

spreads and flows over a flat surface in much the same way that a liquid would do, and as a pint of it poured on the floor will give sufficient vapor to cover 80 square feet with inflammable vapor to a sufficient thickness if ignited at any point to carry the flame back to the point of leakage, it is clear that the floor level is the one which should be specially considered in precautions to minimize danger, and a strong floor draught is one of the most important factors of safety that can be provided.

The reason why so few accidents happened in the past is due to the high temperature needed to ignite the vapor either alone or mixed with air, and a long series of experiments made in the early days of the use of gasoline showed that the vapor could not be ignited by the glowing spark on a splint of wood, a red-hot piece of coke, or a shower of sparks from a flint and steel; and from experiments which I have made since I think we may safely

assume that the ignition point is in the neighborhood of 1,200 deg. Cent., and it is this which has safeguarded its use. How often have we seen the careless chauffeur filling the tank of his car with spirit while at the same time smoking a cigarette, a proceeding which, had the igniting point been as low as that of any ordinary combustible, such as paper, wood or coal, would have led to disaster.

The necessary temperature to cause ignition, although never reached by a glowing body, is attained with the smallest of flames, the temperatures of which are practically all higher than 1,200 deg. Cent., and the throwing down of a lighted match on a surface over which gasoline vapor is flowing has caused many serious fires.

The high ignition point of the explosive mixture of gasoline and air also explains the necessity for a higher density spark for igniting the mixture in the cylinder.

The volume of vapor yielded by a sample of gasoline depends upon its composition, the variation which exists between the various constituents being shown in the following table:—

VOLUME OF VAPOR FROM GASOLINE HYDROCARBONS.

	Specific gravity.	Boiling-point.	Cubic Feet of Vapor	
			Per Gallon.	Per pound.
Pentane.....	0.626	37.6°C.	31.2	4.9
Hexane.....	0.664	69°	27.7	4.1
Heptane.....	0.700	98°	25.7	3.7
Octane.....	0.719	118°	22.6	3.1
Nonane.....	0.741	136°	20.8	2.9

So that the higher the specific gravity the lower will be the gas yield.

The Zodiacal Light

Theories as to Its Cause, and Its Place in the Solar System

THE theory that the zodiacal light is a nebulous ring surrounding the sun is, for the most part, no longer held. It was Baron von Humboldt's theory and Sir John Herschel wrote: "I cannot imagine upon what grounds Humboldt persists in ascribing to it the form of a ring encircling the sun." For dynamical and optical reasons we believe this theory to be untenable.

The theory that it is a solar appendage has received more support and in fact remains the theory most generally accepted. It was originated by Giovanni Domenico Cassini at the Royal Observatory, Paris, about 1685. But it is hard to conceive what form such an appendage can take reaching out from the sun to a distance exceeding the earth's orbit. At Pike's Peak in 1878 during a solar eclipse Professor Langley observed the long coronal streamers extending to a distance estimated at 10,000,000 miles, and the question has been asked: May not the corona in increasingly attenuated form extend 93,000,000 miles? Apart from the fact that the appearance of the Zodiacal Light does not correspond with that of the corona, Laplace declared that the sun's atmosphere "can extend no farther than to the orbit of a planet whose periodical revolution is performed in the same time as the sun's rotary motion on its axis, i. e., only $\frac{1}{8}$ of Mercury's distance from the sun." There is no evidence that the coronal streamers extend even to the orbit of Mercury.

Moreover, if the Zodiacal Light is a solar appendage of the kind supposed, reaching forth unbrokenly from the sun, it must create a resisting medium involving Mercury, Venus, the earth and the moon and of this there is no evidence. A variant of this theory invokes Arrhenius's doctrine of light-pressure, by which it is surmised that streams of electrons expelled from the photosphere are light-borne to a distance just exceeding the earth's orbit and there held in unstable equilibrium. This is a fanciful speculation and, without prejudice to the applicability of Arrhenius's doctrine to the relationship between solar electrical action and terrestrial magnetism, it may be stated that there is no evidence that the zodiacal light can be thus accounted for. The conception of a lenticularly-shaped envelope, which is usually connected with the solar appendage theory, arose in my opinion, from the lenticularly-shaped appearance of the zodiacal light as frequently observed. But this conception is rendered valueless by the fact that *the illuminated part of the Zodiacal Light band does not exhibit the whole of the Zodiacal Light band material at any one and the same time.*

The third outstanding theory to account for the Zodiacal Light is that it is an earth ring, comparable, say, to the "crape" ring of Saturn.

