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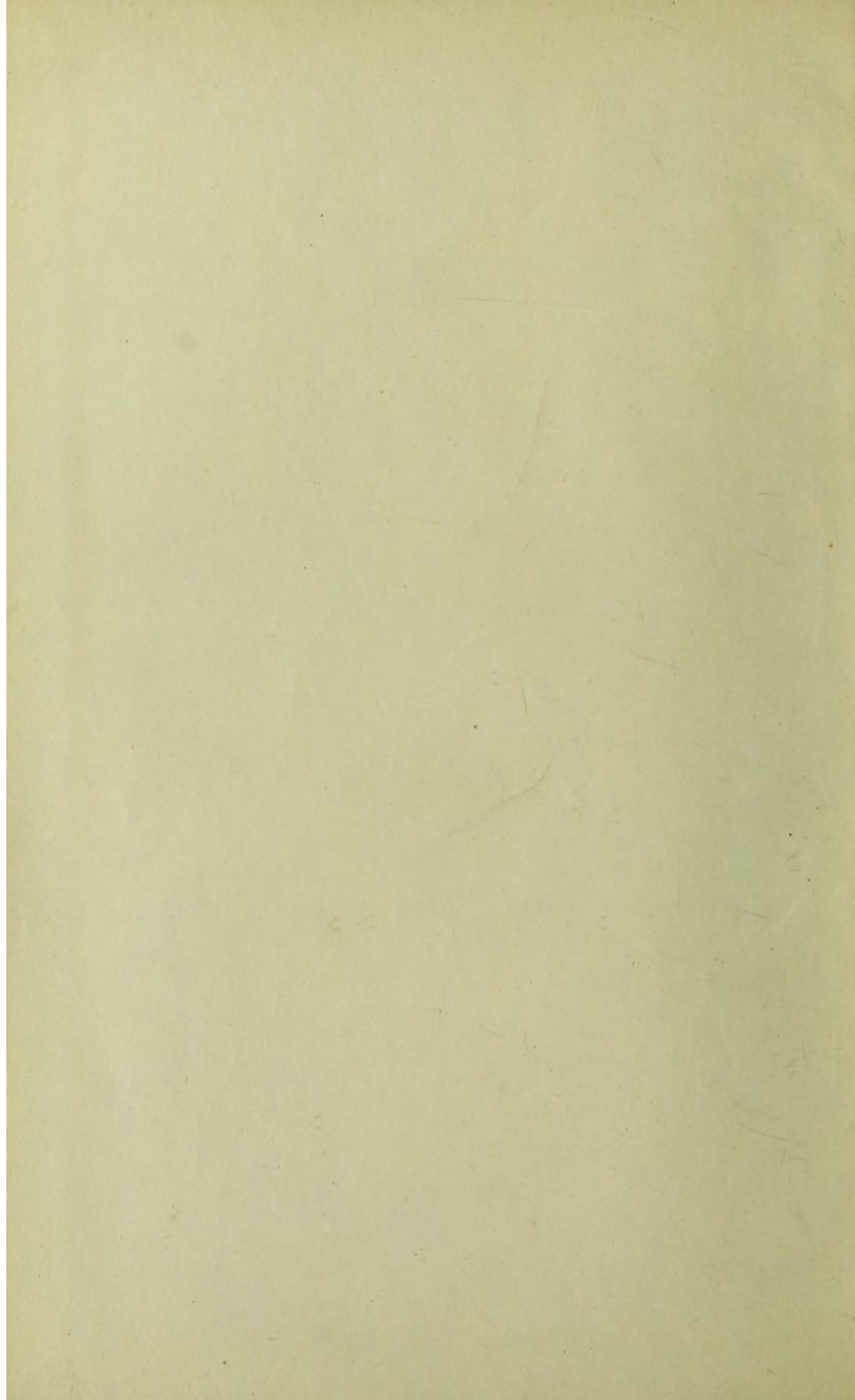
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A STUDY OF
THE PRINCIPLES OF
NATURE



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A STUDY OF
THE PRINCIPLES OF NATURE

329 PAGES. 115 ILLUSTRATIONS. DEMY 8vo. PRICE 6s.

WHAT IS HEAT?

AND

WHAT IS ELECTRICITY?

