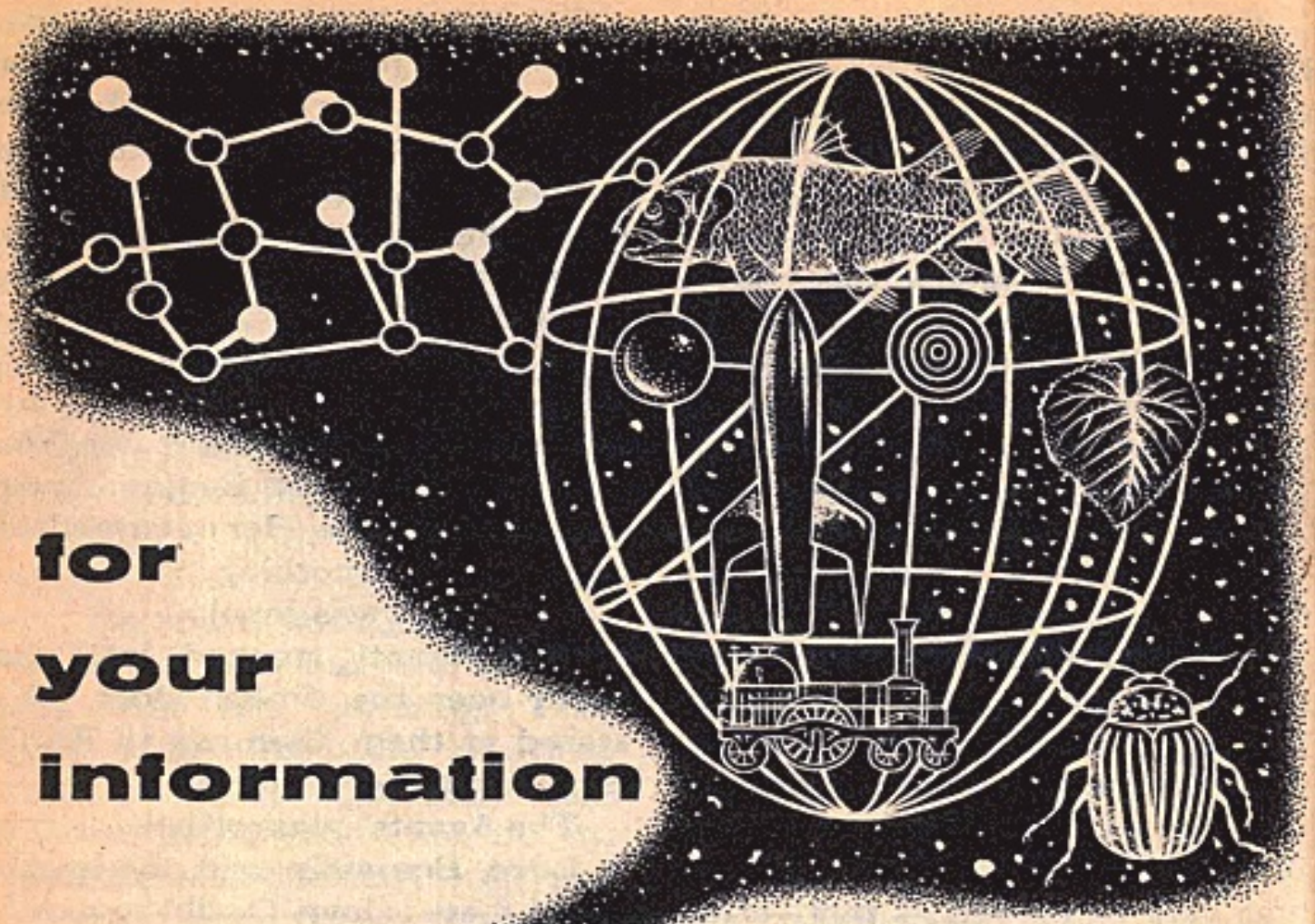

for your information

BY WILLY LEY

THE MOON WORM

THE theme of this column has been suggested to me by the most unusual introduction I have received so far. The place was a small town in Tennessee, the occasion a dinner party preceding a lecture.

