lished, Mr. Morse offered it to the government for \$100,000. Upon adverse representations made by the Postmaster-General, the offer was refused. Mr. Morse then set to work to enlist private capital in the development of his invention. It was not an easy task. Men with money fought shy of the new undertaking. To stir the capitalists up, a short experimental line was laid in New York city from No. 112 Broadway to a house near the Metropolitan Hotel. It was with the utmost difficulty that permission was obtained to have the connecting wires strung along the tops of the houses, the owners fearing an increase of liability of their property being struck by lightning. Mr. Ezra Cornell, afterward the founder of Cornell University, had charge of this experiment. Fifteen thousand dollars were needed to construct a line from Fort Lee to Philadelphia, which was the first link of a projected line to Washington via Baltimore. This money was subscribed, Mr. Corcoran, of Washington, being the first contributor. The first telegraphic charter issued in the United States was granted by the Maryland Legislature. The first company was known as the "Magnetic Telegraph Company."—*Electrical Era*.

LIGHTNING CONDUCTORS.*

THE testing of lightning conductors should comprise—(1) that of the conductor, (2) that of the communication with the earth.

The testing of the conductivity of the conductor, which should have a very low electrical resistance, is very delicate, for it may happen that in consequence of oxidation, or from other reasons, the section of the conductor is reduced in some parts to very small dimensions, while the electrical tests show no appreciable diminution of conductivity. It is certain, moreover, as M. Helmholtz remarked at the last meeting of the *Congrès des Electriciens*, that the continuity of a conductor might be completely interrupted at one point without destroying the efficiency of the conductor as a preservative against lightning, while a fine wire connecting two distant parts of the principal conductor might present a perfect conductivity without offering sufficient capacity for the atmospheric electricity of a storm.

In any case there is no doubt that it is indispensable that the branches of a lightning conductor and their continuity be tested with care from time to time, as is done annually with the lightning conductors on military edifices. As for the frequent trials of continuity, these may be easily made by means of a battery and galvanometer, as will be shown further on.

The good communication with the earth, which is at least as important, can only be accurately measured by means of two other earth wires, completely independent of the first, and embedded in the soil at a distance sufficient to give perfect diffusion of the electric fluid at each point, and to prevent the passage of electricity directly through the earth which separates them. By means of three galvanometrical experiments we may have the sum of the resistances of these communications taken two by two, and deduce from it the value of each. If x , y , and z represent these resistances, a , b , and c the values found for the sums $x + y$, $x + z$, and $y + z$, we have:

$$x = \frac{a + b - c}{2}, \quad y = \frac{a + c - b}{2}, \quad z = \frac{b + c - a}{2}.$$

This experiment, which is very delicate, and in which we must take into account the polarization of the electrodes, evidently cannot be intrusted to inexperienced persons.

For the lightning conductors of Paris, for example, it is generally considered sufficient to plant in the earth, at a short distance from the lightning conductor, a metallic plate, with a surface one decimeter square, and to ascertain that the current passes when this plate is connected with the rod by introducing into the circuit a battery and a galvanometer. The resistance of the two earths thus measured is ordinarily very high; it often exceeds, it appears, 2 to 300 ohms, which is a very considerable figure, if we consider that in telegraph offices the resistance opposed to the current by the contact with the soil at each post does not reach, in general, 20 or 25 ohms. It seems necessary to fix a maximum for the resistance which we ought to take for the communication of lightning rods with the soil. This maximum seems capable of being fixed at 25 ohms; and when we determine the total resistance by taking two independent earth wires, we should not obtain a figure higher than 5 ohms.

For the measurement of this resistance the method which seems most simple and most practicable is that by a differential galvanometer.

The committee proposes, therefore, to establish in a fixed position in every building provided with a lightning rod, in addition to the principal earth contact, a second contact, completely independent of the first, and situated at 20, 30, or more meters from it, according to the nature of the soil and local conditions, which will be tested as to perfect efficiency, once for all, by a competent person. This second contact will be connected with a wire leading to the experimenting room, and may, moreover, be attached to the principal conductor when not required for making tests.

