

Interesting Facts Concerning The Comet

The following was published as a pamphlet by the Manila Bureau of Printing, and was compiled by the Rev. George M. Zwack, S. J., secretary of the weather bureau:

The Government of the Philippine Islands, Weather Bureau,

Manila Observatory, Feb. 4, 1910.
Sir: I have the honour of transmitting a pamphlet entitled "The Return of Halley's Comet and Popular Apprehensions," prepared by Rev. Fr. George M. Zwack, secretary of this Bureau, the publication of which I respectfully recommend.

As the reasons for its preparation are fully stated in the "Introductory Remarks," I need only add that I am convinced that the purpose of its author may be obtained if the pamphlet is given the widest circulation possible.—Very respectfully,

JOSE ALGUE,
Directed of the Weather Bureau.
The Honourable,
the Secretary of the Interior,
Manila, P. I.

Introductory Remarks

The present paper on "The Return of Halley's Comet and Popular Apprehensions" is the outcome of a misunderstanding. A short time ago, the writer was requested by the Executive Bureau to furnish some notes on Halley's comet which would help to quiet the fears of such persons as might anticipate trouble from its approach to the earth. After finishing the task in a great hurry, he discovered that all that was wanted were a few statements denying the existence of danger. It seemed, however, to the staff of the Weather Bureau and to other perfectly disinterested persons that the discussion should be published.

It is said that "history repeats itself" and that "superstitions die hard." If this is true, we may look for all kinds of wild rumors circulated by ignorant or malicious persons, setting forth in glowing colors all the horrors which the "comet" is going to bring upon us poor mortals. It is even stated that these irresponsible mischief-makers are already at work in some sections of Manila.

It is believed that the present discussion of these alleged dangers, if given the widest publicity possible, will help in allaying the night-mares of the timid and furnish material to those who desire to dispel the fears of their neighbor.

This paper is not intended as a deep and broad investigation according to the strictest requirements of modern science. Even supposing that the writer were capable of such work, the hurry in which this treatise had to be written would not have permitted elaborate calculations and deep researches. The only claim made for it is a plain and honest exposition of the groundlessness of fear in regard to comets in general, and particularly as concerns the present return of Halley's comet.

For several months past, scientific and popular periodicals, as well as daily newspapers, have repeatedly mentioned Halley's comet as due to arrive at its distance from the earth some time in May of the present year. Though the times are happily past when soothsayers and astrologers, masquerading as astronomers, predicted "hunger, pestilence, and war, the death of mighty princes, and great calamities" whenever a "hairy star" became visible, it nevertheless goes without saying that the comet will strike terror into the hearts of the ignorant, should it become so conspicuous an object in the sky as during former appearances—which it is very likely to do. Moreover, some statements have appeared in print which might cause even otherwise well-informed persons to feel some apprehensions regarding the celestial visitor. Wherefore, it seemed desirable to the writer to thrash out the whole subject of danger from comets, and he promises to "tell the truth, the whole truth, and nothing but the truth"—at least to the best of his knowledge—without minimizing any real danger which might lurk in the return of Halley's comet, for the sake of allaying popular fears.

Now, is there any reason for uneasiness on account of Halley's comet? Most certainly not! Fear in this case can only be the result of ignorance or superstition, or of both combined. Neither of these is very commendable, either singly or combined, aside from the fact that superstition is sinful.

The only possible reasons for fear could, as far as I can see, be one or several of the following: The comet might be a sign of God's wrath and hence presage impending calamity; or it might have itself some evil influence on our earth; or finally, might it not fall into the sun and cause us to be roasted alive, or worse still, collide with the earth and precipitate doomsday? But the first and second reasons are unreasonable in case of all comets; the third and fourth at least do not apply to the present return of Halley's comet, though there is no denying that such things could happen under different conditions. Let us examine each of these reasons for anxiety!

1. The first cause of fear stated we must dismiss as superstitions. Comets are not signs of God's anger; they are not the fiery rod of the almighty stretched forth over his naughty children as a warning of coming chastisement. Nor are they some kind of uncanny beings, bent on evil, which God permits to hold sway for our punishment.