One gentleman, upon learning my name, took me to meet his wife and introduced me as "the man who doesn't believe anything." While both his wife and

I looked surprised, he continued: "He doesn't think that there are any cosmic secrets in the Great Pyramid; he doesn't believe that Atlantis ever existed; he doesn't think that the Dalai Lama could have killed off the whole invading Chinese communist army with a single magical gesture if he had wanted to use his powers. He also doesn't think that the flying saucers are spaceships watching us. In short, he doesn't think that there are any mysteries!"

All this was stated with a fair amount of belligerence. Next day, looking out across the overcast from an airplane window, I suddenly had the impression that this belligerence had been directed at the lady. But that was an afterthought (and possibly a wrong one); at the moment I had just replied politely that my disagreement with the stories about the Great Pyramid and Atlantis was due to the fact that I believe I know how they came to be written. I added that I am positive I had never said anything about the Dalai Lama and his alleged magical powers. There I had simply had to trust the news services, which reported that he did flee from the invaders and took something as prosaic as money with him.

As for mysteries which are still left, I don't have to "think," as the gentleman phrased it. I know there are a number of them and they are good ones. They are fully documented, but at the same time they are as inexplicable as if they were the merest hearsay.

Here is a sampling.

"WHEN," THE Samoans told the English traveler Powell, "this shrub is covered with blossoms [Powell knew that the blossoms, which he had seen before, would be bright scarlet and that the shrub bore the scientific name of *Erythrina indica*] it is time to see whether the boats and the baskets are ready. Then, when the *Sisi* plant [related to the myrtle] blooms, we look for the Moon. Soon after, the Moon will be just above the horizon toward evening (west) at dawn. Ten days later we will have *Mblalolo levu* and a month after that *Mblalolo lailai*. You'll see."

Powell noted that the islander's face was beaming in anticipation when saying *Mblalolo lailai*. It was a big event for the Samoans as well as for the Fiji Islanders, these two feasts coming a month apart. The term "feast" is to be taken in its primitive meaning, an occasion where everybody present eats until nothing can possibly be stuffed inside any more.

Fig. 1: Palolo morning off Samoa, about 1890
(From *Kosmos*, 1926, original artist unknown)

It must be remembered here that these islands are in the southern hemisphere; though the two months in question are October and November, this was a spring festival. It might also be useful to state that the word *levu* means "little" or "minor" and the word *lailai* means "large" or "major." The word *Mblalolo,* finally, was adapted by somebody, possibly by Powell, for Western tongues by changing it to *palolo.*

During the night of the *Mblalolo* the Samoans did not go to sleep. Late, after midnight, they rowed out, but not very far. While the men handled the oars, the women had loosely woven baskets ready. Other women and boys who did not yet have adult status sat at the shore with their baskets. All of a sudden, at four A. M., the sea became alive. Wormlike shapes wiggled at the surface, as suddenly as if they had been ejected by a submerged explosion. Within less than ten minutes the surface was solidly covered with worm bodies, wiggling, squirming, in steady motion.

The girls scooped them into the boats with their baskets and everybody aboard — and ashore — started to eat. The worms were so thick that one did not even need a basket; just reaching into the water with bare hands

would bring edible results.

But only for an hour or so.

At the end of that time the ocean would look cloudy, as if milk had been poured into it, but no more worms. The boats returned to shore with their catch; the gourmets preferred their worms baked in palm leaves. And countless runners were waiting ashore too, to carry baskets to those living farther inland. On Samoa, as reported by a later investigator, the islanders had organized relays of runners to get the delicacy inland just as fast as well-exercised legs could do it.

These were the cultural aspects, the two feast days, or rather nights in spring, based on the sudden appearance of an edible marine creature.

The zoological aspects were not quite as simple.

THAT the things which came to the surface in uncountable multitudes were worms was beyond any doubt. In fact they were annelid worms, of the same general type as our earthworm, but a large marine version. They came in two colors. One was darkish green or bluish green; these were filled with eggs, literally to the bursting point, for that's the way they disappeared an hour or so later, by bursting. The other kind was whitish or yellowish or about the color of egg yolk. These contained the male sperm.

As for the length of the worms, the reports were at first a bit confusing; any length between one inch and fourteen inches was reported. But it was soon realized that the shorter ones were literally pieces, segments broken off the bigger ones.