A wire covered with gutta percha would be carried off from an elevated part, A, of the lightning rod, and would lead to an interrupter, C, insulated in the normal state. This interrupter would allow of connecting at will, by means of a metallic plug, the lightning rod, A, B, with one of the circuits of a differential galvanometer, G. The other extremity of the same circuit would lead to a second interrupter, Q, in connection with a small battery, P, and with the second earth wire, S.

The second circuit of the differential galvanometer would be connected, on one hand, with the interrupter, Q, and on the other, at the point, H, with the auxiliary earth wire, H, S; a resistance, R, equal to that which should not be exceeded by the earth connection between H and T, or about 50 ohms, would be placed in this circuit.

To make the test, we would commence by closing the local circuit, by putting in the plug of the interrupter, Q, which would enable us to ascertain, by the deflection of the needle, whether the battery, P, is in good condition; then we should put in the plug of the second interrupter, C. The galvanometer needle should return to a state of repose, or even pass to the other side of the zero, if the resistance of the earth is lower than the resistance, R, or 50 ohms, that is to say, if the lightning conductor is in working order. If the deflection should not change in direction, it should be ascertained whether the conductivity of the portion of the rod, A, B, is interrupted, or whether the connections with the earth are defective, which would be the case if, for instance, one of them being formed of a plate, originally immersed in water, had become dry.

This examination should be intrusted to an experienced man, who should be warned by the attendant of the bad state of the connections; but the experiment could easily be carried further. It would be sufficient to have a second wire, L, B, establishing communication between the commutator, C, and the foot of the lightning rod, in which would be placed an interrupter, I, and to connect this wire with the point, H, by a conductor also provided with an interrupter, K.

In the normal condition the circuit would be closed by the plug of the interrupter, I, which would furnish a second connection, A, I, T, between the summit of the rod and the earth; to make the first trial, as was indicated above, it would suffice to remove the plug of the interrupter, I, and proceed as before. In order to insure the continuity of the lightning conductor, metallic plugs should be inserted in the three interrupters, K, C, and Q; the two circuits of the differential galvanometer being closed, the needle should remain at rest or deviate under the action of the current passing through the rod, if the resistance of the circuit, H, N, K, B, A, L, C, is below that of the rheostat, R. A resistance slightly below R, placed at N, would render this test still more exact, and would enable us to make sure that the rod of the lightning conductor and the auxiliary wires offer only an insignificant resistance, and are consequently in good condition. If it were found that the current which ought to pass through the lightning conductor does not do so, the fault could be discovered by arranging a conducting wire in communication, on the one hand, with the interrupter, K, the other extremity being connected with various points of the lightning conductor between B and A.

Lastly, if the principal conductor should be found by experiment to be in good condition, the secondary wire, H, S, should be tested as well, and also the communication with the earth. These tests present no difficulty, and require no complicated instrument, in order to obtain accuracy. The galvanometer may have the ordinary form of the galvanometers at telegraph stations; and as to the battery, it may consist simply of one or two Leclanche elements.

We have indicated 50 ohms as the limit of resistance between the two independent earths; perhaps it would be advisable, in each particular case, to examine whether this limit is sufficient, or if it would not be better to fix a somewhat different value. This value should depend on the more or less advantageous installation of the earth wires.

In order to avoid all danger, it is better that the commutators, C and K, which should be in readiness in the experimenting room, should have, on ordinary occasions, no communication with the lightning conductor, which might be effected by detaching the wires connecting them with the conductor, A, I, B, if the latter be external, or by cutting off, at A and B, the communication of the wire, A, I, B, with the lightning conductor. When there is telegraphic communication with a station situated at a certain distance, the establishment of a second earth wire, H, S, is useless. It is sufficient to connect the point, H, with the telegraph wire itself, placed directly in communication with the earth at its other extremity at the time of the experiment; but then the resistance, R, must be increased by a quantity equal to the resistance of this conductor.

AN APPLICATION OF ELECTRICITY TO SURGERY.

WE borrow from one of the last numbers of the *Elektrotechnische Rundschau* a description of an apparatus constructed by the Electro dynamo Co., of Philadelphia, which will prove an advantageous substitute for the apparatus that have hitherto been employed in resections and trepanning. Resection is an operation that consists in removing an affected part of a bone. In this operation the surgeon holds the decayed parts with one hand and uses the surgical saw with the other.

