The apparatus is protected by a glass cover, which preserves the needle from injury and keeps the graduated scale constantly clean.

The price of the gauge, without the valve, is from 170 to 180 francs, and the gauge and whistle from 30 to 90 francs extra.

This gauge is merely a bad copy of Faber's Magnetic Gauge, patented in this country, and described in this *Journal*, (present Series,) Vol. xxi, p. 215. The Faber Gauge is very superior to the one exhibited at the French Exhibition, which has been altered merely to disguise the theft, and has no novelty but its defects.

EDITOR.

On the Descent of Glaciers. By the Rev. HENRY MOSELEY, M.A, F.R.S.*

If we conceive two bodies of the same form and dimensions (cubes for instance,) and of the same material, to be placed upon a uniform horizontal plane, and connected by a substance which alternately extends and contracts itself, as does a metallic rod when subjected to variations of temperature, it is evident that by the extension of the intervening rod, each will be made to recede from the other by the same distance, and, by its contraction, to approach it by the same distance. But if they be placed on an inclined plane (one being lower than the other), then when by the increased temperature of the rod its tendency to extend becomes sufficient to push the lower of the two bodies downwards, it will not have become sufficient to push the higher upwards. The effect of its extension will therefore be to cause the lower of the two bodies to descend whilst the higher remains at rest. The converse of this will result from contraction; for when the contractile force becomes sufficient to pull the upper body down the plane it will not have become sufficient to pull the lower up it. Thus, in the contraction of the substance which intervenes between the two bodies, the lower will remain at rest whilst the upper descends. As often, then, as the expansion and contraction is repeated the two bodies will descend the plane until, step by step, they reach the bottom.

Suppose the uniform bar AB placed on an inclined plane, and subject to extension from increase of temperature, a portion XB will descend, and the rest XA will ascend; the point x where they separate being determined by the condition that the force requisite to push XA up the plane is equal to that required to push XB down it.

Fig. 1.

Let $AX=x$, $AB=L$, weight of each linear unit= u , i =inclination of plane, ϕ =limiting angle of resistance,

$$\therefore ux = \text{weight of } AX,$$

$$u(L-x) = \text{weight of } BX.$$

Now, the force acting parallel to an inclined plane which is necessary to push a weight w up it, is represented by

$$w \frac{\sin(\phi + i)}{\cos \phi};$$

* From the Lond., Edin., and Dub. Philos. Mag., July, 1855.

and that necessary to push it down the plane by

$$w \frac{\sin(\phi-i)}{\cos \phi};$$

$$\therefore ux \frac{\sin(\phi+i)}{\cos \phi} = u(L-ux) \frac{\sin(\phi-i)}{\cos \phi}$$

$$\therefore x \{ \sin(\phi+i) + \sin(\phi-i) \} = L \sin(\phi-i)$$

$$\therefore x \sin \phi \cos i = L \sin(\phi-i)$$

$$\therefore x = \frac{1}{2} L \frac{\sin(\phi-i)}{\sin \phi \cos i}$$

$$\therefore x = \frac{1}{2} L \left\{ 1 - \frac{\tan i}{\tan \phi} \right\}.$$

Fig. 2.

When contraction takes place the converse of the above will be true. The separating point x will be such, that the force requisite to pull xb up the plane is equal to that required to pull ax down it. bx is obviously in this case equal to ax in the other.

Let λ be the elongation per linear unit under any variation of temperature; then the distance which the point B (see fig. 1) will be made to descend by this elongation.

$$\begin{aligned} &= \lambda \cdot BX \\ &= \lambda (L-x) \\ &= \frac{1}{2} \lambda L \left(1 + \frac{\tan i}{\tan \phi} \right). \end{aligned}$$

If we conceive the bar now to return to its former temperature, contracting by the same amount (λ) per linear unit; then the point B (fig. 2) will by this contraction be made to ascend through the space

$$BX, \lambda = x\lambda$$

$$= \frac{1}{2} \lambda L \left\{ 1 - \frac{\tan i}{\tan \phi} \right\} \quad \dots \dots \dots (1)$$

Total descent l of B by elongation and contraction is therefore determined by the equation

$$l = L \lambda \frac{\tan i}{\tan \phi} \quad \dots \dots \dots (2)$$

Fig. 3.

To determine the pressure upon a nail, driven through the rod at any point p fastening it to the plane.

It is evident that in the act of extension the part bp of the rod will descend the plane and the part ap ascend; and conversely in the act of contraction; and that in the former case the nail B will sustain a pressure upwards equal to that necessary to cause bp to descend, and a pressure downwards equal to that necessary to cause pa to ascend; so

that, assuming the pressure to be downwards, and adopting the same notation as before, except that AP is represented by ρ , AB by a , and the pressure upon the nail (assumed to be downwards) by P , we have in the case of extension

$$P = u \rho \frac{\sin(\phi + i)}{\cos \phi} - u(a - \rho) \frac{\sin(\phi - i)}{\cos \phi},$$

and in case of contraction

$$P = u(a - \rho) \frac{\sin(\phi + i)}{\cos \phi} - u\rho \frac{\sin(\phi - i)}{\cos \phi}.$$