So far things were nice and clear; the two Mblalolo nights were the mating periods of these worms. As the Samoans had said all along, the two mating nights were one month apart, but they did not fall on the same dates in successive years. Outside of these two mating nights, nobody had ever seen a Mblalolo. It obviously lived at the bottom of the sea normally.

The worm was first given a scientific name, *Palolo viridis*, the second word with reference to the green color of the egg-containing segments. A little later the scientific name was changed to *Eunice viridis*. It was quite clear from the outset that the sexes were very strictly separated, each worm being either male or female. But the early observers reported with head-shaking that all the worms were headless.

Samoa, at the time I am talking about (ca. 1890), was still an independent kingdom with three

countries yielding a good deal of influence: the United States (which had leased the harbor of Pago Pago—pronounced Pango Pango—), Great Britain and Germany. In 1898 trouble developed which led to the withdrawal of Great Britain and a partition of the Samoan islands between the United States and Germany.

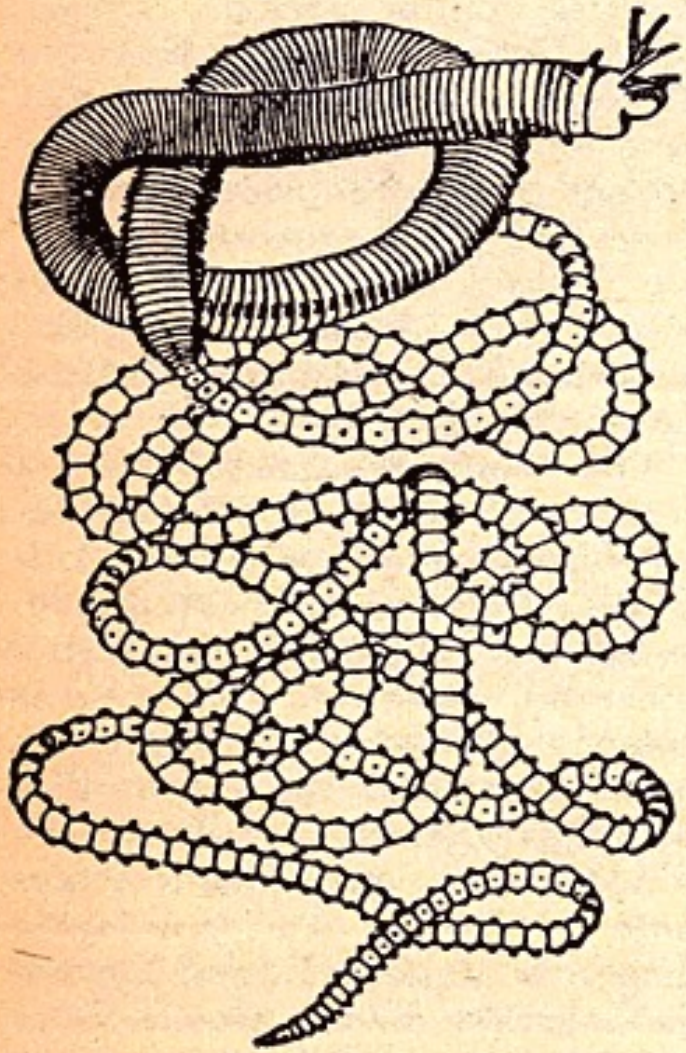

Fig. 2: *Eunice viridis*, alias Palolo. Complete specimen; the spawning break occurs where segments become roundish

But before this political development took place a German zoologist, Dr. Benedikt Friedländer, had arrived on the scene. His first attempt had been to find the palolo in its natural habitat and under pre-swarming conditions. He fished for it a fair distance from the shore and at considerable depth. Of course he caught some marine worms but none of them was *Palolo viridis*. While thinking about the equipment he would need to fish at even greater depths (and, logically, still farther from shore) he talked to Samoans.

Somewhat puzzled, he told after his return to Berlin that the information coming from "an old woman" had been best — presumably he expected that young and actively fishing men should know most about it. The old woman told Dr. Friedländer that the worms lived in cracks of the coral rock, not very deep and close to the shore. Benedikt Friedländer, willing to try everything once — he even tried the green palolo segments when they swarmed, reporting that they tasted like almost unsalted Russian caviar — had a number of blocks of dead coral hauled up. Yes, there was *Palolo viridis*, complete with head and up to about 40 inches long.