By FREDERICK HOVENDEN, F.L.S., F.G.S., F.R.M.S.,

FELLOW OF THE PHYSICAL SOCIETY OF LONDON

PLAINLY WORDED, WITHOUT TECHNICALITIES, EXACTLY
DESCRIBED

PRESS REVIEWS

Chemical News.—"This is a very remarkable book, and the outcome of a remarkable work. . . . The first section of the book is a criticism of 'mathematical and physical concepts.' The aim of the discussion is to disestablish the mathematician from what we should have considered his unquestionable position of leadership in the affairs of science. Mr Hovenden twits him with the unreality of the most ordinary of mathematical operations. . . . Section II. is devoted to destructive criticism of the kinetic theory. We commend this section, as indeed the preceding, for a collection of well-chosen excerpts from the writings of Clerk Maxwell and others who have contributed to the elaboration of this remarkable theory. . . . The succeeding section on 'Gravitation and Weight' is similarly devoted to correcting 'the confusions with which the specialists have surrounded themselves.' Clerk Maxwell and Lord Rayleigh are specially singled out for treatment on account of their pronouncement that gravitation is not a force. . . . The last sections of the book are the most original by far. They contain a careful description of a number of very interesting experiments and observations, preceded by 'a statement of the case,' or a *priori* formulation of the author's view of the micro-cosmos. This view is nothing less than remarkable. There are very few scientific men who are prepared with anything like a complete *credo* in regard to the constitution of matter, of the still more 'elusive' quantity known as 'Ether.' Mr Hovenden has given us an object-lesson of boldness in reducing the results—evidently of years of thought—to a comprehensive statement in twenty-three 'articles.' The author's most important conclusions are that the 'Ether' is an 'anti-gravitating fluid'; that the atoms and molecules—the ultimate forms of matter—are of variable form and dimensions; the difference in dimensions is due to variations 'of the quantity of Ether held by them at a given moment, and is what is called the *temperature* of the atom or molecule'; and lastly, that both *Ether* and *molecules* may be brought to visual demonstration, may be *seen* under conditions which it has been a main endeavour of the author to devise. . . . In these experiments the author shows a good deal of ingenuity. Every student accustomed to the strictly quantitative methods of modern science would find himself very much puzzled by the paradoxical observations which Mr Hovenden is able to create and put before him in such form as to be undeniable. His intuitive scepticism would at once suggest the question: Can these observations, involving not a single quantitative measurement, constitute a destructive criticism of a science which only began to move with the entrance of the quantitative method, and has

progressed *pari passu* with the reduction of the phenomena to mathematical expression? His most natural criticism would be, 'There must be something wrong somewhere.'

Machinery.—"Although there may be differences of opinion as to whether he has succeeded in his object, there cannot be two opinions as to whether he has been successful in producing a book of absorbing interest. This he has undoubtedly done."

The Electrical Engineer.—"This book contains much that is interesting, much that ought to lead to thought, much that is true, many very excellent and instructive experiments. . . . He has most certainly shown how easily existing theories can be attacked, their frailties and weaknesses made plain."

Invention.—"The writer fortunately reminds the reader that all along he has only endeavoured to play the part of a barrister, *i.e.* to state the facts of the case clearly and concisely, and to lay them before the reader so that he may form his own judgment. . . . The book itself is somewhat entertaining by the bold and daring way in which the author deviates from the beaten track of science."

Science Gossip.—"We should like to quote considerably from this work had we space available, for it is one which will interest many people. We will leave to our readers the pleasure of mastering Mr Hovenden's own conclusions, for they would spoil by condensation. Whether they be right or whether they be wrong, they are pleasantly told, and are well worth examining."

Birmingham Daily Post.—"It is not a mere compilation of facts and theories built up on orthodox lines, but a well-thought-out and carefully reasoned essay. Many of his conclusions will require powerful arguments, supported by practical proof, to gainsay and overthrow, and he has fortified his position by copious quotations from the writings of some of the most prominent chemists and physicists of the day. It is an eminently readable book, and anyone who sits down dispassionately to master its contents cannot fail to be struck with the audacity with which the author emancipates himself from scientific tradition. He tells a complex tale in a very simple manner, so that a layman can understand and grasp the issues involved; in fact, it is to this class of reader that the work will most appeal, as it will require great courage on the part of the prejudiced specialist to acknowledge that his preconceived notions are wrong. Part I., on mathematical and physical concepts, is powerfully written and admirably argued. It points out the weakness of some mathematical reasoning on which the fabrics of modern scientific theories are erected. . . . The book will amply repay a careful perusal, and whether one is converted to the views of the author or not, the intense earnestness and tenacity with which he holds to his convictions cannot fail to impress the reader with the great importance of the issues raised."

The Indian Engineer.—"We referred this matter raised in the book to an eminent professor, and this is what he has to say about it. . . . 'This is a very difficult book to review, and the verdict which is pronounced upon it is likely to depend as much on the idiosyncrasies of the reviewer as on its intrinsic merits. . . . Physicists are beginning to recognise that such questions fall within the domain of their science. . . . Such subjects as those treated in the book before us are therefore not to be put aside by engineers as of no practical importance; for if they were fully understood they might enable us to hook our machinery on to the machinery of nature, and cause a complete revolution in every department of industry. . . . He criticises very severely the methods of mathematicians, and in many cases not without just reason. Faraday, the greatest of experimentalists, knew no mathematics, but yet he taught the mathematicians how to interpret their own expressions.'"

Literary World.—"His method of making atoms overlap, and wrap each other, and become concentric, gets rid of many difficulties which belong to the orthodox view."

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(THIRD EDITION)

OR

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A STUDY OF THE PRINCIPLES OF NATURE

(ILLUSTRATED)

BY

FREDERICK HOVENDEN

F.L.S., F.G.S., F.R.M.S., F.R.HIST.S.

