the same temperature have the same number of molecules to the cubic centimetre, this shows that it is not the number but the kind of molecules which determines the scattering. But perhaps the most important experiments were those in which the discharge was allowed to pass into another tube which had been exhausted so far as possible. It was argued that if the cathode discharge was due to the projection of atoms from the cathode that it could not take place in an absolute vacuum. The tube into which the discharge was to pass was exhausted as far as possible, i.e., until a twenty-centimetre spark would not pass from one electrode of the absolute vacuum tube to the other. Notwithstanding this extreme exhaustion, the discharge passed freely through, as was shown by the phosphorescence of substances placed at the other end. The conclusion which Dr. Lenard draws from this experiment is that the cathode rays are really processes in the ether, and not due to the movement of atoms.

On account of the difficulty of obtaining an absolute vacuum, Dr. Lenard's results cannot be accepted as final. Even at the exhaustion obtained by him it may be calculated that there are quite a sufficient number of atoms left to produce the phenomenon (using the results of J. J. Thomson and Chattock in the calculation), even neglecting the number contained in the layer of air on the sides of the tube, and which would be driven off into the tube so soon as the discharge began to pass. Moreover, it is quite possible to conceive that a discharge of atoms from the cathode, on reaching a thin metal sheet, and being abruptly stopped by it, might propagate an electric disturbance proceeding from the other side of the sheet of metal, and so drive off another set of charged atoms. If there were any way of obtaining an absolute vacuum, of course the question could be answered definitely, but this is impossible, and we must wait for further results before attempting an explanation. R. A. F.

LETTERS TO THE EDITOR.

**** Correspondents are requested to be as brief as possible. The writer's name is in all cases required as proof of good faith.*

On request in advance, one hundred copies of the number containing his communication will be furnished free to any correspondent.

The editor will be glad to publish any queries consonant with the character of the journal.

Low Temperatures.

IN your issue of Jan. 27, page 50, it is stated that the Franklin Search Expedition, under Lieutenant Frederick Schwatka, in 1879–80, experienced a temperature of — 71° C.

This is an error, as I have heard Lieutenant Schwatka in many conversations refer to it as "seventy-one degrees below zero, Fahrenheit."

I enclose a copy of a letter now in a collection belonging to my brother:—

TACOMA, WASH., Sept. 15, 1892.

On the third of January, 1880, my Arctic exploring party encountered a degree of cold of seventy-one below zero, Fahrenheit, or one hundred and three degrees below the freezing-point of that scale, the coldest we noted on the trip, and the coldest ever encountered by white men travelling in the field, for that day we moved our camp some twelve miles. It will be a cold day when that record gets left. FREDERICK SCHWATKA.

FRED. G. PLUMMER.

Tacoma, Wash., Feb. 11., 1893.

Where is the Litre?

IT must be a source of regret to all interested in metrology that so much time was expended in the preparation, and so much space in the publication of the leading article in *Science* for March 17, entitled "Where is the Litre?" etc. Even if the instruction contained in the article be reinforced by the amusement which it furnishes, the result is quite incommensurate with the labor which must have been involved in its production.

Ignorance of the recognized principles of metrology has led to certain conclusions which will generally be harmless on account of the very magnitude of their errors. The sermonizing finish to the article, beginning with the sentence, "In spite of the much lauded simplicity of metric measures," etc., may, however, mislead a few readers whose ideas have been befogged by the perusal of the previous three pages. It will be well to remind them, therefore, that the apparent bewildering confusion as to the value of the litre has no relation whatever to the "simplicity of the metric system." Indeed, the confusion might have been rendered vastly greater, the alleged case against the metric system much stronger, and the entire article more picturesque, if the author had introduced the "gus" of Arabia, the "pik" of Egypt, and the "sun" of Japan, the value of each of which in metres must always be a matter of considerable uncertainty.

The following simple statements may be of value. It is generally agreed among metrologists that *natural* standards of length and mass are not at present easily attainable. Our knowledge of physical or astronomical constants must continually increase in precision as methods and instruments are improved. Such constants are, therefore, unsuitable for standards, because standards should, first of all, be invariable as far as possible. Artificial standards can be made of more convenient dimensions, can be multiplied with almost any required degree of precision, and their invariability is perhaps as well assured as that of any suggestive national standard.

It was originally proposed to derive the metre from the dimensions of the earth. We know that the metre is not the one ten-millionth of the quadrant of the meridian passing through Paris, but that fact does not in the slightest degree lessen the value of the metre as a unit of length. Its value is so nearly that, that it is exceedingly convenient to use in ordinary calculations relating to the earth, not requiring a high degree of precision.

It was also proposed originally to establish some sort of a simple relation between the unit of length and the unit of mass. As length and mass have no natural relation to each other, any numerical ratio must depend on a physical constant, namely, the density of some selected kind of matter. The determination of this must be a matter of experiment, and its value can never be absolutely known. For this reason any relation between the unit of length and the unit of mass must always be an approximation. The unit of mass must, therefore, be an artificial, independent unit.

The new international prototype of the metre is, in length, an exact reproduction of the old metre of the archives, as far as can be determined by the most recent and most perfect means of comparison. The new international prototype kilogramme is identical, in mass, with the old kilogramme of the archives, as far as can be determined by the most precise and delicate weighings ever made.

It was originally intended that the mass of the kilogramme of the archives should be that of a cubic decimetre of pure water at its maximum density. As this involves the knowledge of a physical constant, it was not possible to realize this relation exactly, and it never will be possible.

In determining volumes which do not exceed a certain limit, it has been found that greater accuracy can ordinarily be secured by the indirect method of determining the mass of a liquid of known density, than by direct geometrical processes. The application of the latter requires simple forms whose linear dimensions may be easily and accurately measured. The former depends only on the accuracy attainable in mass measurement and density determination.

This method of volume measurement has usually been regarded, however, as a matter of convenience only. Thus, the U. S. gallon is defined as a volume of 231 cubic inches; in standardizing measures of capacity in gallons, it has always been customary to use the indirect mass-density method. The mass of water which has been assumed to represent this volume has varied from time to time as our knowledge of the physical constants involved advanced.

The litre was originally assumed to be identical in volume with the cubic decimetre, and there could be no possible objection to confining the term *litre* strictly to this meaning. But, as noted above, it being vastly more convenient to use the mass-density method in determining volumes, much of the uncertainty of precise volumetric work would be avoided by defining the litre as the volume of a kilogramme of water at maximum density.