The old woman had also told him that the worms in the coral

rock, if placed in pails of sea water, would swarm at the same time as the worms in the open. Friedländer was too busy to make the experiment but did not doubt the statement; he just stated honestly that he had not verified it.

ONCE you had the complete worm (Fig. 2) many of the puzzles became quite clear. The worm as a whole does not swarm. The head and about the first fifth of its length stays quietly where it always lives. The latter part of the body, the portion containing the eggs or the sperm, is detached at the right moment, rises squirming to the surface and, after a while, bursts, thus uniting eggs and sperm. One segment of the worm population does this in October; this is the smaller group. The larger group (suspected to be the older worms) does it in November. Friedländer watched the *Mblalolo lailai* of November 16, 1897.

Well, all this is admittedly somewhat weird, but the facts are established. What is the "mystery"?

The mystery is the timing.

The Samoans, as has been mentioned, looked for the Moon after the *Sisi* plant bloomed. Friedländer found that the first swarming occurred when the Moon was in its last quarter, after the first full moon in October. The second (and bigger) swarming took place when the Moon was in its last quarter after full moon in November. Now these figures must *not* be understood as being approximations. The palolo does not swarm "about a week after full moon," but at the moment the Moon is in its last quarter, with a leeway to be measured in hours only.

Nobody has been able to figure out why.

It can't be the light of the Moon. To begin with, the moonlight is obviously much stronger when the Moon is full, but nothing happens then. Moreover, the *Mblalolo lailai* watched by Friedländer happened to be a night with heavy cloud cover, and during the second part of that night rain poured unceasingly. It can't be the tidal influence. Again, that would be more pronounced at full moon. The great Swedish scientist Svante Arhhenius thought that it might have something to do with atmospheric electricity — the Samoans had said that sometimes there had been thunderstorms during those nights. But more often there had been no thunderstorms.

There is no use wasting space on the problem. We simply do not know.

But since Friedländer's day

we have found something else: a related worm with the same behavior, this time in the northern hemisphere and in the Atlantic. It is *Eunice fucata* of the island Loggerhead Key in the West Indies. It also swarms when the Moon is in its last quarter, but here it is the last quarter following the full moon in July.

Because the numbers are smaller, it is not as spectacular as around Samoa and the Fiji Islands. But the performance is the same and the mystery of the timing is the same.

SLOW LIGHTNING

JUST AS dictionaries and encyclopedias are in need of constant revision, our popular sayings should be amended too from time to time. The man who says "Everything that goes up must come down" should be obliged to add "unless it reaches escape velocity." Likewise the man who says "with the speed of lightning" should make the provision "but I don't mean ball lightning."

Ball lightning may move as slowly as three inches per second. It may even stand still for a short time. Ball lightning is one of the things I have yet to see myself. I also have never seen a volcanic eruption, but this problem (if it prayed on my mind) could be easily solved by flying to the scene of an erupting volcano. Ball lightning is, as far as we know, pure chance. But I do know that my chance would be somewhat better in Europe north of the Alps.

So many Americans have never even heard of ball lightning because it happens to be very rare in North America. That a natural phenomenon should be rare in one area and not rare in another seems somewhat incredible at first glance. But it is a fact, for example, that "twisters" are rare in northern Europe (and if they do occur they are quite weak compared to their American counterpart) and ball lightning, while by no means a frequent phenomenon in Europe, seems to be positively abundant compared to its rarity in the United States.

Instead of describing ball lightning and how it behaves, let me give a condensed quotation of a case which took place in Paris just after noon on July 5, 1852, and for which sworn statements were filed with the French Academy of Science.

It was during the summer and for this reason the fireplace in the apartment was not in use. According to custom the front opening of the fireplace had been closed by a wooden frame to

which stout wrapping paper had been pasted. Likewise the curved stove pipe on top of the fireplace had been taken down and the round hole in the wall into which the stovepipe fitted had also been pasted over with wrapping paper.

The apartment in the Rue St. Jacques, next to the Val-de-Grâce Church, was located on the fourth floor and occupied by a tailor. He had finished lunch but remained seated at the table because there was a thunderstorm going on. Some time (not immediately) after a very strong thunderclap, the frame closing the fireplace was pushed out as if by a strong gust of wind. Then a fiery ball, the size of a human head, emerged from the opening and meandered slowly about the room, a few inches above the floor. The ball was brightly luminous but did not radiate any heat.