No doubt, comets are strange looking affairs. As seen with the naked eye, a large

comet usually appears like a dim star surrounded by a patch of more or less luminous nebulousity, which latter seems to stream out in the direction away from the sun, forming one or more tails, some of which have been known to stretch over 35 to 60 deg. of the sky. The bright, star-like point, which on an average is present in four out of every five comets, is called the "nucleus" (Latin word meaning kernel) and the surrounding nebulousity "coma," being the Latin word for hair. The word "comet," however, is not derived from the Latin, but from the Greek "kometes," which means a person or thing with long hair. Not less bewildering is their behaviour. While the fixed stars are, to all intents and purposes, immovable and the planets move all in one direction around the sun and never depart far from the ecliptic, the greatest inclination known being that of the small planet "Eros" (10 deg. 50 min.); the comets apparently observe no law; they move direct or retrograde, and the inclination of their orbits to the ecliptic may have every value between 0 deg. and 90 deg.

Nevertheless, telescope and spectroscope, with the aid of mathematics, have proved beyond the possibility of a doubt that, all their peculiarities notwithstanding, comets are celestial bodies which do not differ essentially from the sun and the planets, our earth included; that they are composed of matter such as we are accustomed to; and that they follow the universal law of gravitation and other physical laws, as it behoves a somewhat eccentric but orderly member of star society. Nor are they new creations when they appear to us be it even for the first time; they have wandered through space for ages. Halley's comet in particular is an old acquaintance of the human race, nay, a member of our own planetary family, since it is a periodic comet—that is, a comet which revolves around the sun like the earth and the other planets of our solar system—and, therefore, becomes visible at stated intervals. The fact that its path is very eccentric and of vastly greater length than that of our earth, and that, consequently, the comet needs over seventy-six years to complete it once, while the earth needs only one, does not alter the truth that the comet belongs to our solar system; that is, to the group of comets which revolve around our sun.

But Halley's comet is not the only representative of its class in the sun's family. About seventy-five comets are known to move in elliptical orbits around our central luminary and, while some fifteen of these have periods of revolution exceeding one hundred years, some more than one return. But besides these seventy-five belonging to the sun's retinue, there is a vast number of comets which come into view only once, because their orbits are parabolic or hyperbolic; that is, they are curves whose branches separate farther and farther. These celestial wanderers come from interstellar space and whisk around the sun with so tremendous a speed that their momentum carries them again beyond the controlling force of our central body, wherefore they pass out again into boundless space until they fall under the dominating influence of some other sun, when they repeat the same performance, until they are caught in some solar system and thenceforth are members of it.

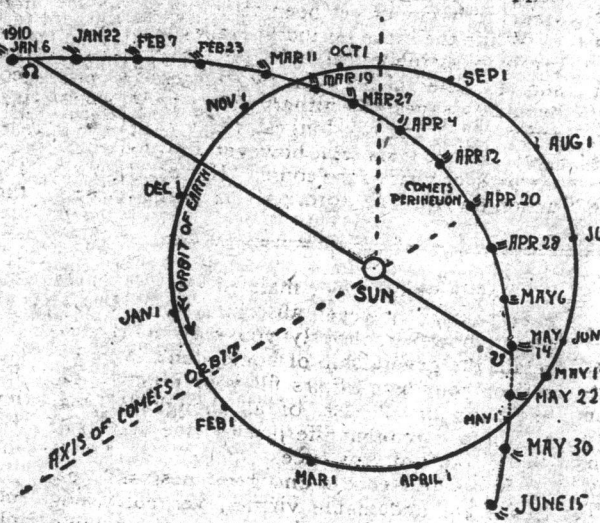
The foregoing exposition makes it clear that comets are by no means warnings of impending calamities, but very natural phenomena. Great disasters have doubtless followed the appearances of comets; but the reasoning "post hoc, ergo propter hoc" (after it, therefore on account of it) is exceedingly illogical. The comet had as little to do with them as you or any sneezing on December 27, 1908, had to do with the Calabrian earthquake of the following day.

11. But granted that comets are neither evil beings in themselves nor harbingers of coming chastisement, may they not, in a merely natural way, affect conditions of life on earth and thus cause harm? To answer this question we may consult experience and science. Both deny it emphatically.