The operation is not of the easiest character, and always

necessitates the expenditure of considerable muscular strength, as may easily be imagined. The apparatus shown herewith is designed expressly to substitute mechanical force for muscular, so that the whole attention of the operator may be devoted to the delicate parts of the operation.

The instrument consists essentially of a metallic handle, to the center of which is screwed a small Griscom electric motor. To the left, and in the axis of this latter, there is mounted a circular saw. The upper half of the latter moves in the interior of a shield, so that the apparatus may be placed in any position whatever, without the operator's running any risk of having his hand wounded by the teeth of the saw.

The apparatus is equally well adapted for trepanning, the circular saw in this case being merely replaced by a trepan one.

The electromotive force necessary may be obtained by means of six Trouve elements. The results of some experiments made by Dr. Th. Stein are of the most satisfactory nature, both as regards the accuracy and the rapidity with which operations may be performed. For example, it is found that with this instrument the very largest bones may be sawed through in thirty seconds, a result that could not possibly be obtained with the best instruments and most skillful hand by ordinary processes.—*La Lumière Electrique*.

THE RELATIONS OF THE SOIL TO HEALTH.*

By GEORGE H. ROHE, M.D.

I.—THE SOIL.

THAT wisest and most learned of the ancients, Hippocrates, called the Father of Medicine, treated at length in one of his works of the sanitary influence of the soil. Others of the older writers, especially Herodotus and Galen, called attention to the same subject, and Vitruvius, the celebrated Roman architect, who flourished about the beginning of the Christian era, taught that a point of first importance in building a dwelling was to select a site upon a healthy soil.

From this time until the beginning of the eighteenth century, very little of value is found in medical literature bearing upon this subject. In 1717, however, Lancisi published his great work on the causes of malarial fevers, in which he laid the foundation for the modern theory of malaria and pointed out of the relations existing between marshes and low-lying lands and those diseases, by common consent, called malarial. Other authors of the eighteenth and the early part of the nineteenth century refer to the connection between the soil and disease, but exact investigations have only been made within the last thirty years. The general want of definite knowledge upon this subject, even among well-educated people, is the occasion of the following pages.

When we consider that the air we breathe, and much of the water we drink, are influenced in their composition by the matters in the soil, the great importance of possessing a thorough knowledge of the physical and chemical conditions of the soil becomes evident to every one.

In the hygienic, as in the geological sense, we include rock, sand, and gravel in the consideration of soils.

The soil, as it is presented to us at the surface of the earth, is the result of long ages of disintegration of the primitive rocks by the action of the elements, of the decomposition of organic remains, and possibly of accretions of cosmical dust. The principal factor, however, is the action of water upon rock, in leveling the projections of the earth's surface, produced by volcanic action.

Soils vary considerably in physical and chemical constitution. We may have, for example, a soil consisting exclusively of sand, of clay, or of disintegrated calcareous matter. Other soils may consist of a mixture of two or more of these, together with vegetable matter undergoing slow oxidation. In forests, we find a layer of this slowly decomposing vegetable matter of varying thickness covering the earthly substratum. This organic layer is called *humus*, and when turned under by plow or spade, and mixed with the sand or clay-base, it constitutes the ordinary agricultural soil.

II.—THE ATMOSPHERE OF THE SOIL, OR GROUND AIR.

The interstices of the soil are occupied by air or water, or by both together. The soil's atmosphere is continuous with and resembles in physical and chemical properties that which envelops the earth. Its proportion to the mass of the soil depends upon the degree of porosity of the soil and upon the amount of moisture present. In a very porous soil, such as for example a coarse sand, gravelly loam, or coarse grained sandstone, the amount of air is much greater than in a clayey soil, granite, or marble. So, likewise, when the soil contains a large proportion of water, the air is to this extent excluded. The porosity of various soils, as evidenced by the amount of air contained in them, is much greater than would, at first thought, be supposed. Thus it has been found that porous sandstone may contain as much as one-third of its bulk of air, while the proportion of air contained in sand, gravel, or loose soil may amount to from thirty to fifty per cent.

The ground air is simply the atmospheric air which had penetrated into the interstices of the soil and taken part in the various chemical decompositions going on there. In

* From the Third Annual Report of the State Board of Health of West Virginia.