It approached the tailor's feet ("like a cat," he said later) but the man did not wish to be touched. He pulled his feet back without rising from the chair and watched the ball which slowly moved around in the center of the room. Then it suddenly rose to about one yard above the floor. It became slightly elongated and flew to the hole in the wall. The paper was peeled off without being damaged in the process and the ball disappeared in the chimney. After it had climbed to the top of the chimney — very slowly — it exploded with a loud noise, destroying the top portion of the chimney.

TO SOMEBODY who reads such a description for the first time, all this sounds pretty far-fetched. But to anyone who is conversant with the behavior of ball lightning this is merely typical, as can easily be seen from another case, this time from Königsberg, East Prussia.

The owner of a beer garden outside the city, a Herr Babinski, rendered the following description: "We had a strong thunderstorm during the early afternoon hours and my beer garden was hit by lightning which, however, did not cause any damage. Immediately afterward there appeared, at about my eye level, a reddish rotating ball approximately 16 inches in diameter, in the open door of the restaurant kitchen. Since the other door of the kitchen was open too there was a considerable draft. The sphere, rotating all the time, passed quite a number of people, climbed up along the wiring of the electric bell, was then apparently caught by the draft, then moved along another electric wire to the stable and ex-

ploded with a loud noise above the door of the stable."

That ball lightning likes to travel along a conductor is almost proverbial. One was seen on May 19, 1925, in the Dutch city of The Hague. It moved for a very considerable distance along a streetcar rail, then jumped into a transformer box and disappeared.

A real estate owner in East Prussia, Reich by name, had the interesting experience of being pursued by ball lightning. In the evening of "the Day of Pentecost, 1890, at 8 P.M." Herr Reich drove his carriage along a country road lined on both sides by wire fences. His carriage was of the open type, with four rather large iron-rimmed wooden wheels, running on iron axles and normally drawn by two, but since this was in horse-breeding East Prussia, more likely by four horses.

"The sky was covered with clouds, but it was not raining. Two very bright head-sized balls appeared on both wire fences, moving along the fences at the same rate as the carriage. Many sparks jumped from these balls to the carriage axles. The horses shied and increased their pace but the faster the carriage moved the faster the .fire balls moved until we came to the end of the wire fences. There both balls, collapsed into nothing, without an explosion but with a noise like crumbling a sheet of paper."

Finally a case which happened near the small town of Bischofswerda in Saxony on April 29, 1925, at half an hour after noon. It was one of the rare cases of a violent lightning ball which was described by many witnesses.

Taking it chronologically, the first witness was a mailman by the name of Fasold who asserted that he had not known about ball lightning. He was on the road and saw "a grayish-black cloud from which something dangled which almost looked like a trouser leg. Suddenly something fell from this dangling trouser leg which looked like a golden beer barrel. This body landed near a telephone pole with a loud crash and I had the impression that it came apart, somewhat like emptying a basket of potatoes. From this heap real lightning jumped and one of the strokes hit the school. I was so surprised that I can't say whether the crash was followed by real thunder or not, but I know that it was raining a bit before and that a little hail fell afterward." Mailman Fasold also stated that the trees looked for a short time like Christmas trees, as if they had candles at the tips of the twigs.

AT THE school they saw a lightning ball move along the telephone wire (later it turned out that it had first smashed a transformer box) traveling at about the rate of a briskly walking man. The ball moved into the apartment of the teacher (which was part of the school building). The teacher (male) was using the telephone and stated that the lightning ball threw him to the floor. The telephone itself was not damaged. The door to the teacher's apartment had a glass pane; later it was found to have two holes both perfectly circular and clean. One of these two holes was the size of a silver dollar, the other that of a quarter (the German report mentions other coins, of course, but of the size of the American coins named) and it is thought that the bigger hole was that caused by the entry while the smaller one was caused on leaving, when the ball had expended some of its energy. Like other lightning balls, it moved along wires, but this one melted the wires into tiny spherules of metal. But it did not ignite inflammable material in its direct path — also a common feature of all the reports, lightning balls have been known to melt down quarter-inch bronze rods, but nestle in excelsior without igniting it — and then proceeded along a ceiling. It must have moved under the plaster, because the plaster was forced off. Then it broke through a wall and disappeared.

