invertebrates is constantly and easily demonstrable. Chatin, in the previous paragraph, referred to osmic acid; it is natural to suppose that the organisms and globules were submitted to that treatment, a method which, at least in my hands, has proved extremely uncertain in its results.

In conclusion, allow me to request some of your very numerous correspondents to inform us if the spectroscope would give any material assistance in the solution of the true nature of these markings. (I, of course, mean the diffraction spectrum), my acquaintance with the instrument being limited to test fluids.

Since writing the above my colleague, W. F. Pentland, has persuaded me not to be too dogmatic with regard to the reticulation of the invertebrate corpuscles and individual (especially conjunctival) cells of invertebrates till after next spring, as in the meantime he intends working up the subject.

THE BACTERIOLOGICAL ANALYSIS OF WATER.

BY J. H. STOILER, UNION COLLEGE, SCHENECTADY, N. Y.

WHEN, in 1881, Koch announced the gelatine culture method for bacteria devised by him, it was believed that one of its most important applications would be in the examination of waters with reference to their potable use. This method, as is now well known, renders possible an exact determination of the abundance of bacteria in water. But it was soon discovered that the mere demonstration of the presence of bacteria was of little value in estimating the qualities of waters, inasmuch as waters of unquestionable suitability for potable use often contained bacteria in considerable abundance. However, the general result was established that the numbers of bacteria are in relation to the amount of putrescible organic matter in the water.

The ideal value of the gelatine culture method not having been realized, it is probable that its true usefulness in water analysis has not been estimated as highly as it deserves. An experimenter who has familiarized himself with the distribution of bacterial life in waters will be able to form definite and reliable conclusions upon the basis of numbers of bacteria. This is especially true in the case of river water subject to polution by sewage from towns. Numerical determinations of abundance of bacteria having been made of samples taken at various points from the same river, a fair judgment may be formed of the amount of sewage polution at any required point. The first step requisite to be taken is to determine, for use as a standard, the numbers of bacteria in unpolluted water *in the stream under investigation.* Comparisons made with this standard give reliable quantitative indications of polution. Any access of sewage raises the number of bacteria above the normal for that stream and the excess is a definite indication of the extent to which the water has suffered polution. The standard is obtained by testing the water, both at such points and at such times as give the condition approaching nearest to purity for that stream. In general, samples taken from the head waters of the river, above the first town from which sewage polution is received, and at a time of continued fair weather when the water is free from rain-wash, are best suited for the control tests. In regard to the effects of surface washings from the land by rains, as indicated by turbidity of the water, it is necessary to eliminate them from all tests by taking samples only when the water is clear. This rule being observed, comparisons of results give indications of the extent of contamination due to sewage.

It should be added that there are other conditions which enter in a minor degree as factors in the results of numerical determinations of bacteria. These are temperature of water, depth at which the sample is taken, point at which the sample is taken with reference to rifts and pools in the stream, free exposure to air and light (prevented in winter by ice), etc. Consideration should always be given to these conditions and as far as possible samples should be taken under similar conditions throughout in order to render the results comparable.

The writer, working in association with Prof. C. C. Brown, consulting engineer for the New York State Board of Health, in furtherance of his work in investigating rivers as sources of water supply, has made numerical determinations of bacteria for some six hundred samples of water from the Hudson and Mohawk rivers. A statement of the results of this work is given in the annual reports of the State Board of Health of New York for the years 1891 and 1892.

It naturally occured to us, early in the work here alluded to, that a method of differentiating sewage bacteria from ordinary water bacteria would be of great value as affording a more exact means of ascertaining the degree of sewage pollution than is possible by the method outlined above. Dr. Theobald Smith, of Washington, D. C., was then consulting bacteriologist for the New York State Board of Health and upon submitting the idea to him he informed us of a method of differentiating gas-producing bacteria from others which he had devised and published some time previously (*Centralblatt fur Bakteriologie,* Vol. VII., p. 302 and Vol. XII., p. 367) and which he believed was applicable to the end sought by us.

