DRILLING MACHINES.

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THE first of these, represented by the left-hand figure, is a drilling machine *k*, which presents several specialties of detail. The drill is made to revolve by means of bevel gearing on the head of the spindle, and on the pulley-shaft which passes through the frame of the machine. The spindle can be driven either direct through the pulleys or through the gearing marked *a*, which can be put into gear by throwing over the lever *b*. A strap from the pulley *d* passes over *e*, and drives the feed motion, which consists of a bevel pinion, driving a wheel on the vertical spindle *f* carrying a worm at its upper end. This spindle is supported by two bearings *g* and *h*, which are free to move slightly in guides, and by turning the spindle *i* sufficient motion is given to the spindle *f* to throw the worm at the upper end free of the worm-wheel. The spindle may then be thrown up or down by means of the lever *k*, a series of levers and a counterbalance being provided to facilitate this operation. It will be seen that on the shaft of the worm-wheel is a pinion gearing into the rack on the upper part of the spindle. By this means the latter is raised and lowered, or, when desired, the drill may be actuated by the hand-wheel *l*. The upper table may be thrown round out of the way when greater space is required for the work to be drilled.

movement of ponderable matter. Nevertheless, the phenomena discovered by Mr. Crookes have been elucidated, if not in their cause, still in their form and their starting-point. The ingenious counter-proof to which M. Arthur Schuster has submitted them places it beyond doubt that it is by no means the direct action of the rays emanating from the luminous source which determines the movement of the disks of the radiometer, but that the repulsive power here called into play has its seat in the walls of the transparent vessel which serves to contain the mill, and that this power is set in action by the pencil of rays directed upon the apparatus. As the true explanation of the totality of the phenomena has not yet been given, and as the hypothesis of the materiality and of the impulsive force of light will probably not soon be abandoned, the author thinks it useful to submit this hypothesis to the test of the method of successive elimination. M. Crookes has calculated the apparent repulsion exerted by the solar rays at 1 grm. per square metre. This pressure is more than one thousand times greater than the maximum value possible for reflecting bodies, and more than two thousand times superior to the maximum value possible for absorbing bodies. We may, then, affirm that the phenomena which Mr. Crookes has made known are nowise due to the effect of an impulsion of light, and do not imply the idea of mass of density as regards radiant light and heat. However carefully the vacuum in the vessel inclosing the radiometer or torsion balance may be made, there remain, nevertheless, quantities of gas or

perfect regularity of the radiometer. Moreover, the theory in question expressly requires that there shall never be an equilibrium of temperature between the gas in the case and the disks of the radiometer. But how are we to admit that in every experiment this equilibrium is not ultimately established? Moreover, the rotation ought to stop at last instead of maintaining itself indefinitely at the same speed. The author then cites certain experiments difficult to explain by the supposed movement of gases in the interior of the apparatus. Thus the instrument was heated nearly to redness, when it commenced turning, but the rotation was sensibly accelerated by the momentary presence of a single flame, which joined its action to that of the radiant heat. An apparatus was constructed with disks exclusively polished. On throwing a pencil of solar rays upon one of the two hemispheres of the glass case a perfect rotation was obtained, without interruption, and as free and rapid as with an ordinary radiometer fully exposed to the light. The author bases his explanation of the phenomena upon a mechanical action of the "ether" perpendicular to the direction of its rays of propagation, and not in the same direction as these rays. This interpretation is calculated to calm the legitimate disquiet of the partisans of undulation. In Germany there is a leaning to an explanation based upon electricity. They rely upon the experiment that when a radiometer with disks exclusively polished, and where one of the hemispheres of the case is traversed by a continuous electric spark, the instru-

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The second is a radial drilling machine, the arrangement of which will be clearly understood from the engraving.