SURGICAL ELECTRICITY

* *Annales Telegraphiques*.—Extract from a Report of the Committee of Improvement of the Postal and Telegraphic Administration.—*Electrical Review*.

consequence of these chemical changes, the relative proportions of the oxygen and carbonic acid in the air are changed, oxygen disappearing and giving place to carbonic acid. It is well known that, during the decay of vegetable matter in the air, carbonic acid is formed; one constituent of this compound—the carbon—being derived from the vegetable matter while the oxygen is taken from the air. Hence, if this action takes place where there is not a very free circulation of air, as in the soil, the air there present soon loses its normal proportion of oxygen, which enters into combination with the carbon of the vegetable matter to form carbonic acid.

Thirty years ago, MM. Boussingault and Levy, two distinguished French chemists, examined the air contained in ordinary agricultural soil, and found that the oxygen was diminished to about one-half of the proportion nominally present in atmospheric air, while the carbonic acid was enormously increased. The exact results obtained by Boussingault and Levy were as follows:

In one hundred volumes of ground air there were 10.35 volumes of oxygen, 79.91 volumes of nitrogen, 974 volumes of carbonic acid. In atmospheric air, on the other hand, there are in one hundred volumes 20.9 volumes of oxygen, 79.1 volumes of nitrogen, 0.04 volume of carbonic acid, or about one twenty-fifth of one per cent. of carbonic acid.

In spite of the striking results obtained by these two chemists, very little attention was paid to them by sanitarians, as very few seemed to have any clear notion of the relations existing between the motions of the air above ground and that under ground.

In 1871, however, Prof. Von Pettenkofer, of Munich, whose authority in sanitary matters is second to none, published the results of his own examinations into the constitution and physical conditions of the ground air, and the relations of the latter to the propagation of epidemic diseases. These researches, which created a widespread interest in the subject, were extended by other observers in all parts of the world. These observers, prominent among whom were Professors Fleck and Fodor in Germany, Drs. Lewis and Cunningham in India, Prof. Wm. Ripley Nichols in Boston, and Surgeons J. H. Kidder and S. H. Griffith, of the U. S. Navy, in Washington, demonstrated that the increase of carbonic acid in the ground air is due to increased vegetable decomposition and to lessened permeability of the soil. A permeable, that is to say, a sandy or gravelly soil, is likely to contain less carbonic acid in its atmosphere than a dense, less permeable clay, although the amount of decomposition going on, and the production of carbonic acid in the former, may considerably exceed the latter. In the loose sandy soil the circulation of the air is less obstructed, and the carbonic acid may easily escape and be diffused in the superincumbent air, while the close-pored clay imprisons the carbonic acid and prevents or retards its escape into the air above.

The disappearance of oxygen from the ground atmosphere is coincident with the production of an equivalent amount of carbonic acid. It appears from this that in the soil an oxidation of carbonaceous substance takes place, the product of which is the excess of carbonic acid in the ground air.

Prof. Nichols has found the proportion of carbonic acid in the air taken from a depth of often feet below the surface in the "made land" of Boston, amount to 21.21 per thousand, the observation being made in August. In December, at a depth of six feet, the proportion was 3.23 per thousand. Fodor, in Buda-Pesth, found the proportion of carbonic acid to be 107.5 per thousand (over 10 per cent.), the air being taken from a depth of thirteen feet.

Movements of the ground atmosphere are principally due to differences of pressure and temperature in the air above ground. Owing to such differences the air from the soil frequently permeates houses, entering from cellars or basements. In winter, when the air of houses is very much more heated (and consequently less dense) than the air out of doors, the difference of pressure, thus caused, draws the ground air up through the house, while the cold external atmosphere penetrates the soil and occupies the place of the displaced ground air.* A similar effect occurs in consequence of heavy rains. The water fills up the interstices of the soil near the surface, and forces the ground air out at points where the pores remain open. These places are the dry ground under buildings, where the air escapes and passes through floors and ceilings into the house above. Heavy rains may thus be the cause of pollution of the air in houses. The greater the porosity of the soil, the more likely is this to happen. This pollution of the house air may be prevented by having impervious floors and walls to cellars and basements, or by interposing a layer of charcoal between the ground and the floor of the house.