Afterward additional damage was found, presumably caused before the lightning ball entered the school building. The telephone wire had been melted down for 700 feet of its length, several telephone poles, including a fifteen-foot support of angle iron, were splintered, a cable 2½ feet below ground was severed as if with a stroke with a sharp axe, the trunk of a cherry tree was split and several men working near the road were thrown to the ground without harming them otherwise. And all this, as far as the witnesses could recall, without making any noise at all!

The overall picture is that a rather large amount of electrical energy is concentrated in one spot, that the lightning ball prefers to follow electrical conductors which it may or may not melt in the process, that it does not set fires and does not electrocute people. Several people have been touched by lightning balls, much against their will and inclination, in most cases without experiencing any sensation. Some people were thrown to the ground, but without other harm than that caused by the

fall itself. Most of the time the end of the ball is by way of an explosion which is described as sounding like the sharp crack of an enormous whip. But the damage caused by the explosion is minor. Often the balls just go out. In most cases the witnesses cannot tell where the ball came from. In a few cases it has been seen to fall from a cloud, but very slowly, as if its weight were negligible. In a few other cases witnesses think that it followed the path of a normal lightning stroke which preceded it.

Sometimes lightning balls have appeared without an accompanying thunderstorm. Most of them, however, were associated with thunderstorms, though it is almost a rule that they appear at the end of the storm — the end for the area in question, that is.

Now, how do they originate?

Well, that's the mystery in this case.

A Norwegian engineer by the name of A. Nielson once obtained an artificial lightning ball by accident when short-circuiting a 12,000-volt generator. This ball rose in the air and then disappeared (dissipated?) — it may not have been a real lightning ball but just a cloud of superheated air and metal vapor which happened to take on a spherical shape.

BACK in 1954, the well-known Soviet atomic scientist P. L. Kapitsa busied himself with a theoretical study of ball lightning. His reasoning is very interesting, though I have a feeling that it is not the answer. Academician Kapitsa pointed out that the cloud resulting from an atomic explosion lasts a very short time in spite of its enormous size. Such an explosion cloud consists of gases which Kapitsa assumes to be 100 per cent ionized. Ball lightning, which must consist at least partly of ionized gases, is known to last for a minute and longer, and its size, compared to that of an atomic explosion cloud, is virtually microscopic. Hence, Kapitsa reasoned, the lightning ball must have a steady "energy income" during its lifetime. When this "energy income" is cut off, the ball shrivels into nothing; it just goes out. If the supply is cut off very suddenly the ball collapses, its collapse causing a shock wave which makes the sharp crack. The noise, then, would be that of an implosion rather than that of an explosion. (The nature of the sound is no clue as to which it is, unfortunately. Either an explosion or an implosion can cause such a sharp crack.)

Kapitsa's guess as to what feeds the lightning ball for the

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duration of its existence is natural radio waves, presumably generated by the storm cloud and reflected by the ground. A very interesting idea, but this is really explaining one unknown by another one. It seems logical that a thundercloud might generate radio waves, but we don't know to what extent. Kapitsa is too much of a scientist to insist that his idea is right just because it is his idea. His paper begins with the sentence: "The nature of ball lightning is not as yet understood."

But while I don't think that Kapitsa's reasoning, novel as it is, has solved the problem of the origin of ball lightning, he quoted a case reported in *Nature* (No. 563, April 1952) where a lightning ball entered the interior of an airplane flying at an altitude of 9,200 feet. This is the first recorded instance of high-altitude ball lightning that has come to my attention. But I have always suspected that high-altitude ball lightning exists.

Naturally I have not quoted all the cases on record — they would fill a book. In fact, they *do* fill a book; it was written by Dr. Walther Brand in 1923 and published during the same year in Hamburg by the publisher Henri Grand. (Its title is *Der Kugelblitz.*) In reading through this book soon after it was published, I was impressed by the fact that only a small number were reported from flat land areas near sea level. Ball lightning seemed to occur much more frequently in mountainous areas, at least a thousand feet above sea level. I may add here that the only two eyewitness accounts I got in the United States conformed to this pattern: one came from a mountainous area in the East and the other from Denver.