1. What does experience teach? The number of comets which visit our solar system is much larger than is ordinarily supposed. Of course, prior to the invention of the telescope in the beginning of the seventeenth century, only those have been noticed which attained a brightness equal at least to a star of the sixth magnitude. Hence we find only about 400 comets recorded from the earliest times down to the year 1600. Since then some 300 more have been discovered, of which number only about one-fifth were visible to the naked eye. As many as eight have been found in a single year (five in the year 1909). There are in fact not many days on which one or more can not be seen by means of modern powerful instruments. Naturally enough, very conspicuous specimens, such as the comet which appeared in 1858 and the great comet of 1882, are not very frequent; nor are these usually the ones which approach closest to the earth. But several comets have already come near enough to warrant our speaking of "experience." Now, while these comets had their periods of revolution changed by the attraction of the earth by amounts measured by weeks, no influence of theirs was noticed. The closest approach was probably that of Lexell's comet in 1770, which came within 1,500,000 miles of the earth. But even in this case not the least harmful effect, nor, in fact, any effect, could be detected. Why, therefore, should Halley's comet behave differently?

2. But science assures us that it can not behave differently. No harm to the earth or its inhabitants can possibly result from any comet ever observed, except through collision, which we will discuss later on. What could such evil effects be? They would have to consist either in an alteration of the earth's path around the sun, or in the streaming into our atmosphere of noxious matter, or in the setting afire of the comet's tail. None of these occurrences is to be feared.

(a) As to the first, comets are indeed exceedingly large, but, considering their bulk, also exceedingly flimsy creatures. Thus the head of Encke's comet (period three and three-tenths years) has a diameter of 300,000 miles when it first becomes visible at a distance of 130 millions of miles. This gradually diminishes as the comet approaches the sun; but even so, at a perihelion distance of 33 millions of miles the head has still a diameter of 12,000 to 14,000 miles. Now Encke's comet is by no means a large one. Of still vaster dimensions are the tails with which comets are ornamented while in the neighborhood of the sun. These are rarely less than 10 millions of miles long, but may reach much greater lengths. Thus the tail of the great comet of 1882 was 100 millions of miles long, 200,000 miles in diameter near the head, and 10 million miles near the end. Such incomprehensibly bulky affairs appear



very formidable if we compare them with our little earth of only 8,000 miles in diameter, and they would be, if they were as solid as the earth. But they are not! As stated, several comets come so near to the earth that they had their periods altered by several weeks by the attraction of the latter; but the earth's period—that is, the year—was not affected by the action of the comet, even to the amount of a second. Since attraction is mutual, if the immense bulk of the comet had contained only so much matter that one hundred thousand comets would weigh as much as the earth (1-100,000), the effect of its attraction upon the motion of the earth would have been very appreciable. As in no instance any influence could be detected, no one of these comets can have weighed even one two-hundred-fifty-thousandth part (1/250,000) of the earth.

Thus a comet 40,000 miles in diameter would probably have a mean density of a little of air at the earth's surface, or much less than has the residual air in a vacuum tube exhausted by the best air pump.

The orbits of other comets have been greatly altered by the huge planets Jupiter and Saturn, but not the slightest effect upon the motion of the latter has ever been observed. Nay, even their satellites showed no perturbation.

Hence there is no danger of our earth's ever being thrown into new and disastrous paths by the action of a comet.

(b) But might not some "harmful matter stream into our atmosphere and suffocate every living creature on earth? or set it on fire? As Halley's comet, its closest approach to the earth on May 19, 1910, will be 13,000,000 miles. As far as the head is concerned, this is a very safe distance; but we have to reckon with the tail. Rev. Searle, C.S.P., of Washington, D.C., has figured out that on May 19 of the present year, our earth will probably come within the tail of Halley's comet. As at that time the tail will point in our direction, will possibly be several times the length of the comet's distance from the earth and, maybe, a few millions of miles in diameter, it is almost certain that we will get mixed up in it, unless indeed its curvature be such as to cause it to clear the earth. Dreadful prospect, is it not? Well, as far as the writer is concerned, he devoutly wishes that we may get into it as far as we can, his only fear being that neither he nor anybody else in the Philippines will be aware of the fact that a comet's tail is sweeping over us, unless his suggestion be carried out that self-registering magnetic and electrical instruments be mounted in a suitable place, for instance at Mirador Observatory, Baguio, and continuous observations made from May 15 to 21.

In order to understand why there is nothing to be feared from an encounter between the earth and a comet's tail, we have to say something about the constitution of comets, or rather discuss several hypotheses, because, to tell the truth, nobody knows with certainty in what state of aggregation cometary matter exists.