In the spring and early summer the ground being colder than the air above it, and the ground air consequently heavier and denser, the latter is not easily displaced. It is perhaps due to this fact that those infectious diseases which are probably dependent upon the movements of the ground air, are less prevalent in the spring and early summer than in the latter part of summer, autumn, and early winter. In the autumn, the ground air being warmer than the air above ground is easily displaced by the latter, and forced out into the streets and houses to be inspired by men and animals. The same conditions may explain the greater likelihood of infection at night, which is proved for such diseases as malarial and yellow fevers. The colder outside air penetrates the interstices of the soil, and forces out the impure ground air.

The researches of Fodor have demonstrated that the proportion of carbonic acid in the ground air may be taken as an approximative measure of the impurity of the soil whence the air is taken. The influence of the permeability of the soil, as before pointed out, must however not be overlooked in estimating the signification of the carbonic acid. Fodor has shown that the proportion of carbonic acid in the ground air, and consequently the amount of organic decomposition, is greatest in July and least in March. That the carbonic acid is derived from the decomposition of organic matter has been proved by Pettenkofer. This observer examined specimens of air brought from the Libyan desert, and found that the proportion of carbonic acid in the ground air was exactly the same as in the air collected above ground. There being no vegetable growth in the desert there can, of course, be no vegetable decomposition going on in the soil.

The excess of carbonic acid in the ground air is an indication of the deficiency of oxygen, as has been shown. The air at a depth of thirteen feet below the surface was found to contain only from 7 to 10 per cent. of oxygen—one-half to one-third of the normal proportion. Many basements occupied by people as living rooms extend from five to ten feet underground, and hence are liable to be supplied with an at-

mosphere approaching in impurity that just mentioned. It requires no very vivid imagination to appreciate the dangers to health that dwell in such habitations.

III.—THE WATER OF THE SOIL, OR GROUND WATER.

At a variable depth below the surface of the ground, a stratum of earth or rock is found through which water passes with difficulty, if at all. Above this, there is a stratum of water which moves from a higher to a lower level, and which varies in depth at different times according to the amount of precipitation (rain or snow-fall) and according to the level of the nearest body of water toward which it flows. This stratum of water is termed the *ground water*, and has within the last few years assumed considerable importance from its apparently close relations to the spread of certain of the infectious diseases. The direction of horizontal flow of the ground water is always toward the drainage area of the district. Thus, it is usually toward lakes, rivers, or the sea. Rains or a rise in the river cause a rise in the ground water, while long continued dry weather, or a low stage of the river, which drains off the ground water, causes a fall in the latter. On the sea-coast the ground water oscillations probably correspond with the tides. The writer is not aware of any observations made to determine this point. In Munich, where the ground water flows toward the river Isar, which divides the city, it has been found that the annual range or oscillation (the difference between the highest and lowest level during the year) is ten feet, while the horizontal movement amounts to fifteen feet per day. In Buda-Pesth the annual range was found by Fodor to be less than three feet, while in some portions of India it amounts to more than forty feet. As it is from the ground water that the greater portion of the supply of drinking water in the country and in villages and small towns is drawn, it becomes at once manifest how important it is to prevent, as far as possible, pollution of this source. Cess-pools and manure heaps and pits, of necessity, contaminate the soil, and also ground water, for a distance below and around them, and such water is clearly unfit for drinking and other domestic purposes. Hence, the reason why wells should not be placed too near privies and manure heaps or pits becomes apparent.

Between the level of the ground water, or that portion of the soil where its pores are entirely occupied by the water—where, in other words, the ground is *saturated*—and the surface is a stratum of earth more or less *moist*; that is to say, the interstices of the soil are partly filled with water and partly with air. It is in this stratum that the processes of organic decay or putrefaction are going on, in consequence of which the pollution of the ground air occurs. Recent observations seem to show that these processes of decomposition are initiated and kept up by minute organisms, termed *bacteria*, just as fermentation in liquids containing sugar can only take place in the presence of the yeast plant. It has been found that when non-putrefactive decomposition goes on, there are always present multitudes of one variety of these minute organisms; while if putrefactive decomposition is going on, a different variety of these organisms is present. Just as, when a fermenting liquid becomes putrid, the yeast plant disappears and its place is taken by the ordinary bacteria of putrefaction, so in the soil, if the access of oxygen is necessary to the life of the bacteria of decay is prevented, these organisms die and are succeeded by the organisms of putrefaction. It has been found that in a soil saturated with water the bacteria of decay cannot live, while those of putrefaction may flourish, because these latter organisms can sustain life in the absence of oxygen. Prof. Fodor's researches indicate that the organism of non-putrefactive decomposition or decay is that which is termed by Cohn *bacterium lineola*; and that the *bacterium termo* is the principal organism of putrefaction.

