From the foregoing statement it appears that the present position in regard to the employment of quick-running turbines in association with reduction gear is one of great interest; and it may be hoped that many questions will soon be settled by experience which are for the time being necessarily matters of opinion and estimate. Whatever system may prove the best and most efficient on the whole, the conclusion is inevitable that by the use of some reducing gear a still further step will be made possible in the association of lightness with the development of power in marine propelling apparatus and in economy of steam and fuel consumption in war fleets and in the mercantile marine. In the case of cargo steamers of moderate and low speed it also appears probable that geared turbines will find employment, although the competition of the internal combustion engine, and of the Diesel engine in particular, in vessels of this class and of low power, may play an important part. It is unnecessary to enlarge on this aspect of the question because those interested therein will find it fully discussed in the

Proceedings of the Northeast Coast Institution of Engineers and Shipbuilders for the current year. The conclusion reached by Sir Charles Parsons and expressed in the course of that discussion is, however, worth notice. He said: "With the geared turbine and 100 degrees of superheat the cost of running a vessel with coal at 15 shillings a ton would be the same as with the Diesel engine with oil at 23 shillings (per ton)." If this estimate is correct, and there is no reason to doubt it, then the chances of the extensive use of geared turbines in future tramp steamers should be good; because there seems no probability of an approximation being made to such a low price of oil, particularly if very large quantities of oil were required for marine propulsion.

PREVENTION OF NOISE AND WEAR.

Prof. Biles, in his paper on the new Southwestern Railway steamers, said that the trials of the "Normania," "proved to those who were on board that the anticipation that the noise of the gearing would be negligible was a correct one," and it is understood

that subsequent experience on service has confirmed that favorable verdict. In other cases where geared turbines have been used experience has been equally favorable, and with well cut mechanical gearing running in oil there should be no trouble from this cause.

As regards the necessity for or the desirability of having something in the nature of a "floating frame," it may be said that no similar arrangement has been fitted hitherto with Parsons geared turbines, nor has there been any evidence in these vessels that elasticity in the bearing is necessary or important for the automatic elimination of unequal tooth pressures. Whether or not with very large powers some such elasticity in the bearings may prove desirable is a matter which will be decided by experience. If there should be evidence that such elasticity is desirable it can be provided readily; but experience up to date, and with powers much exceeding the power installed in the collier "Neptune," shows that the Parsons system of gearing has been successfully applied and worked for long periods without any such feature having been found necessary.

The Flashing Arcs*

A Volcanic Phenomenon

By Frank A. Perret

ON the afternoon of April 7th, 1906, the present writer, in company with Prof. Matteucci, was skirting the southern flank of Vesuvius on a trip to the main source of the lava at the Bosco Cognoli. The volcano at this time was entering one of those paroxysmal phases by which the eruption—already three days old—worked progressively up to its great culmination, which occurred, it will be remembered, between this and the following day. The ejected detritus was of a mixed nature, viz., the fresh lava, clear red in full daylight, being mingled with old material from the upper portions of the cone, then in process of rapid demolition. The frequency of the explosions varied from approximately one every three or four seconds to at least three per second. Although powerful, they were very sharp and sudden in their nature, and at the instant of each—but before it could be sensed by the eye or ear—a thin, luminous arc flashed upward and outward from the crater and disappeared in space. Then came the sound of the explosion and the projection of gas and detritus above the lip of the crater. The motion of translation of the arcs, while very rapid in comparison with that of the detritus, was not above the limits of easy observation and there could be no doubt as to the reality of the phenomenon, which was repeated some hundreds of times.

The writer attempted photography but without success, the failure being due in part, perhaps, to the velocity of the arcs and their very moderate brightness, but also most certainly to the extreme unlikelihood of the shutter being snapped at the precise instant of the apparition. One of the photographs is reproduced in Fig. 1, and I have permitted myself to trace upon the negative film with aniline two circles which print out in the approximate appearance of the arcs, assuming these to have been arrested instantaneously during their up- and out-springing from the crater.¹ It should be stated that this illustration, because of its crudeness and the lack of motion, conveys but a poor idea of the actual phenomenon, the beauty of which lies in the delicate luminosity, the elegance and perfection of form, and the grace and vivacity of the arcs amid the contrasting color and relatively sluggish movement of their surroundings.

