original temperature, but less vapour-laden, will be reduced below this point at comparatively low elevations. Suppose the former to be carried over the latter and then further chilled, the rain falling through the colder air will be frozen in its passage, and will reach the earth as hail.

---

*Suggestions respecting the Process of determining Depth from an Observation of the Time taken by a Weight in its Descent* By JOHN R. CAMPBELL.

THE common method of getting a rough notion of the height, or, perhaps more correctly speaking, *depth* of a wall of rock by timing the descent of a stone is so old and well known that it would be waste of time to enter into a long description of it. The process may be applied to certain waterfalls where the pool into which the stream plunges is inaccessible to a climber, and which therefore cannot be measured by the aneroid; of such there are several examples in Norway. Probably, too, the depth of crevasses might occasionally be arrived at in this way. Indeed, with all its liability to error, supposing that error not to exceed what may be called a *reasonable* amount depending on the circumstances of the case, since it is the only plan that can be adopted in some instances without going to great trouble and expense—especially by a traveller in a mountain country—it may be fairly said to merit some consideration. The operation is not limited to the few cases in which a weight can be dropped vertically; the time occupied by the descent is the same if we can throw it horizontally forward so as to fall clear of the rock. I ought also to observe that the unavoidable error in the result is, as a rule, so great as to warrant our neglecting the resistance of the air in the calculation.

Now, when a stone of moderate size, such as one can easily throw, has to descend several hundred feet it becomes almost lost to view, and where it drops into the pool of a waterfall the spray may conceal it during the last second or more of its course; in both cases, therefore, we have a difficulty in determining the exact instant of its reaching the bottom. The question then arises,—Is it practicable to overcome this difficulty by using some other kind of weight in place of a stone?

The plan I am about to describe I would at once acknowledge possesses little claim to originality; I doubt not it bears much resemblance to more than one that have been tried at different times, although I have never seen an account of them.

My idea, briefly expressed, is to substitute for a stone a weighted *marroon* furnished with a detonating fuze that shall explode it on its striking the ground; and to compute the depth from the number of seconds elapsing between the instant of its being let go and that of the report being heard.

Fig. 1 represents the arrangement complete, and fig. 2 (drawn to a larger scale) is a section of the fuze with its striker. A is the marroon,

Digitized by Google

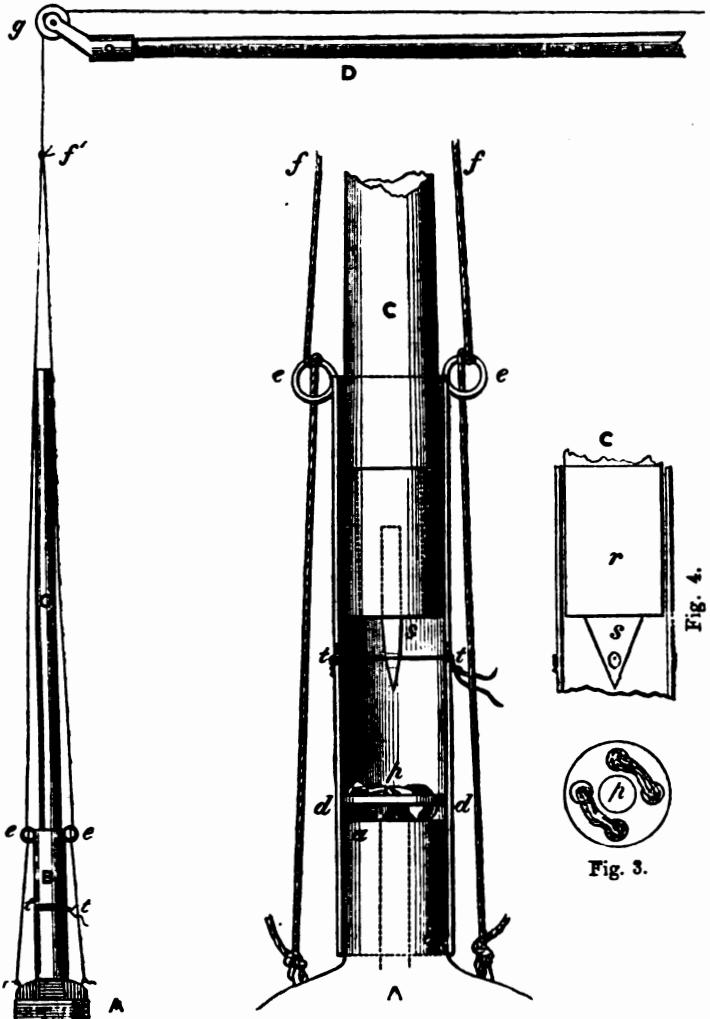



Fig. 1.

Fig. 2.

Fig. 4.