IV.—THE DISEASES SPREAD BY SOIL IMPURITIES.

Given now an area of soil, say the ground upon which a house or city is built, with a moist stratum in which the processes of decay are active, and imagine a rise in the ground water. The ground air, charged with carbonic acid and other products of decomposition, is forced out of the pores of the soil by the rising ground water, and escapes into the external air, or through cellars and basements into houses, and may there produce disease. But the saturation of the soil with water prevents the further development of the bacteria of decay, and putrefaction takes place. If, now, the ground water sinks to its former level or below, the processes of decay again become very active in the moist stratum, and large quantities of carbonic acid and other inorganic compounds are produced. If the germs of infectious or contagious diseases have been introduced into the soil, they also multiply, and may escape with the movements of the ground air into the external atmosphere, and there produce their infective action.

This, it is held by Pettenkofer and his followers, is what actually occurs in cholera and typhoid fever. Prof. De Chaumont has laid down the rule that a soil with a persistently low stage of ground water, say 15 feet below the surface of the ground, is healthy; a persistently high stage of ground water, less than 5 feet below the surface, is unhealthy, while a fluctuating level of the ground water, especially if the changes are sudden and violent is very unhealthy. This would lead us to expect that places where this fluctuation is very great would show a large mortality from such diseases as are attributed to impurities in the soil. And this we find especially true in India. In certain localities in India, cholera, for example, is endemic—that is to say, the disease is never entirely absent in such localities. Calcutta is one of these places. The rainy season begins about the first of May and continues until the end of October. During the next six months there is very little rain. It is fair to assume that the ground water rises during the rainy season, and checks decay and the multiplication of the germs of the disease in the soil, and that these processes become more active as the dry season advances and the ground water level falls. If we note the death rate from cholera in Calcutta, it will be found that it bears a distinct relation to the movement of the ground water. The deaths from cholera begin to increase from October, and reach their height in April. Dr. Macpherson, who has written a very elaborate history of Asiatic cholera, shows this relation very clearly. For twenty-six years the average annual rainfall was 63 inches. From May to October 57 inches fell, while the remaining 6 inches fell from November to April. The average number of deaths from cholera annually was 4,013. Of these, 1,238 died in the rainy season, while 2,775—nearly three-fourths—died during the period of dry weather.

In the cholera epidemics of 1866 and 1873 in Buda-Pesth, the same relations existed between the ground water and the cholera. As the level of the ground water rose, the cholera diminished, while the disease increased upon the sinking of the ground water. Exactly the same behavior was exhibited by the disease in Munich in 1873.

There seems good reason to believe that typhoid fever is propagated in consequence of movements of the ground water, in the same way as above explained for cholera. This does not exclude the infection of drinking water by the disease germ, since much of the drinking water used, as before stated, is drawn from the ground water. Pettenkofer, Buhl, and Virchow have shown that the death rate from typhoid fever has a distinct and definite relation to the ground water oscillations. This has been incontestably proved for two cities, Munich and Berlin. When the level of the ground water is above the average, typhoid fever decreases; when it is below the average, the number of cases becomes greater.

Facts at present on record indicate that the stage of the ground water has an unquestionable relation to the sickness rate from intermittent fever. Malarial fevers are generally believed to be the invariable accompaniments of life in marshy regions, and so they usually are. But it is a noteworthy fact that malarial diseases are neither most frequent nor most virulent when the swamps are full. It is in the latter part of summer and early autumn, when the water is being gradually evaporated, and the swampy soil is drying out here and there—when the decomposition becomes active—that the fevers begin. In the winter and spring, when the ground becomes saturated to the surface from the abundant precipitation, and the processes of decomposition are checked, the fever disappears or, at all events, the cases decrease in number and severity.