The position of the head carrying the drill and attachment upon the radial arm is regulated by a screw as shown, and the drill-holder is driven from the coned pulleys at the foot of the pillar, different speeds being obtained by gearing as in the fixed drill. The pulley-shaft carries a bevel-wheel which gives motion to a vertical shaft in the pillar, and having a bevel-wheel at the upper end. The latter gives motion to the horizontal shaft *a*, and this through the system of gearing shown to the drill-spindle. A strap passing over the coned pulleys *b* and *c* feeds the drill down through the bevel gearing *d* and the worm and worm-wheel *e* and *f*. As in the fixed drill the worm *e* may be thrown out of contact with the wheel by turning the spindle *g*, and the drill-holder may be thrown up and down by the lever *h*. As shown in the engraving, the drill is provided with a small table carried by an arm from the main standard, and capable of being raised or lowered by a screw, as shown, while a larger fixed table for heavy work forms part of the base-plate on which the standard is fixed. The drill, it will be noticed, can swing completely round, the turning portion of the former being shaped so as to form apparently a continuation of the fixed standard. The whole design is exceedingly neat.—*Engineering*.

WHAT MAKES THE RADIOMETER TURN?

Views of M. G. A. Hirn.—The attention of the scientific world has been latterly drawn to the singular phenomena which Mr. Crookes has studied with the radiometer. The conclusion which has presented itself to the mind of many is that these phenomena are due to an impulsive action of the luminous rays, and that it is thus demonstrated that light is a

vapor relatively enormous. The maximum pressure which the solar radiation can exert upon 1 square metre of absorbing surface is 0.0004157 grm. : let us suppose that the disks of the radiometer are ten square centimetres, the maximum pressure upon them will be 0.000004157 grm., or a little more than $\frac{1}{240000}$ of 1 grm. The slightest agitation of the small quantity of gas remaining in the apparatus will produce upon the radiometer pressure comparable to this. However transparent may be the glass case of the radiometer, it still absorbs a part of the calorific or luminous rays; one of its surfaces is heated more rapidly than the other. This inequality of temperature necessarily determines electric polarity, or the manifestation of static electricity. The vacuum, it is said, is so perfect that the electric spark cannot traverse the apparatus. But electric attractions and repulsions traverse the vacuum. However feeble may be this cause of attraction and repulsion, it may nevertheless have a considerable value in comparison with our maximum of 0.000004157 grm.

Views of M. A. Ledieu.—The author's experiments become less and less favorable to the theory of the apparatus based upon the movements of gases and vapors remaining within the glass case after the vacuum has been made. This theory, as we know, is subdivided into various doctrines, of which a very complete and lucid exposition has been given by M. Bertin in the June number of the *Annales de Chimie et de Physique*. The capital objection which mechanicians oppose to these different explanations is, they are all reduced to admit, that the radiometer is an instrument of reaction. But in such apparatus, having regard to the impossibility of the motive power being rapidly produced with a sufficiently constant intensity, there ensue merely rotations accompanied by retardations and bounds far from being reconcilable with the

ment takes a rapid rotation, always opposite to the direction of the spark, this direction being understood according to the common convention. "In any case, the radiometer of Mr. Crookes seems to us a serious instrument, and not a paradoxical apparatus destined to enjoy an ephemeral scientific repute and then to rank as a mere physical amusement. Its experimental study, pursued under all modifications and with an indefatigable perseverance, will certainly lead to important results as to the mechanical properties of the ether."

Views of M. G. Salet.—The author makes the disks of his radiometer of mica, and blackens both on the same side. He considers his results difficult to reconcile with the idea of a direct impulse due to light or to the ether, but contrary to the theory which seeks to explain the movements of the radiometer by the disengagement of gases condensed on the disks. Can the minimum quantity of gas which remains in an apparatus exhausted with such care suffice to occasion the movement, according to Tait's theory?

Views of M. W. de Fonville.—The author has had constructed a radiometer, the disks of which (of mica) are coated on both sides with lampblack, and the case is blackened in the same manner over half its surface. If the light is received perpendicular to the diametral section which separates the transparent hemisphere from the darkened hemisphere the apparatus remains motionless. If, on the contrary, the diametric plane is inclined to the left, the left-hand disks, more strongly illuminated than those on the right, are repelled more energetically, and the radiometer takes a regular movement from left to right. The same phenomenon is observed in the inverse direction if the diametric plane is inclined to the right. The rotation is the most rapid possible when the diametric plane is rendered parallel to the rays of light which illuminate the apparatus.