Reducing, these formulæ become respectively

$$P = \frac{u}{\cos \phi} \left\{ 2\rho \sin \phi \cos i - a \sin(\phi - i) \right\} \quad . \quad . \quad (3)$$

$$P = \frac{u}{\cos \phi} \left\{ a \sin(\phi + i) - 2\rho \sin \phi \cos i \right\} \quad . \quad . \quad (4)$$

My attention was first drawn to the influence of variations in temperature to cause the descent of a lamina of metal resting on an inclined plane, by observing, in the autumn of 1853, that a portion of the lead which covers the south side of the choir of the Bristol Cathedral, which had been renewed in the year 1851, but had not been properly fastened to the ridge beam, had descended bodily 18 inches into the gutter; so that if plates of lead had not been inserted at the top, a strip of the roof of that length would have been left exposed to the weather. The sheet of lead which had so descended measured, from the ridge to the gutter, 19 feet 4 inches and along the ridge 60 feet. The descent had been continually going on, from the time the lead had been laid down. An attempt made to stop it by driving nails through it into the rafters had failed. The force by which the lead had been made to descend, whatever it was, had been found sufficient to draw the nails.* As the pitch of the roof was only $16\frac{1}{2}^\circ$, it was sufficiently evident that the weight of the lead alone could not have caused it to descend. Sheet lead, whose surface is in the state of that used in roofing, will stand firmly upon a surface of planed deal when inclined at an angle of 30° ,† if no other force than its weight tends to cause it to descend. The considerations which I have stated in the preceding articles led me to the conclusion that the daily variations in the temperature of the lead, exposed as it was to the action of the sun by its southern aspect, could not but cause it to descend considerably, and the only question which remained on my mind was, whether this descent could be so great as was observed. To determine this I took the following data:—

* The evil was remedied by placing a beam across the rafters near the ridge, and doubling the sheets round it, and fixing their ends with spike nails.

† This may easily be verified. I give it as the result of a rough experiment of my own. I am not acquainted with any experiments on the friction of lead made with sufficient care to be received as authority in this matter. The friction of copper on oak has, however, been determined by General Morin to be 0.62, and its limiting angle of resistance $31^\circ 48'$; so that if the roof of Bristol Cathedral had been inclined at 31° instead of 16° , and had been covered with sheets of copper resting on oak boards, instead of sheets of lead resting on deal, the sheeting would not have slipped by its weight only.

Mean daily variation of temperature at Bristol in the month of August, assumed to be the same as at Leith (Kaemtz, *Meteorology*, by Walker, p. 18,) $8^{\circ}\cdot 21$ Cent.

Linear expansion of lead through 100° Cent. $\cdot 0028436$.

Length of sheets of lead forming the roof from the ridge to the gutter 232 inches.

Inclination of roof $16^{\circ} 32'$.

Limiting angle of resistance between sheet lead and deal 30° .

Whence the mean daily descent of the lead, in inches, in the month of August, is determined by equation (2) to be

$$l = 232 \times \frac{8^{\circ}\cdot 21}{100} \times \cdot 0028436 \times \frac{\tan 16^{\circ} 32'}{\tan 30^{\circ}}$$

$$l = \cdot 027848 \text{ inches.}$$

The average daily descent gives for the whole month of August a descent of $\cdot 863288$. If the average daily variation of temperature of the month of August had continued throughout the year, the lead would have descended $10\cdot 19148$ inches every year. And in the two years from 1851 to 1853 it would have descended $20\cdot 38296$ inches. But the daily variations of atmospheric temperature are less in the other months of the year than in the month of August. For this reason, therefore, the calculation is in excess. For the following reasons it is in defect:—1st, the daily variations in the temperature of the lead cannot but have been greater than those of the surrounding atmosphere. It must have been heated above the surrounding atmosphere by radiation from the sun in the day-time, and cooled below it by radiation into space at night. 2dly, One variation of temperature only has been assumed to take place every twenty-four hours, viz: that from the extreme heat of the day to the extreme cold of the night; whereas such variations are notoriously of constant occurrence during the twenty-four hours. Each cannot but have caused a corresponding descent of the lead, and their aggregate result cannot but have been greater than if the temperature had passed uniformly (without oscillations backwards and forwards) from one extreme to the other.

These considerations show, I think, that the causes I have assigned are sufficient to account for the fact observed. They suggest, moreover, the possibility that results of importance in meteorology may be obtained from observing with accuracy the descent of a metallic rod thus placed upon an inclined plane. That descent would be a measure of the aggregate of the changes of temperature to which the metal was subjected during the time of observation. As every such change of temperature is associated with a corresponding development of mechanical action under the form of work,* it would be a measure of the aggregate of such changes and of the work so developed during that period; and relations might be found between measurements so taken in different equal periods of times, successive years for instance, tending to the development of new meteorological laws.†

* Mr. Joule has shown (*Phil. Trans.* 1850, Part I.) that the quantity of heat capable of raising a pound of water by 1° Fahr. requires for its evolution 772 units of work.

† The remainder of this paper, in which these principles are applied to the explanation of glacier motion, is founded on a misconception and is fallacious. It has therefore been omitted.