This may sound very strange to the reader who remembers the statement about the mean density of a comet being less than that in a vacuum tube, but he will please also kindly remember that I said "mean" density. Hence the nucleus may consist of a huge swarm of

meteors, 100 to 8,000 miles in diameter, and the individual meteors may vary in diameter from several feet to mere particles of dust; all that is required is that either they are sufficiently far apart, or that the density in other parts of the comet is so exceedingly small that the mean density of the whole is equal to, or less than, one nine-thousandth of the density of air at the earth's surface.

However, whatever may be the state of aggregation in a comet, one thing is sure; comets as a whole are not luminous by incandescence. That their light depends in some manner or other on the sun is shown by the fact that on receding from it they disappear on account of faintness, while still presenting a measurable diameter. This would be utterly impossible if they were self-luminous in the strict sense of the word. As to their light, the spectroscope tells us that a part of it is reflected sunlight. But the greater part of it gives an emission spectrum which reveals the presence of some gaseous carbon compound, which may be cyanogen or some hydrocarbon, if not both. That the gas is glowing throughout the comet, no scientist will dare assert. Its luminosity is probably due to phosphorescence caused by sunlight; but by far the most probable hypothesis makes it an electrical phenomenon. In speaking of incandescence, the writer was careful to limit the denial to the comet "as a whole"; because when a comet approaches very close to the sun, the bases and even the meteors which are supposed to constitute the nucleus may become heated to such an extent as to become self-luminous for a short time. This explains why the spectrum of the great comet of 1882, which latter passed within 300,000 miles of the surface of the sun (perihelion distance 0.008) showed, besides the carbon bands, also the bright lines due to the vapors of sodium and magnesium, with a multitude of others belonging probably to iron, though the phenomenon did not last long enough to identify the latter.

These facts make it self-evident that there can be no danger of the comet's tail setting fire to the earth or its atmosphere—even if the comet's head consisted of glowing gases at the time of perihelion passage, and these gases streamed out in the tail—first, because they would be cooled down very much by expansion before they reached us; and secondly, because the small quantity encountered by the earth could do no harm, even as close as 54,000,000 miles to the surface of the sun (perihelion distance 0.58), and as its nearest approach to the earth will take place a full month after perihelion passage, still less is it to be feared.

But what about the gases constituting the tail and their effect upon life? It was mentioned as probable that cyanogen forms a constituent part of comets. Now, cyanogen (CN₂) is a poisonous gas! This looks serious enough; but happily it is by no means as bad as it appears. Assuming, but not granting, that the tail is formed of gas, or other ponderable matter ejected by the head, some cyanogen, if such is present, would no doubt be picked up by the earth and remain in the atmosphere. But at a distance of 13,000,000 miles this could not possibly amount to one one-hundred-millionth part of the comet. Now, as the whole comet is in mass perhaps equal to our atmosphere, the quantity thus entering the latter would be far less than 0.00000001 of 1 per cent. One hundred thousand times this amount would be absolutely harmless, no matter what the gas might be.

But then the tail is most probably not at all composed of ponderable matter, but merely an electrical phenomenon, similar to the cathode rays seen in a vacuum tube through which passes an electrical discharge. For this assumption speak, first, the fact that the tail always points away from the sun, as if repulsed by it; secondly, the striking similarity between the telescopic appearance of comets' tails and the phenomena of an electric discharge through a vacuum; thirdly, and above all, the consideration that, if the tail really consisted of gas or dust thrown off by the comet under the repellant action of the sun, the comet would very soon be dispersed through the universe. As the tail points always away from the sun, its end would have to move much faster than the head in order to retain the indicated position. But it is utterly impossible that the comet should move millions of miles farther from the sun than the head should have a greater orbital velocity than the latter! Hence, at every return of the comet to the neighborhood of the sun its substance would be strewn along its path at a rate which no comet could afford very long, especially as no considerable part of it could ever be regained, even by periodic comets, and none at all by the others. Moving almost radially to the orbit of the comet, the matter thus thrown off would be far from the comet's path by the time when

*The writer is fully aware that the negatively charged particles constituting the B-rays have also a mass (0.0005 of an atom of hydrogen). The expression "ponderable matter" is used merely to obviate the necessity of unwieldy circumlocutions. Moreover, he by B-rays especially as the tails of comets are the ultimate dispersion (though many thousands times farther than the other hypothesis) not to mention other difficulties which would arise from the assumption of identity. The cathode rays are used as a familiar simile; nothing more.

