the surface of the earth at a point where the transmitter is located. As the shadow moves downward it will spread over the earth's surface, first with infinite and then gradually diminishing velocity until at a distance of about 6,000 miles it will attain its true speed in space. From there on it will proceed with increasing velocity, reaching infinite value at the opposite point of the globe. It hardly need be stated that this is merely an illustration and not an accurate representation in the astronomical sense.

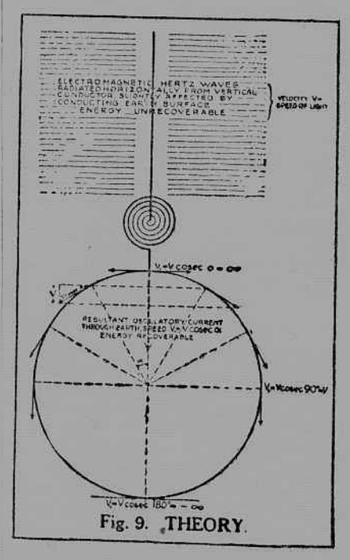


Fig. 9. THEORY.

"The exact law will be readily understood by reference to Fig. 9, in which a transmitting circuit is shown connected to earth and to an antenna. The transmitter being in action, two effects are produced: Hertz waves pass through the air, and a current traverses the earth. The former propagate with the speed of light and their energy is unrecoverable in the circuit. The latter proceeds with the speed varying as the cosecant of the angle which a radius drawn from any point under consideration forms with the axis of symmetry of the waves. At the origin the speed is infinite but gradually diminishes until a quadrant is traversed, when the velocity is that of light. From there on it again increases, becoming infinite at the antipole. Theoretically the energy of this current is recoverable in its entirety, in properly attuned receivers.

"Some experts, whom I have credited with better knowledge, have for years contended that my proposals to transmit power without wires are sheer nonsense, but I note that they are growing more cautious every day. The latest objection to my system is found in the cheapness of gasolene. These men labor under the impression that the energy flows in all directions and that, therefore, only a minute amount can be recovered in any individual receiver. But this is far from being so. The power is conveyed in only one direction, from the transmitter to the receiver, and none of it is lost elsewhere. It is perfectly practicable to recover at any point of the globe energy enough for driving an airplane, or a pleasure boat or for lighting a dwelling. I am especially sanguine in regard to the lighting of isolated places and believe that a more economical and convenient method can hardly be devised. The future will show whether my foresight is as accurate now as it has proved heretofore."

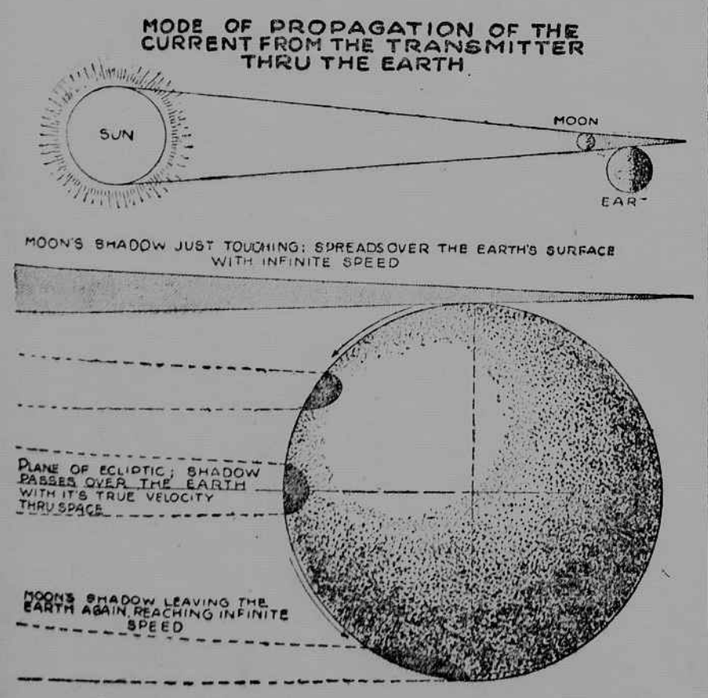


Fig. 8. This diagram illustrates how, during a solar eclipse, the Moon's shadow passes over the Earth with changing velocity, and should be studied in connection with Fig. 9. The shadow moves downward with infinite velocity at first, then with its true velocity through space, and finally with infinite velocity again.

The Fallacy of Franklin's Pointed Lightning Rod

TESLA next addresses himself to the lightning rod, and comments as follows:

"The display of atmospheric electricity has since ages been one of the most marvellous spectacles afforded ta the sight of man. Its grandeur and power filled him with fear and superstition. For centuries he attributed lightning to agents godlike and supernatural and its purpose in the scheme of this universe remained unknown to him. Now we have learned that the waters of the ocean are raised by the sun and maintained in the atmosphere delicately suspended and that they are wafted to distant regions of the globe, where electric forces assert themselves in upsetting the sensitive balance and causing precipitation, thus sustaining all organic life. There is every reason to hope that man will soon be able to control this life-giving flow of water and thereby solve many pressing problems of his existence.