The method thus placed at our disposal consists in the use of a culture fluid of which sugar (glucose) is a component and which is placed for inoculation in tubes similar in principle to the ureometer employed by chemists. Bacteria capable of causing sugar-fermentation when introduced into such culture-tubes give rise to a gas the quantity and composition of which can be ascertained. In the application of this method to the bacteriological analysis of water its value rests upon the fact that the most common species of bacteria present in feces are gas generators. As is well known the most constantly occuring species of bacteria in feces is *Bacillus coli commune;* and for some time our experiments related to the determination of the abundance of this species in the waters under investigation by means of the characteristic quantity and composition of the gases which it generates in the fermentation-tubes. Later others of the more common fecal bacteria were isolated and studied with reference to their gas-generating character. In this way a method was elaborated by which, it is believed, there can be determined with approximate exactness the numbers of prevailing species of fecal bacteria in a unit quantity of water. This determination is taken as a definite indication of the amount of sewage pollution.

In the practical use of this method the procedure is as follows : The saccharine culture fluid contained in a set, say eight, of fermentation-tubes is inoculated with a measured quantity of water from the source of supply under investigation. The tubes are immediately placed in an incubator and kept at a temperature of thirty-eight degrees centigrade for forty-eight hours or somewhat longer. (This is favorable to the development of fecal bacteria and probable destruction of the greater number of ordinary water bacteria.) Those tubes in which gas has been developed are then examined withreference to the amount and composition of the gases present and note is taken of those which agree in these respects with the effects produced by known fecal bacteria. Finally

upon these data the number of fecal bacteria per cubic centimetre in the water under examination is calculated.

A part of the results thus far obtained by the use of this method, together with a more detailed account of the method is published in the 1892 report of the State Board of Health of New York.

BRITISH STONE CIRCLES—V. OXFORDSHIRE, SHROPSHIRE, AND WELCH CIRCLES*.

BY A. L. LEWIS, F. C. A., LONDON, ENGLAND.

THERE is a well-known circle called the Roll-Rich, better known locally, however, as the "King-stones," four miles from Chipping Norton, Oxfordshire (Great Western Railway). It is 100 feet in diameter, and consists of fifty-four stones and fragments, varying from one to seven and a half feet in height, one to five and a half in width, and one to two in thickness. Many of these stand close together, giving the idea that the circle when complete may have been a continuous wall of enclosure; but this is a point on which the visitor can form his own opinion. Two hundred and fifty feet from the circle, in a direction 55° north of east, is a stone called the "Kingstone," 9½ feet high and from 1½ to 5 feet broad and thick; it is on the other side of the road which divides Oxfordshire from Warwickshire, and is therefore in the latter county. Though very similar in position to the "Friar's Heel" at Stonehenge, it would appear to be too far north to mark the point of sunrise; but it may have marked the point of the first appearance of light on the longest day. About 300 yards from this circle, in a direction 10° south of east, stand five stones called the "Five Knights," which are from eight to eleven feet in height and one to four in breadth and thickness. As they now stand they enclose a small square space, three of them standing in a contiguous line facing S. S. E., one standing four feet behind them, and the fifth forming the northeast side of the enclosure, but it is possible that the latter was originally a capstone on the top of the others, and has fallen into the position which it now occupies. The ground enclosed by these stones is two feet higher than that outside them; they may have been designed in connection with the circle, or they may not; this is a point for the consideration of the visitor. There is a monument very like the "Five Knights," some four miles south from Chipping Norton, at a place called Enstone. These stones are called the "Hoarstone," and are four miles from Charlbury Station (G. W. R.).