In speaking of the possibility of a collision of the earth with a comet, the caution was added "provided both the earth and the comet last long enough." This reservation was suggested by the history of a comet discovered in 1826 by Biela and hence called "Biela's comet." Its orbit comes within a few thousand miles of that of the earth, the nearness varying somewhat on account of the perturbations which the comet suffered during its wanderings through the solar system. On

the latter returns again to the same region of space. As one of the periodic comets comes to perihelion once in every 3.3 years and twelve in periods ranging from 5.2 to 7.6 years, the effect of such throwing off of matter should gradually become noticeable.

However, the argument best calculated to dispel all apprehensions regarding the passage through a comet's tail consists in the fact that the thing has actually happened less than half a century ago. According to several astronomers of repute the earth traversed the tail of the great comet of 1861 at 6 o'clock and 12 minutes a.m. of June 30, 1861, some 300,000 miles within it and approximately two-thirds of its entire length from the head. Nothing was noticed except a faint luminosity resembling the zodiacal light, which was seen in the evening of that day.

From all these considerations we must conclude that, whatever may be the nature of the tail of Halley's comet, the passage of our earth through the same on May 19, 1910, will be a very interesting and equally harmless occurrence.

111. From data interspersed in the foregoing explanations it is perfectly clear that Halley's comet, at least at its present return, can not possibly do any mischief by either tumbling into the sun or colliding with the earth. Its least distance from the former will exceed 54,000,000 miles; from the latter it will be 13,000,000 miles. As comets have passed unscathed so close as 750,000 miles from the sun, there can be no danger of the present one falling into it; still less, if possible—need there be of its crashing into the earth.

With this remark we might dismiss the question of danger from comets. But we promised to tell the whole truth. Now, although Halley's comet is perfectly harmless in every respect, the same can not be said of comets in general, at least as far as regards collisions with the sun or our earth.

1. As to falling into the sun, no one of the periodic comets is likely ever to become dangerous, except "Encke's comet." The period of this small comet (3.303 years) is continually shortening, first by 2.5 hours per revolution, but since 1868 by only about half this amount. If this state of affairs continues indefinitely, the comet will finally fall into the sun. But no one living at present need have any concern about it, nor any of those to come for the next 4,500 years; because, if the acceleration continues at the present rate, the comet's perihelion distance will even then be still about ten times that at which the great comet of 1882 passed in safety; a fair margin even if we take into account the smaller velocity of Encke's comet.

It is, however, somewhat different with the non-periodic comets. Though exceedingly improbable, it is absolutely possible, that some fine day one of these wanderers enters into the solar system so accurately aimed that by the time it gets into the vicinity of the central luminary, its orbit falls closer to the latter's centre than the sun of the radii of sun and comet, or even that they meet on the line of their centres. There would be an awful crash! What would be the outcome? Nobody can tell. The late Prof. Charles A. Young, whose "General Astronomy" is unsurpassed for clearness, has to say the following on this subject:

"If a comet actually strikes the sun, it is not likely that the least harm will be done. If a comet having a mass equal to one one-hundred-thousandth of the earth's mass were to strike the sun's surface with the parabolic velocity of nearly 400 miles a second, it would generate about as much heat as the sun radiates in eight or nine hours. If this were all instantly effective in producing increased radiation at the sun's surface (increasing it, say, eightfold, for even a single hour), mischief would follow, of course. But it is almost certain that nothing of the sort would happen. The cometary particles would pierce the photosphere, and liberate their heat mostly below the solar surface, simply expanding, and so adding to its store of potential energy, about as much as it ordinarily expends in a few hours. There might, and very likely would, be a flash of some kind at the solar surface, as the shower of cometary particles struck it, but probably nothing that the astronomer would not take delight in watching."

2. As to the possibility of a collision between a comet and the earth, the chances are even less than of a comet falling into the sun, as regards the comets which move in non-elliptical orbits, since the diameter of the earth is less than one of that of the sun.