During the extraordinary activity of Stromboli in 1907 the writer did not observe the flashing arcs although some of the explosions appeared to have the qualities which should have produced them, but the place of observation was probably too near the crater. The small eruption of Etna in 1908 was not observed, but the conditions were not, in my opinion, such as to have reproduced the phenomenon. At Teneriffe in 1909, although incandescent lava was still available for research work upon my arrival, the explosive effects, which had been powerful, were virtually at an end, and it was therefore with the greatest delight that during the 1910 eruption of Etna I again observed the flashing arcs.

By a rare good fortune the explosions in this case were almost without detritus, thus forming a condition the very opposite to that at Vesuvius in 1906. It will be remembered that this eruption of Etna produced a fissure two kilometers in length over which were formed some twenty-four small craters. The explosive

forces were thus so subdivided and distributed that no very large cones of scoriae were built up, many of the craters being little more than holes in the ground. One of these, although larger than the average, was so perfectly free from surrounding debris that a post-

Fig. 1.—Circles Indicate the Appearance of the Arcs.

Fig. 2.—Bomb Thrown Out in Etna Eruption.

eruption visitor might well have been pardoned for considering it the least important of the entire series. It was, however, the seat of all the heavier explosions, each of which hurled one or two bombs of stiff, incandescent lava to a considerable distance, but without any accompaniment of ash or other detritus. On the morning of March 30th bombs as large as a meter in diameter were ejected (Fig. 2), and these explosions produced the flashing arcs which were in all respects identical with those of Vesuvius. Until they were pointed out to him my guide did not observe them, and it is quite possible that I myself might not have seen them had I not known what to look for, as the absence of a darker setting and the lesser distance of

the viewpoint rendered them more difficult of observation than at Vesuvius. Some fifteen were clearly seen by us, all the stronger explosions producing them.

What is the nature of this phenomenon? The only hypothesis which seems in accord with the observed characteristics sets forth a proposition which, at first thought, may seem almost startling, viz., that we have to do with *visible sound waves*. According to some far from accurate measurements made on the spot the velocity of propagation of the arcs seemed to correspond with that of sound. We may certainly assume the outburst to be spherical or at all events globular, as though a huge soap bubble were rapidly blown from the crater and that the edge alone is visible and therefore appears from any point of view as an arc. The movement of this visible portion will therefore be at right angles to the line of sight and the arrival of the sound—from the crater radially to the observer—must be compared with the arrival of the arc at some point equidistant from the crater but at right angles to this radius. As the arcs rapidly fade into invisibility with increasing distance from their source the difficulty of accurate measurement will seem to be very great.

But if we attack the problem by the way of exclusion we shall find, I believe, that the velocity—even assigning to it values having a considerable margin above or below that of sound—can be made to harmonize with no other mode of motion. Actual mass movement, i. e., motion of translation of any material, solid, liquid or gaseous, is negated by the flashing of the arcs amid the relatively slowly rising and perfectly undisturbed volutes of vapor and detritus as well as by their direction of propagation, which is outward and downward as well as upward. On the other hand, any attempt at explanation on the basis of Hertzian or electromagnetic effects, due possibly to stress relief, etc., must also be excluded on the speed basis, which now becomes much too low.

After all is said, is there any real difficulty in accounting for the flashing arcs on the basis of the proposed hypothesis? Sound is propagated in air by compressional-rarefactional waves projected normally. The conditions for the production of the arcs are sudden explosions on a large scale. Given these in sufficiency, may we not imagine that in the resulting aerial condensational-rarefactional wave—or sheet of superposed waves—the refractive and reflective indices will be so altered as to form in bright daylight a zone visible by contrast, especially when viewed longitudinally, i. e., through the edges of the transparent sphere? We are familiar with the visibility by contrast of the refrangibility of hot and cold air, and it would seem that mechanically engendered compressional-rarefactional aerial waves should be visible in the same manner if sufficiently accentuated. It is a question of the degree of condensation and rarefaction, and this evidently depends directly on the power and inversely on the time factor. The proposition will be more truly scientific and possibly more acceptable if stated thus: An explosion propagates normal condensational-rarefactional waves in air—these are perceived by the ear as sound and may also be visible by unequal refraction when sufficiently powerful.

As observed by the writer at Vesuvius and Etna, the flashing arcs may be considered one of the most beautiful of all volcanic phenomena.

* Reproduced from the *American Journal of Science*.

¹ It may be that I have centered the circles too high above the crater.