Assuming that ball lightning was more likely in a somewhat rarefied air, I wondered whether it might not occur fairly high up — say 10,000 feet — in free air. When, near the end of the Second World War, we got those reports about the so-called "foo fighters" — balls of light following our airplanes near their wingtips for long distance without ever doing anything — I immediately thought of the two lightning balls which had accompanied the open carriage on the country road.

Taking the same risk which Kapitsa took, namely of calling on one unknown to explain another one, I have held for a long time that the answer to many "flying saucers" is ball lightning in mid-air. Since we don't know how ball lightning forms, one might even speculate whether the presence of the airplane is

not one of the factors which causes it to form.

But at least we do know that ball lightning exists.

What we still have to learn is how it comes into existence.

PINWHEELS UNDER WATER

IN THE CASE of the palolo, we know everything except the reason behind the timing, or, better, the mechanism of the timing. In the case of ball lightning, we know that the phenomenon is electrical and we have a number of case histories, but do not know reasons or conditions for its occurrence.

Our next mystery is one where we just know that it exists. It has been well described just once, in the January 1952 issue of the *United States Naval Institute Proceedings*, by Commander J. R. Bodler USNR.

Like a good seaman, Commander Bodler supplied all the detail: "Date, 14 November 1949, Time 1830 GMT, Position 26° 17.5′ N., 56° 51′ E. Wind NW'ly force 1. Sea calm with slight surface ripples; no swell. Air 75° F., sea 83° F. Visibility: very good. A clear bright night with no moon. Course 157° T., speed through the water 11.6 knots, actual speed over the bottom approx. 9 knots due to strong head current. At no time were any unusual deviations of the magnetic compass observed."

In landman's language this means that the vessel, bound for India, had come from some port on the Persian Gulf and was about to enter the Gulf of Oman. At that time the third mate called the skipper to the bridge. "About four points on the port bow, toward the coast of Iran, there was a luminous band which seemed to pulsate." At first Commander Bodler thought that it was near the horizon; then it turned out that it was below the horizon, in the water. The luminous patch, which clearly pulsated, happened to be on course of the vessel so that the two drew together.

"At a distance of about a mile from the ship," to quote Commander Bodler, "it was apparent that the disturbance was roughly circular in shape, about 1000 to 1500 feet in diameter. The pulsations could now be seen to be caused by a revolving motion of the entire pattern about a rather ill-defined center; with streaks of light like the beams of searchlights, radiating outward from the center and revolving (in a counterclockwise direction) like the spokes of a gigantic wheel."

A sketch drawn by Commander Bodler shows that the

outer ends of the "spokes" lagged behind, as if whatever made up the spokes of the wheels moved with a nearly uniform speed, so that the extreme ends naturally lagged.

"For several minutes the vessel occupied the approximate center of the phenomenon. Slightly curved bands of light crossed the bow, passed rapidly down the port side from bow to stern, and up the starboard side from aft, forward. The bands of luminance seemed to pass a given point at about half-second intervals. . . . The central 'hub' of the phenomenon drew gradually

