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which is just about sufficient to bring the plate into contact with the point. The speed of the motor can be varied by screwing the thumbscrew up or down. Two wires similar to those described above are seen in the illustration running to a pin and nut at the other end of the cross bar, and a second short-circuiting arm could be used on this side, too. This double short circuit, however, was found to be superfluous. The motor represented was originally designed as a small series-wound electro-plating dynamo, and when running as a motor the armature revolves in the clock-wise direction, as seen from above.

The speed of this machine remains constant to within one part in 200; further, if stopped, left for a while, and started again on some future day, it will run with the same speed as before to within one part in 200, provided no very large change is made in the e. m. f. or resistance of the motor circuit. A large change in either of these quantities, however, will alter the speed slightly. For instance, an increase in the current supplied the motor from .8 to 1.4 amperes, increases the speed by about 2 per cent. The fact that this change in speed takes place is due probably to the jarring of the platinum contact. There is very little or no sparking when the contact is broken, and it does not appear to be necessary to keep the platinum surfaces clean. As a matter of fact, these particular pieces of platinum have not been cleaned since the machine was constructed.

The synchronizing device is as follows: Two motors similar to that represented are placed at the two stations, respectively, and regulated to run at approximately the same speed. The axle of each motor is joined to the line wire by means of a metal rod passed up through the center of a fixed commutator seen in the illustration just below the flywheel. One end of this rod is soldered to the steel-bearing plate upon which the axle rests, and the other is connected by a wire with one of the small binding posts on the wooden base of the machine and thence to the line. In this line circuit is inserted a battery of sufficient strength to work a high-resistance relay. A metal brush fastened to the flywheel revolves with it, and touches in succession the insulated segments of the fixed commutator.

Let us call one of the motors *A* and the other *B*. One segment of *A*'s fixed commutator is divided into two halves insulated from each other. One-half of the corresponding segment of *B*'s commutator is cut away and the space filled by insulating matter. Let *a* be the half of the divided segment that *A*'s brush touches first in its revolution, and *a'* the second half, and let *b* be the corresponding segment in *B*'s commutator. The segment *b* is connected directly to the earth or the return wire, and *a* and *a'* are connected through two coils of a double relay, respectively, to the earth or the same return wire. This double relay is so constructed and joined up that a current from *a* through the coil joined to it pulls a small lever arm over and short circuits part of the resistance of *A*'s motor circuit, and a current from *a'* through its coil pulls the same lever arm back again, breaking the short circuit. Suppose that *A* has been regulated so as to run slightly slower than *B*. If they are started running, *A* gradually falls behind *B* until, when *B*'s brush touches *b*, *A*'s brush touches *a*. This completes the circuit through *a*'s coil of the relay, the lever arm is drawn over and the portion of *A*'s motor circuit is short circuited. *A*'s speed then increases as explained above, and *A* gradually gains on *B* until when *B*'s brush touches *b*, *A*'s brush touches *a'*. This completes the circuit through *a'*'s coil of the relay, the lever arm is pulled back and the short circuit broken. *A* is now running slightly slower than *B*, and the above process is repeated. This keeps the motors running nearly in phase with each other. One motor will gain on the other slightly and then fall behind, but in the case actually tried the difference in phase did not exceed one-fiftieth of a complete revolution.

The advantages of this method of synchronizing motors are that, as stated above, a very small current sent over the wire, namely, enough to work a sensitive relay, is sufficient to maintain synchronism, and since the wires are used for this purpose during a small part of the time only, they may be used for telegraphing almost all the time. Further, if one of the motors is stopped for any reason and started again, they will get into synchronism automatically, and will run together in only one relative position with regard to each other; i. e., so that when *B*'s brush is on segment *b* *A*'s brush is on segments *a*, *a'*.

The commutator in the machine represented in the picture was designed for multiplex telegraphy. It has 18 segments in addition to that used for the synchronizing device. A key placed in a circuit joining any of these segments to the earth or return wire, will operate a relay similarly placed in a circuit connecting the corresponding segment in the other machine with the same return. In this way 18 distinct circuits have been operated simultaneously over a single wire and return, running the length of the university campus, and containing a resistance of 500 ohms. Only one battery was required to operate these 18 circuits and the synchronizing device. Whether the above described scheme will work over a very long line or not remains still to be investigated.

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On the Elevation of the Electrically-Conducting Strata of the Earth's Atmosphere.

BY A. E. KENNELLY.

ACCORDING to the measurements of Professor J. J. Thomson ("Recent Researches in Electricity and Magnetism," p. 101), air at a pressure of 1-100 mm. of mercury has a conductivity for alternating currents approximately equal to that of a 25 per cent aqueous solution of sulphuric acid. The latter is known to be roughly 1 mho-per-centimeter, so that a centimeter cube would have a resistance of about one ohm. Consequently, air at ordinary temperatures, and at a rarefaction 76,000 times greater than that at sea level, has a conductivity some 20 times greater than that of ocean water, although about 600,000 times less than that of copper.

If we apply the ordinary formula for finding the elevation corresponding to a given air-rarefaction, we find that if the air had a uniform temperature of 0 deg. C., the height of this stratum of air with a rarefaction of 76,000, would be

18.39 log 76,000 kilometers above the sea,
or 89.77 kilometers,
or 55.77 miles.

If the air had a uniform temperature of —50 degs. C. this elevation would be reduced 18.3 per cent, or to 73.3 kilometers (45.5 miles). The temperature of the earth's atmosphere has only been measured within a range of a very few kilometers above the surface of the sea, and consequently the materials are not at hand for any precise calculation of the height of electrically conducting strata. It may be safe to infer, however, that at an elevation of about 80 kilometers, or 50 miles, a rarefaction exists which, at ordinary temperatures, accompanies a conductivity to low-frequency alternating currents about 20 times as great as that of ocean water.

There is well-known evidence that the waves of wireless telegraphy, propagated through the ether and atmosphere over the surface of the ocean, are reflected by that electrically-conducting surface. On waves that are transmitted but a few miles the upper conducting strata of the atmosphere may have but little influence. On waves that are transmitted, however, to distances that are large by comparison with 50 miles, it seems likely that the waves may also find an upper reflecting surface in the conducting rarefied strata of the air. It seems reasonable to infer that electromagnetic disturbances emitted from a wireless sending antennæ spread horizontally outwards, and also upwards, until the conducting strata of the atmosphere are encountered, after which the waves will move horizontally outwards in a 50-mile layer between the electrically-reflecting surface of the ocean beneath, and an electrically-reflecting surface, or successive series of surfaces, in the rarefied air above.

If this reasoning is correct, the curvature of the earth plays no significant part in the phenomena, and beyond a radius of, say, 100 miles from the transmitter, the waves are propagated with uniform attenuation cylindrically, as though in two-dimensional space. The problem of long-distance wireless wave transmission would then be reduced to the relatively simple condition of propagation in a plane, beyond a certain radius from the transmitting station. Outside this radius the voluminal energy of the waves would diminish in simple proportion to the distance, neglecting absorption losses at the upper and lower reflecting surfaces, so that at twice the distance the energy per square meter of wave front would be halved. In the absence of such an upper reflecting surface, the attenuation would be considerably greater. As soon as long-distance wireless waves come under the sway of accurate measurement, we may hope to find, from the observed attenuations, data for computing the electrical conditions of the upper atmosphere. If the attenuation is found to be nearly in simple proportion to the distance, it would seem that the existence of the upper reflecting-surface could be regarded as demonstrated.

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