By using the word "comparable" it is not intended that the Zodiacal Light band corresponds in every respect to the crape ring of Saturn. Variety in similarity appears to be Nature's method. Saturn's ring system is situated in the line of the planet's equator. The Zodiacal Light band follows the line of the ecliptic and maintains with respect to the Sun's illumination a uniform appearance the year round, but as viewed by an observer on a fixed station the light changes in direction and intensity in the course of the year, according as the angle made with the horizon is more oblique or more nearly approaches a right angle. The points of resemblance suggested by the word "comparable" are (1) that, like Saturn's "crape ring," the Zodiacal Light band is a planetary ring and (2) that, like the crape ring, it is well-nigh transparent.

After the famous Leonid display of 1833, a discussion arose on the possibility of the Zodiacal Light being the origin of meteors. In the course of that discussion J. C. Houzeau contributed a paper to the *Astronomische Nachrichten* in which (as the result of his own observations) he argued that the causes of the Zodiacal Light

may be "more local than has been hitherto supposed." A few months ago a well-known English astronomer, knowing of my interest in Zodiacal Light investigation, wrote me that no definite, stable results can be obtained concerning the place of the Zodiacal Light in the Solar System "until we have a continuous series of observations on both sides of the equator." Presumably he was not aware that such a series had been made. From April 2, 1853, to April 12, 1855, Sundays excepted, for every day of good observing weather, the Rev. George Jones, A. M., U. S. N., chaplain of the U. S. Japan Expedition, made observations of the Zodiacal Light. His report, comprising notes made at the time of each observation, accompanied by carefully drawn charts, was published by authority of Congress as a government document and forms volume III of the report of the U. S. Japan Expedition under the command of Commodore W. C. Perry. Under no better conditions could a series of observations possibly be made, and the length of time, extending over two years, in both the eastern and western hemispheres, north and south of the equator, from 41 degrees 50 minutes north (near Hakodadi, Japan), to 53 degrees 38 minutes south. (Straits of Magellan), permitted of as diversified a study of the Zodiacal Light as could be desired. Of the 328 observations reported and charted, 148 were made in the tropics. On each chart is marked the horizon line for each observation (sometimes three or four on the same evening or morning); the ecliptic line is marked, also the place of the sun on the ecliptic below the horizon showing the angle between the sun and the horizon; the outline of the stronger part of the light for each observation is drawn with reference to conspicuous stars or planets and a dotted line surrounding this shows the extent of what Chaplain Jones calls the Diffuse Light spreading North and South of the stronger band as far as he could see it.

Among other interesting special features of his report we note the shifting of the Zodiacal Light, as projected against the starry sky, from hour to hour; but always along the ecliptic; the gegenschein visible in the east in the evening; the Moon Zodiacal Light in the evening in the east prior to moonrise; the joint Sun and Moon Zodiacal Light, seen in the west in the evening, the moon being at first quarter; the simultaneous eastern and western Zodiacal Lights, seen in favorable latitudes, the cone of light reaching up from both east and west horizons about midnight, the eastern light growing stronger as the western light fails; the pulsations of the light due either to atmospheric conditions or to com-motions in the Zodiacal Light band material; the varying brightness of the gegenschein sometimes well-defined, at other lines quite elusive and much elongated, due to change of angle of reflection in the course of the year.

While strenuously resolved not to begin his observations with any preconceived theory of the place of the Zodiacal Light in the Solar System, Chaplain Jones states that after a few month's observations, strive as he might, he could not banish the thought that it is an earth ring and this thought ripened into conviction by the time the cruise ended.