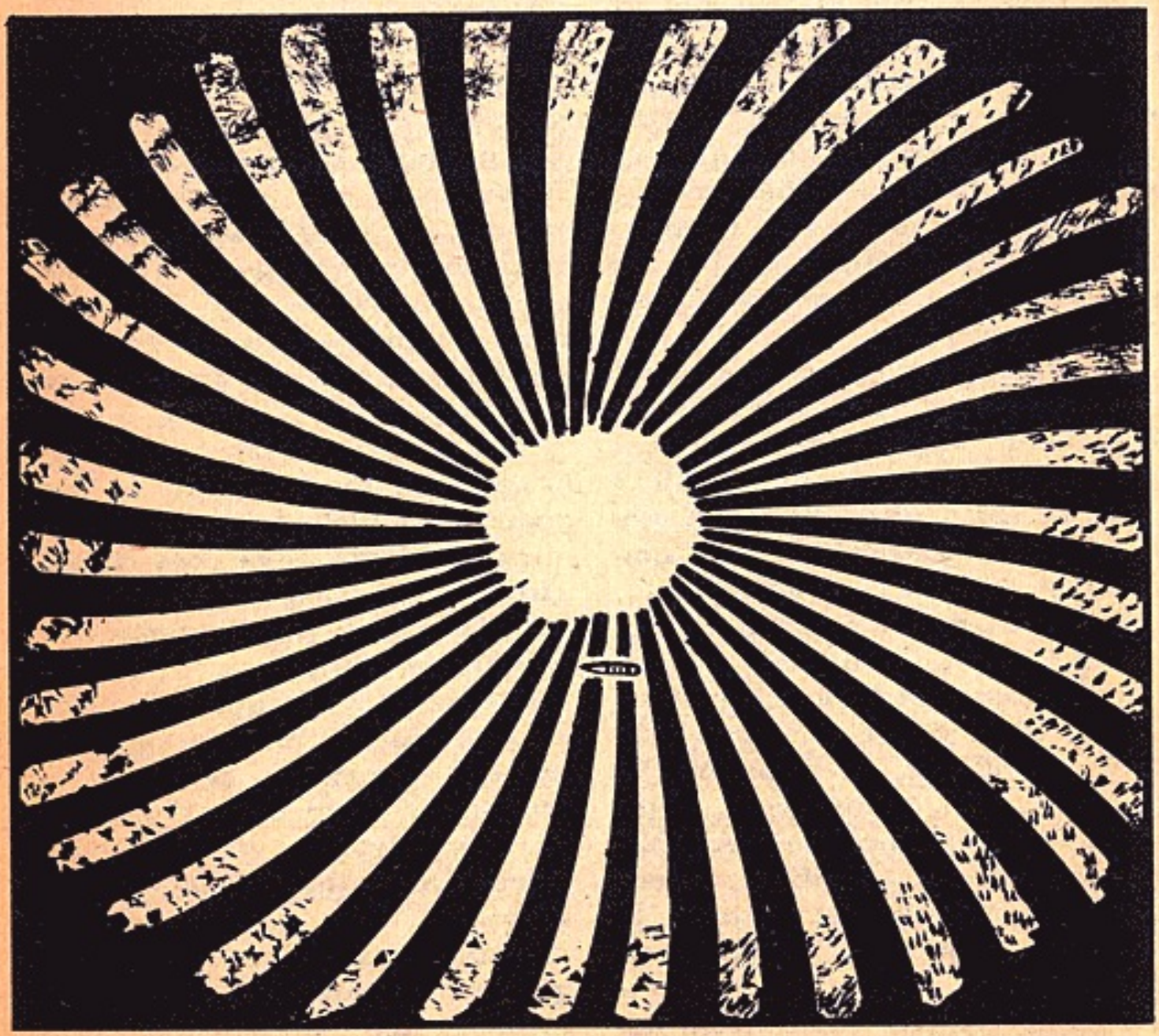

Fig. 3: How Commander Bodler's phenomenon might have looked from an airplane

to starboard and passed aft; becoming more and more distant on the starboard quarter. While it was still in sight, several miles astern and appearing, by this time, as a pulsating band of light, a repetition of the same manifestation appeared fine on the starboard bow. This was slightly smaller in area than the first, and a trifle less brilliant.

"Approximately half an hour later, a third repetition of this manifestation was observed. The general characteristics, direction of rotation, etc., were the same as the others, but this one was much smaller and less brilliant. Its diameter was not over 800 to 1000 feet and compared to the other two was unimpressive."

I CANNOT recall having read another report just like this. Some fifty years ago somebody whose name I don't remember wrote a description of an especially impressive example of phosphorescence he had witnessed from board of a passenger liner bound from the Mediterranean for Yokohama. He wrote that sometimes it looked as if the ship were the center of a gigantic fireworks pinwheel — but such a comparison can well be made, as everybody knows who has seen it, without experiencing the phenomenon described by Commander Bodler.

No, I don't know the explanation, but the discussion of the palolo phenomenon made me think of another marine worm, the fire worms of Bermuda. Like the palolo, they come to the surface to spawn a few days after the full moon, but not with such precise timing, and several months in a row in midsummer and early fall. The females come to the surface first and circle around, emitting flashes of greenish light. This attracts the males, which dart after them, also emitting flashes of light. Then they mate and burst open like the palolo — but the fire worms die because they take their heads along when swarming.

It has been suggested that the much discussed light which Columbus saw during the night before landfall was not a native's torch on the water, but fire worms in the water. It is, of course, possible that Commander Bodler's observation has a similar explanation. But at the moment this is just conjecture. We know of no marine organisms whatsoever which swarm in such a pattern.

— WILLY LEY

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