"Atmospheric electricity became of special scientific interest in Franklin's time. Faraday had not yet announced his epochal discoveries in magnetic induction but static frictional machines were already generally used in physical laboratories. Franklin's powerful mind at once leaped to the conclusion that frictional and atmospheric electricity were identical. To our present view this inference appears obvious, but in his time the mere thought of it was little short of blasphemy. He investigated the phenomena and argued that if they were of the same nature then the clouds could be drained of their charge exactly as the ball of a static machine, and in 1749 he indicated in a published memoir how this could be done by the use of pointed metal rods.

"The earliest trials were made by Dalbrand in France, but Franklin himself was the first to obtain a spark by using a kite, in June, 1752. When these atmospheric discharges manifest themselves to-day in our wireless station we feel annoyed and wish that they would stop, but to the man who discovered them they brought tears of joy.

"The lightning conductor in its classical form was invented by Benjamin Franklin in 1755 and immediately upon its adoption proved a success to a degree. As usual, however, its virtues were often exaggerated. So, for instance, it was seriously claimed that in the city of Pietermaritzburg (capital of Natal, South Africa) no lightning strokes occurred after the pointed rods were installed, although the storms were as frequent as before. Experience has shown that just the opposite is true. A modern city like New York, presenting innumerable sharp points and projections in good contact with the earth, is struck much more often than an equivalent area of land. Statistical records, carefully compiled and published from time to time, demonstrate that the danger from lightning to property and life has been reduced to a small percentage by Franklin's invention, but the damage by fire amounts, nevertheless, to several million dollars annually. It is astonishing that this device, which has been in universal use for more than one century and a half, should be found to involve a gross fallacy in design and construction which impairs its usefulness and may even render its employment hazardous under certain conditions.

. . . .

"All points or projections on the surface of a conductor of such vast dimensions as the earth would be quite ineffective were it not for other influences. These will be elucidated with reference to Figure 4, in which our artist of the Impressionist school has emphasized Franklin's notion that his rod was drawing electricity from the clouds. If the earth were not surrounded by an atmosphere which is generally oppositely charged it would behave, despite all its irregularities of surface, like a polished sphere. But owing to the electrified masses of air and cloud the distribution is greatly modified. Thus in Figure 4 the positive charge of the cloud induces in the earth an equivalent opposite charge, the density at the surface of the latter diminishing with the cube of the distance from the static centre of the cloud. A brush discharge is then formed at the point of the rod and the action Franklin anticipated takes place. In addition, the surrounding air is ionized and rendered conducting and, eventually, a bolt may hit the building or some other object in the vicinity. The virtue of the pointed end to dissipate the charge, which was uppermost in Franklin's mind, is, however, infinitesimal. Careful measurements show that it would take many years before the electricity stored in a single cloud of moderate size would be drawn off or neutralized through such a lightning conductor. The grounded rod has the quality of rendering harmless most of the strokes it receives, though occasionally the charge is diverted with damaging results. But, what is very important to note, it invites danger and hazard on account of the fallacy involved in its design. The sharp point which was thought advantageous and indispensable to its operation is really a defect detracting considerably from the practical value of the device. I have produced a much improved form of lightning protector characterized by the employment of a terminal of considerable area and large radius of curvature which makes impossible undue density of the charge and ionization of the air. These protectors act as quasi-repellents and so far have never been struck though exposed a long time. Their safety is experimentally demonstrated to greatly exceed that invented by Franklin. By their use property worth millions of dollars which is now annually lost can be saved."

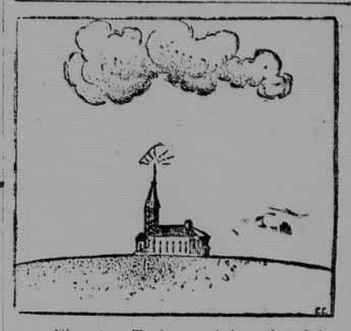


Fig. 4. Tesla explains the fallacy of the Franklin pointed lightning rod, here illustrated, and shows that usually such a rod could not draw off the electricity in a single cloud in many years. The density of the dots indicates the intensity of the charges.

Aeronautics: A Question About Its Future

WHAT is to become of aeronautics after the war? This problem is discussed in "Le Petit Journal" of Paris by Jacques Mortane.

Considering the enormous progress aviation has made during and on account of the war, he says, only one answer to the above question is possible. Regular aerial lines of communication will be established throughout the world. And these lines will serve not only passenger traffic and the mails, but they will be used in increasing proportions for long-distance freight transportation.

The establishment of regular commercial air routes, however, has to be accompanied by the working out of an international code of air navigation.

For one thing, how will the air be mapped out between the different nations? Shall each country have not only its own aerial fleet and stations, but also its own exclusive lines? Is it possible at all to establish a rigid system of right of way in the air? How far will the jurisdiction of a country apply to lines internationally used?

But there are other no less complicated problems. What qualifications will be demanded from commercial pilots? Will a pilot's certificate issued in one country, be accepted as valid in another? This question involves the safety not only of aerial shipping itself, but also that of the population above whose heads the shipping passes.

Will there be a standardization of machines? This is an important question, as it pertains to the safety of traffic and to the facilities of relaying and repairs.

What about aerial customs regulations and policing?

It is comparatively little known that as early as 1910 an international conference was held in Paris to consider some of the above outlined questions. Difficulties of a military character, however, prevented reaching an agreement.