Present-day astronomers are generally agreed that the Zodiacal Light is at no great distance from the earth; that, as is said, there is something "familiar" about it. A careful perusal of Chaplain Jones's data, illustrated by his charts, leads one—no less than he was led when actually making the observations—to the conclusion that the theory of the Zodiacal Light being an earth-ring fits the facts more fully than any other theory. Especially the relation of the reflected moonlight in the eastern evening sky to the Zodiacal Light band; the presence at midnight of both eastern and western lights; the uniformly broad base of the light along the horizon, narrowing and sometimes tapering toward the observer's meridian circle; all of these facts considered in connec-

tion with the laws of the reflection of light argue a circularly or elliptically curved band at no remote distance from the earth, from which the light is reflected according to the angle of incidence.

Why, then, it may be asked, has not Chaplain Jones's conclusion won acceptance?

It is my judgment that the theory of a ring of nebulous or meteoric matter surrounding the earth was held untenable because, if the Zodiacal Light band were such a ring, the light would be *strongest directly behind the earth* as in the case of the full moon. It is, I venture to believe, this consideration which has led astronomers to reject the earth ring theory. Can this crucial objection be removed? It is unanimously conceded that there is a dimming of the Zodiacal Light directly behind the earth. At times nothing can be seen of it, at other times the gegenschein can be made out. The question naturally arises: Why is the Zodiacal Light dimmed (at times invisible), right behind the earth? My answer is: *The earth's shadow falls arthwart it.* The Zodiacal Light lies along the ecliptic—i. e. runs along the signs of the zodiac, the zodiacal constellations;—therefore, if within the range of the earth's shadow, it must thereby be dimmed. Lying on the ecliptic, the central part, so to speak, of the Zodiacal Light band is *exactly in the place of a full moon totally eclipsed.*

This, I beg to submit, is an adequate explanation of the reason why the Zodiacal Light is not strongest directly behind the earth. Accepting this reasonable explanation the crucial objection to the earth ring theory is demolished and the theory itself is strengthened to the point of demonstration. Further objection may be urged that if the Zodiacal Light band be an earth-ring the illumination should be strong and clear-cut right to the point where the earth's shadow intervenes. In considering this objection I suggest that allowance should be made for the penumbra section of the earth's shadow which should have the effect of *diminishing* the brilliancy of the Zodiacal Light as it approaches the umbra. The persistence of the light through the penumbra and even into the umbra, though dimly and more narrowly, as reported from observations in the tropics seems to indicate that the Zodiacal Light material may be more agglomerated along the axis of the band.

On account of the feeble intensity of the light spectroscopic examination is very difficult and a specially designed spectroscope—such as Dr. Michie Smith's at Kodaikanal—is desired. Recent work by Professor Fath at Lick and Mt. Wilson corroborates previous examinations to the extent of affirming that the light is reflected sunlight.

It may therefore be affirmed that the theory of the Zodiacal Light being a planetary ring is in good standing and that the preponderance of evidence is in its favor.—*Rev. W. E. Glanville in Popular Astronomy.*

Zepplin Bombs

THE incendiary bomb used by the Germans in their raids on London, as a rule, is conical, of 10-inch diameter at the base, wrapped round with tarred rope and having a metal handle at the apex. The base is a flat cup, onto which a pierced metal funnel is fitted, having the ignition device and handle fitted at the top. The funnel is generally filled with thermit. The latter, upon ignition, generates intense heat, and by the time of the concussion has taken the form of molten metal, having the extraordinary high temperature of over 5,000 deg. Fahr. The molten metal is spread by the concussion. Outside the funnel is a padding of a highly inflammable or resinous material, bound on with an inflammable form of rope. The resinous material creates a pungent smoke. There is generally some melted white phosphorus in the bottom of the cap, which develops nauseous fumes. In some cases celluloid chippings are added, and occasionally a small quantity of gasoline.

¹ By "directly behind the earth" is meant the point of the sky exactly opposite to the sun, e. g., at midnight.