Matters are, however, vastly different with the periodic comets. The orbits of several of the latter pass closer to the earth's path than the semi-diameter of their heads. Therefore, provided both the earth and the comet last long enough, the two bodies are bound to come together. But such encounters are extremely rare occurrences. Babinet estimates that their likelihood is about one in every 1,500,000 years. As such an event could, and would, be predicted by astronomers months, and perhaps years, in advance, this possibility needs not rob us of a minute's sleep until they sound the alarm.

In speaking of the possibility of a collision of the earth with a comet, the caution was added "provided both the earth and the comet last long enough." This reservation was suggested by the history of a comet discovered in 1826 by Biela and hence called "Biela's comet." Its orbit comes within a few thousand miles of that of the earth, the nearness varying somewhat on account of the perturbations which the comet suffered during its wanderings through the solar system. On

several occasions the two orbits so closely that, had the earth arrived simultaneously at the distance, the former would have passed through the outer portion of the comet's tail. At the time of the comet's first recovery, in 1832, there was a great number of inhabitants of southern France who were of an impending reality earth and comet never came together than 15,000,000 miles, and had passed the critical point before the earth arrived there. In 1846, the comet divided while in full view. When they were seen again in 1852 they had from each other about 1,500,000 miles, then nothing has ever been seen though they should in the meanly appeared no less than eight times. On the night of November 27, 1871, earth was passing the old path of it, she encountered a most magnificent meteor. The same phenomenon, though with less splendour, occurred in 1885 and 1892. In collision was averted by the comet failed to last long enough.

But suppose a comet does come earth! What will happen? No one and the writer is not anxious to find own experience. All would depend on the mass of the comet, the state of its matter, the velocity with which it came together, and the angle. Matters would likewise differ greatly as the blow would be central or not. As it is not feasible to discuss all cases, we will take the most serious, undoubtedly would be central or both bodies moving in the same directions."

The gaseous constituents of the head would probably be stopped by the distance of our atmosphere before very far into it. But, as thereby it would be converted into heat, they sibly make it uncomfortably warm as their density is so very small minute fraction of the comet's. come into contact with our dimir the effect might, after all, be not trous.

The same, however, can not be smashing into the nucleus. Suppose had a mass equal to only one one-thousandth part of the earth's mass, relatively so small that 6,130 com made out of our little moon. New would be equivalent to an iron ball miles in diameter, weighing some 12,000,000 tons. Since the comet would have a velocity of less than 26 miles per second, it would be bad enough, but most favorable case—that is, if it would overtake the earth—as the orbital velocity of 7.5 miles per second to get at least some idea of what mean, let us make a comparison:

A shell weighing half a ton of United States 13-inch gun (1898) city of only 2,100 feet per second, a plate of solid steel (not armor) 27 in. if the latter is placed close to the m gun. The energy of the projectile would be 1,102,500 tons. The effect of the coming with a velocity of 7.5 miles would be 355 times as great, and if tile had the supposed weight of a nucleus, its striking energy would be 8,600,000,000 tons. Of course knows that cometary nuclei can n were it only for the fact that they contract by thousands of miles, as in Encke's comet; but the combined the meteors forming it would be only by the amount to be deducted of the increased friction in our atm to a greater surface presented by small particles instead of that of having the same aggregate mass. mechanical effect of such bombardi be nobody can foretell. Nor would much, because the heat generated, pact, if expressed in "calories," w be written: 21,053 followed by seven This quantity of heat would be s raise the temperature of more tha cubic miles of water from the free boiling point, an amount of water w cover the whole surface of the earth of 84.5 feet. No living being w the corresponding rise in temperat

But results would be vastly wor and comet would come together on the line, moving in opposite directions case they would collide with a vel miles per second, and as the striking creases with the square of the vel of a rear collision would be as 4.5 that is about thirty-six times more s view of these figures, such questions er the attraction of the comet wou disastrous flood prior to the collisio would be the composition of the a after the event, etc., have little signi head-on collision would simply me of the world as far as the human rnered.

Now, what are the chances of so catastrophe. As stated before, it is happen, provided the earth lasts lon and comets do not become extinct, individual comet striking the earth, t

*Whether there is any probability angle between the directions of tions would (or even could) be zero, is a debatable question. As r following conclusions, the introd small angle would only complicat tions without materially affecting t

*A "calorie" is the amount of required to raise the temperature of 1 of water (2.2 pounds) 1 deg. centig deg. F.).