Letters to the Editor.

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The Flight of Flying-fish.

IT is disputed whether the flight of flying-fish is a genuine flight or simply a leap and a glide. The question is referred to in the section devoted to flying-fish in the Natural History Museum, South Kensington. Recently I have had ample opportunity to study these fish in the tropical waters of the Atlantic and Pacific Oceans.

The observations which I have made and the conclusions at which I have arrived are corroborated by the officers of the R.M.S. *Victoria*. Many of these gentlemen were surprised to hear that there was any doubt on the matter. That the flight is a genuine one is proved by the following facts:—

(1) During flight these fish are able to turn at right angles, and even at a very acute angle. More than once I have seen a fish turn with great rapidity at an acute angle and come back in a direction opposite to the direction in which it set out. A mere glide will not enable any animal to do this.

(2) Standing at the bow of the ship directly above some flying-fish which were in a hurry to get out of the way, I saw the wings flap as distinctly as the wings of any frightened bird.

(3) Some of these fish fly for a distance of from 150 to 200 yards without rising more than a couple of feet above the surface. They rise over the crests of the waves and sink into the hollows. They could not do this by a mere leap and a glide.

(4) Besides flying low over the surface of the waters, they are also able to rise to a considerable height, and not infrequently come on board large steamers. When they fall on deck their wings can be seen, as well as heard, flapping. It is true that they are unable to rise from the deck, but the same is true of many sea-birds.

(5) When in full flight the outlines of the wings are indistinct and blurred in contrast with the clear outline of the body. This can only be due to the very rapid movement, as in the case of hovering flies and humming-birds.

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An Experiment on the Spectrum.

IN school and college courses little experimental work is done on the infra-red and ultra-violet parts of the spectrum. The student is, of course, told about these regions, and how they can be detected respectively by the heating and actinic properties of their rays. But he is not allowed to investigate these rays himself, nor are their properties demonstrated before him. This is on account of the elaborate nature of the apparatus necessary; the infra-red region requires a thermopile or bolometer, together with an expensive galvanometer, and the ultra-violet requires photographic methods and a spectrograph. So much apparatus cannot be afforded for one experiment, and besides is apt to distract the student's attention from the simple nature of the facts involved.

If, however, a very intense spectrum is used, the infra-red can be mapped roughly with an ordinary thermometer, and the ultra-violet with a photographic exposure-meter. Neither galvanometer nor spectrograph is necessary. The thermometer I have used is a Fahrenheit one, range 0° to 220°, the bulb of which is blackened by dipping it into lamp-black shaken up with methylated spirits; the bulb is 5 mm. in diameter. The exposure-meter is the Imperial exposure-meter for dull light and interiors, which costs 1*s*. 6*d*. together with a refill. In this instrument a piece of sensitive paper is exposed to the light, and the time noted that it takes to darken to a standard tint. The sensitive paper supplied darkens two or three times as fast as ordinary P.O.P. As source of light I have used a little 5-ampere arc lamp, which is run off the lighting circuit through a rheostat. The anode is horizontal and the cathode vertical; they are both enclosed in a glass cylinder which restricts the supply of oxygen, and so lengthens the life of the carbons. Lamps of this pattern burn very steadily, and have come into wide use during the past ten years. It is because so many laboratories have these lamps that I describe this experiment here. An arc of this pattern is absolutely necessary; a pointolite or half-watt lamp is of no use for the purpose.

As lens I have used a spectacle lens of 25 cm. focal length, and as prism a single equilateral dense flint 1¼ in. high. The spectrum and arc are equidistant from the lens. As slit I have used the crater of the arc, which measures about 3 mm. in diameter, since the carbons in this type of lamp are only 5 mm. thick. If the rays of light from the anode fell squarely on the lens we should have a point image of a point source, and the spectrum would be only 3 mm. high, but by setting the lens obliquely, rotating it through 30°, an astigmatic line image is formed, and we get a reasonably sharp spectrum 12 mm. high. Stray light is excluded by enclosing the arc in a box.

The following table gives a set of results taken in somewhat less than an hour:

Scale cm.	Colour	Rise of temperature ° F.	Photographic action
7·0	—	0·0	—
7·5	—	0·8	—
8·0	—	3·4	—
8·5	—	5·4	—
9·0	Infra-red	3·4	—
9·5	Red	2·0	—
10·0	Yellow	0·5	0·5
10·5	Green	—	2·7
11·0	Blue	—	1·5
11·5	Violet	—	2·4
12·0	End of visible	—	5·0
12·5	Ultra-violet	—	5·0
13·0	—	—	0·57

The ends of the visible spectrum were at 9·2 and 12 cm The first column gives the readings on a centimetre scale placed along the spectrum, the second column the name of the colour, the third the rise of temperature experienced by the thermometer in three minutes, and the fourth the reciprocal of the time in minutes taken by the paper to darken to the standard tint. In the case of the last two readings the exposure-meter was illuminated by stray light. It is possible to go further into the ultra-violet if a crown glass prism is used. The infra-red measured goes to 2·2 μ or thereabouts. If a piece of P.O.P. is exposed to the spectrum for a couple of minutes, it shows bands—one from 10–11 cm., another from 11·3–11·7 cm., and a third from 11·8–12·7 cm., the positions all being measured on the centimetre scale above referred to.

It is interesting to remember that when Sir William Herschel discovered the heat spectrum in 1800 he used thermometers. The source of light was the sun, and the arrangement was similar to Newton's original one—the prism was placed close up to a slit at a window, no lenses were used, and the spectrum