Fig. 3.

which in pyrotechnical language means a paper box welded round with kitted twine worked crossways. This contains 3 oz. of powder and is weighted with a small plate of lead in the form of a cross, the ends of

Digitized by Google

which are bent up so as to grip it tightly. The fuze B consists of a tin tube some 4 inches long, into the lower end of which the neck *a* of the marroon is inserted when the instrument is made ready for use. The tube is divided by a plate *d d* (of which fig. 3 is a plan) having a patch of fulminating powder *p* over its centre and pierced with several holes. These holes serve as communications between the flash of the detonation on the upper side of the plate and the powder in the marroon, and ought to be primed with pieces of quick-match threaded through them as shown in fig. 3. C is a deal rod 14 inches long and of slightly smaller diameter than the tube; it has a ring of lead *r r* round its lower end in order to increase its weight and steady it in the tube, and is fitted with a 'striker' *s* consisting of a pointed piece of iron with an eye-hole through it (best seen in the side view, fig. 4). A piece of silk thread stretched between two holes *t t* in the sides of the tube (to the exterior of which the ends are made fast) passes through the eye of the striker, and it will be easily seen that so long as this thread is unbroken the striker is prevented from coming into contact with the fulminating powder on the plate *d d*. In putting the parts together the strings *f f* attached to the marroon are brought up and knotted round the rings *e e* projecting from the sides of the tube —supposing that the instrument is to be thrown horizontally. Should circumstances, however, admit of its being let fall vertically these strings (after passing round the rings) are knotted together at *f'*, thus forming a sling by which it can be suspended from the end of a long rod D a few feet beyond the edge of the precipice or crevasse. The rod is fitted with a brass pulley *g* over which a cord from the sling passes to the hand of the operator. The action of the fuze is very simple. On the motion of the marroon being destroyed by impact with the ground, the momentum of the rod C causes the breakage of the silk and the striker to impinge with considerable force on the fulminating patch, thereby producing an instant explosion of the marroon.

Of course, in order to ensure even moderate accuracy, the time ought to be measured on a stop-watch; and, as a general rule, I think, half a second may safely be subtracted from this time before applying to it the equation which gives us the depth, in order to make allowance for the minute intervals occupied by the muscles of the hand in the actions of throwing (or liberating) the marroon and stopping the watch. In other words, it may require about that time for the hand to follow the eye and ear.

Let $\top$, then, represent the observed number of seconds diminished by $\frac{1}{2}$ a second.

Put D = the depth (in feet)
$g$ = acc. force of gravity = 32·2
$a$ = velocity of sound = 1130 (about).

Now the time occupied by the report in its ascent is clearly $\frac{D}{a}$,

Hence $D = \frac{g}{2}\left(\top - \frac{D}{a}\right)^2 = \frac{g}{2}\top^2 - \frac{g}{a}\top D + \frac{g}{2a^2}D^2$ . . . (a);

from which we obtain

Digitized by Google

$$D = a\left(T + \frac{a}{g} \pm \sqrt{2\frac{a}{g}T + \frac{a^2}{g^2}}\right).$$

The term under the square root has a double sign; but since D=0 when T = 0, it is evident we must consider it negative. Putting for *a* and *g* their numerical values, the expression becomes

$$D = 1130(T + 35 - \sqrt{70T + 1225})$$

If in the equation (*a*) we neglect the term $\frac{gD^2}{2a^2}$ (and we may safely do so in all cases, since for a depth of 1130 feet it only amounts to 16·1), the value of D is expressed in a simpler and more easily applied form; viz.:—

$$D = \frac{a}{2}\left(\frac{T^2}{T + \frac{a}{g}}\right) = 565\frac{T^2}{(T+35)}.$$ *

In constructing the instrument it is obviously unnecessary to follow the dimensions just given so long as the principle is carried out. The tube for the fuze can be obtained from almost any tinman. *Possibly some better kind of fuze might be devised than the one I have described.* As to the marroons, they must be purchased of a firework-maker; they vary in price according to size from 6*d.* to 1*s.* a-piece. Mr. James Pain (Pyrotechnist), 15 Heygate Street, Walworth Road, would be a good person to apply to regarding this portion of the arrangement.

---

## M. LOPPÉ'S PICTURES.

In the world of nature, as in the world of thought, we are not satisfied until the emotions of which we are conscious have been put into a concrete form by the hand of genius.

It must be the wish of all members of the Alpine Club whose love of the mountains is something more than the mere physical enjoyment of exercise in the open air and the moral enjoyment of overcoming obstacles of ice and rock to see the glories of mountain nature translated by art, both for their own sakes, and also for the benefit of the dwellers in the plain, amongst whom are those whom strength does not allow to climb, but whom culture has made most capable of appreciating every form of beauty.

---

* Any *formula* for the computation of depth by the descent of a weighted marroon in which the resistance of the air is taken into account, must be one of considerable complexity; and it would involve at least two constants, one having reference to the weight of the whole arrangement, the other to the diameter of the base. I may observe, however, without attempting a discussion of this subject, that in the case of an arrangement 2 inches in diameter and weighing 2 lbs., the air's resistance for depths requiring less than 6 seconds will not (considering the unavoidable roughness of the experiment) seriously affect the result. When the observed interval is longer, say 6 to 8 seconds, I should, in order to insure greater accuracy, subtract ½ of a second from the value of T before inserting it in the above equation.

Digitized by Google