About twenty years ago Dr. Henry I. Bowditch, of Boston, called attention to the frequent connection between cases of pulmonary consumption and dampness of the soil upon which the patients lived. After a very extended and laborious investigation, Dr. Bowditch formulated these two propositions:

"First—A residence in or near a damp soil, whether that dampness be inherent in the soil itself or caused by percolation from adjacent ponds, rivers, meadows, or springy soils, is one of the principal causes of consumption in Massachusetts, probably in New England, and possibly other portions of the globe.

"Second—Consumption can be checked in its career, and possibly—nay, probably—prevented in some instances by attention to this law."

Dr. Buchanan, of England, about the same time showed that the thorough drainage of certain English cities had markedly diminished the deaths from consumption in the drained cities. So far as the writer is aware, not a single fact has been established which militates against the law laid down by Dr. Bowditch and as strongly supported by the statistical researches of Dr. Buchanan, yet hardly any notice has been taken of these results by physicians. Few know anything of them, and still fewer seem to have made practical use of such knowledge in advising patients. As corroborative of the views of Dr. Bowditch, the rarity of consumption in high and dry mountainous districts or plateaus may be cited.

V.—DISEASES OF ANIMALS PROBABLY DUE TO SIMILAR CONDITIONS OF THE SOIL.

The modern study of the sanitary relations of the soil is still in its infancy. Whatever definite knowledge has been gained relates merely to physical or chemical conditions of the soil and its atmosphere and moisture, or possibly the relations of these to the spread of certain diseases in human beings. But there is, perhaps, a wider application that may be made of such knowledge than has been heretofore suggested. The domestic animals which form such a large proportion of the wealth of this country—horses, cattle, sheep, and hogs—are liable to infectious and contagious diseases as well as human beings, and many millions of dollars are lost annually by the ravages of such diseases. Now, from what is known of such diseases as *splenic fever* among cattle, and of the so-called *swine plague*, it does not appear improbable to the writer that the source of infection is a soil polluted by the poisonous germ of the diseases, just as it seems demonstrated that cholera and typhoid fever, and possibly malarial fevers, are so caused. The laborious investigations of M. Pasteur in France have shown that the cause of splenic fever when once introduced into a locality will remain active for months and even years, and it does not seem out of place to suggest to the readers of this report, most of whom are interested in the preservation of the health of the domestic animals, that a study of the soil in its relations to the diseases of these animals is a subject to which they may direct their attention with profit.

It is well known that milk cows frequently suffer from a disease identical in its nature with the consumption in human beings. It is believed by many that the milk of such animals is not only unfit for food by reason of its poor quality, but that it may convey the disease to human beings when used as food. The observations of Bowditch and Buchanan, quoted above, show that consumption in man may be, and doubtless is, frequently caused by soil wetness. It seems probable that the same cause should produce similar effects in the lower animals, and it is the writer's firm conviction that an examination into the circumstances under which cows get consumption would prove this probability a fact.

VI.—THE PREVENTIVE REMEDY—DRAINAGE.

To secure a constant level of the ground water at a sufficient depth below the surface, drainage is necessary in many soils. Agriculturists know the value of proper and efficient drainage in improving the productive capacity of wet soils, but the men who build houses for human beings to live in, or stables to shelter animals, never give this matter much thought. Few of our architects have ever heard of the injunction of the ancient master of their craft, quoted in the beginning of this paper, to select a healthy soil upon which to build a dwelling, while a stable is frequently built partly underground, and in localities where all the conditions promoting disease are present. If farmers can once be made to understand that a wet stable, whether for horses, cows, sheep, or hogs, is an unhealthy stable, reform would soon be introduced. If they could be further convinced that a marshy or springy soil is not a healthy pasture ground, such places would soon be drained. If it were found, then, that by taking these precautions the health of animals was improved and their lives preserved, perhaps architects and builders in town and country would also learn that a dwelling cannot be healthy and comfortable unless built upon a clean, dry soil.

The Boston *Watchman* says that within the last nine years nearly eight hundred churches have been burned in America. A church that will not burn seems to be a much needed invention.

* It is, of course, not strictly correct to say that the air is drawn up through the house by the diminution of pressure; it being rather forced out of the soil by the colder and denser outside air; but the phrase is sufficiently exact and will be readily understood.