On a hill above Penmænmawr, on the north Welsh coast, there is a circle called "Y Meinen Hirion" (the long stones), eighty feet in diameter; seven stones from three to five and a half feet high remain upright, and one, eight feet long, lies prostrate; there are also sundry fragments and stumps. This monument, described in Gough's "Camden's Britannia" as one of the most remarkable in North Wales, is not unlike the Roll-Rich in character, but is smaller, and, as regards the circle itself, even insignificant. The ground toward the northeast falls rapidly away into a deep hollow, on the other side of which are lofty hills; but about 500 feet to the northeast, down in the valley, is a stone, now prostrate, nine feet long, five feet wide and two feet thick, and in the same direction, but about 400 further, is another prostrate stone of the same length and width, but twice as thick. These stones, placed like the "Friar's Heel" at Stonehenge and the "Kingstone" at the Roll-Rich, being down in a valley, do not themselves show up on the horizon against the rising sun, but they lead the eye directly to a hill on the other side of the valley, over the top of which the sun would probably rise on the longest day, as it is between 45 and 50 degrees east of north, and not very much higher than the circle. This hill, one on the north side of it, and the Great Orme, form a group of three, and we shall find that in the hilly districts of Great Britain triple summits or groups of three hills are often to be seen to the northeast of circles, from which it may be inferred that the circles were, for some reason or other, intentionally placed in such positions as to command views of triple summits in that direction.

There are two other circles which are only just over the border of Wales, in Shropshire, and are most conveniently reached from Minsterley, to which there is a railway from Shrewsbury. The farther and larger of the two is about seven miles from Minsterley, and is called Mitchellsfold; it seems to be slightly oval, the diameters being 86 and 92 feet; it consists of thirteen stones, varying from six to two feet in height, and one to three feet in thickness. There are also some fragments, but the original number of stones may have been from 27 to 30. Two hundred and fifty feet from the south side of the circle are two stones, fifty feet apart, the dimensions of which are from two to three feet each way; and half a mile due south was formerly a monument of some kind called the Whetstone, which may or may not have been planned in connection with the circle. The top of a high hill, called Stapeley Hill, is 50° east of north from the centre of Mitchellsfold (the same direction as the "Friar's Heel" at Stonehenge), and about three-quarters of a mile from it. Between the two is a single stone, now fallen, eight feet long. Still farther, in exactly the same line, on the other side of Stateley Hill, and at the same distance from its summit on the northeast as Mitchellsfold is on the southwest, is another circle, called the "Hoarstone," or Marshpool, circle; and beyond this, looking northeasterly, may be seen three low hills. The Hoarstone circle is about 74 feet in diameter, and consists of 33 stones and fragments, the general size of which is from two to three feet in height, width and thickness. The largest stone is in the middle of the circle, a little to the southwest of the centre, and is only three feet and a half high; but, as the ground is soft and swampy, the stones may be sunk to some depth in it, and their original height may have been greater, and, if so, the bottom of the central stone, which now leans to the southwest, may be nearly at the centre of the circle. Many of these stones have artificial holes in them; these are not ancient, but have been made by the miners, who fill them with powder and fire them when a wedding takes place in the neighborhood. Mitchellsfold, otherwise Madge's Pinfold or milking fold, is said to have received its name from a legend connecting it with a cow which gave milk enough for all honest people who wanted any, until some wicked person drew her milk into a sieve, from which time the cow disappeared. The fallen stone between the circle and Stapeley Hill is called the "Dun Cow," probably in connection with the same legend.

There is another circle on Penywern Hill, two miles south from Clun in Shropshire, but it is nearly destroyed; it appears to have been about thirty yards in diameter, and to have had an outlying stone ten feet high, 120 yards or so to the southeast†.

There is also a circle at Kerry Hill, in Montgomeryshire, eight or ten miles west of Clun, which, I am told, is about thirty feet in diameter, with a central block, like the Marshpool circle†.

*No. 1 Abury appeared in No. 529, March 24.
No. 2 Stonehenge appeared in No. 537, May 19.
No. 3 Derbyshire Circles appeared in No. 545, July 14.
No. 4 Somersetshire and Dorsetshire Circles appeared in No. 555, September 22.

†I have not seen either of these, and am indebted to Mr. Luff, a former resident of Clun, for the above information concerning them.