FELLOW OF THE PHYSICAL SOCIETY OF LONDON
VICE-PRESIDENT OF THE LONDON INSTITUTION

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PREFACE

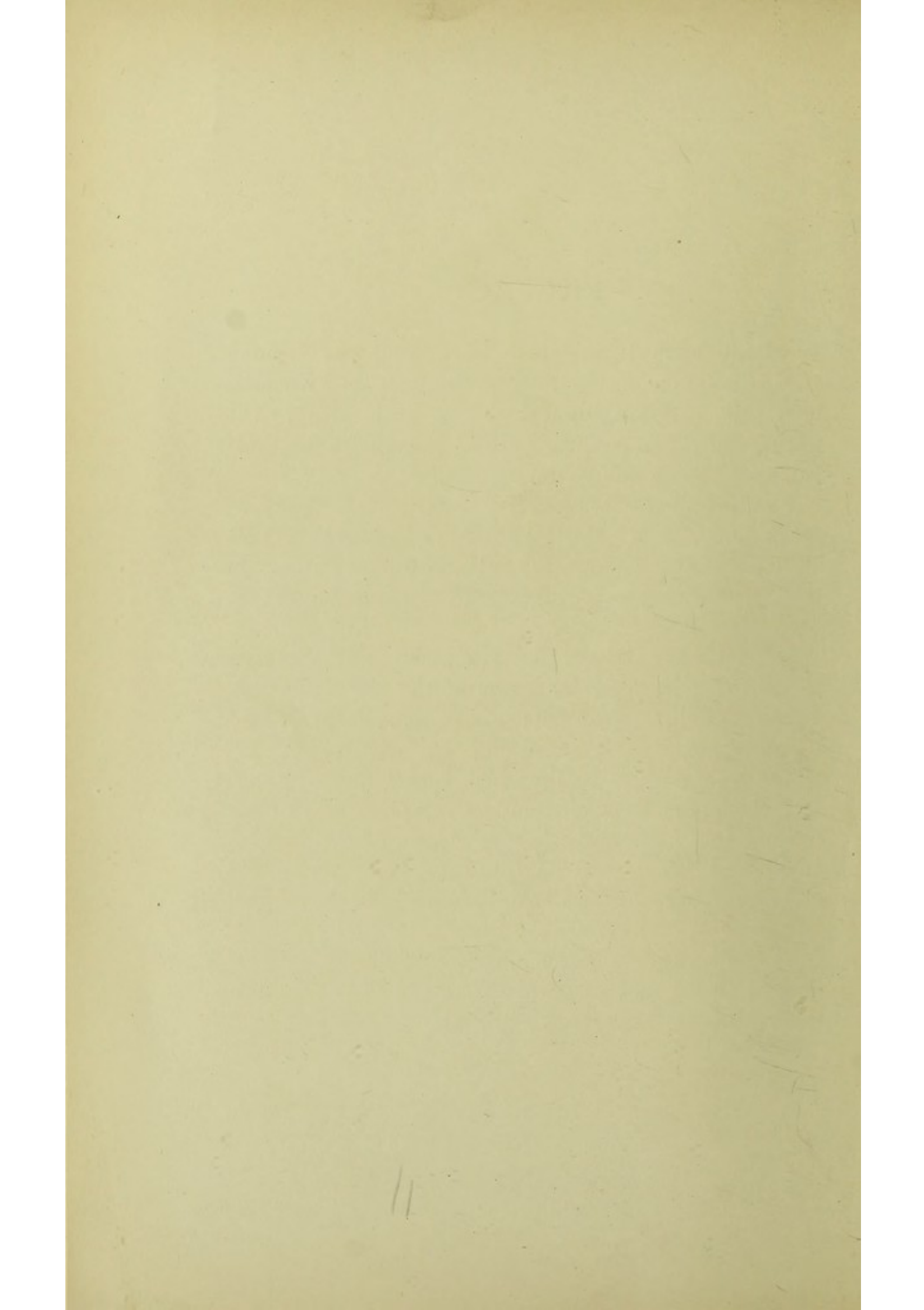
IN March 1908 I gave four lectures at the London Institution, London, entitled "A Study of the Principles of Nature." So many inquiries were made whether the lectures would be published, that I thought it desirable to do so—hence this volume.

I am indebted to my two friends Mr Donald Cameron-Swan and Mr F. Martin Duncan, and my son Mr William Hovenden, for the admirable illustrations in the first lecture, and generally the production of the book.

Mr F. Martin Duncan illustrated many of the experiments in my lectures by means of the cinematograph. This was a unique performance, and was much appreciated by the audience.

The style adopted is that which I used in my lectures, and which gave so much approval. So the reader must imagine that he is in the lecture-theatre of the London Institution listening to the lectures. Some very slight alterations and additions have been made to the original lectures.

The illustrations in the first lecture are all original (except three), and prepared for this book. The illustrations in the three other lectures are all original.



A STUDY OF THE PRINCIPLES OF NATURE

LECTURE I

RECENTLY the Proprietors of the London Institution did me the honour of electing me to the post of Vice-President. It is a position I much appreciate, and this is the first opportunity I have had for thanking the Proprietors for what they have done. But I have no idea of being simply a figure-head of this Society, for I hold that it is my duty to advance the general objects of the Institution if I can possibly do so. I think I can be of value in this direction, and this is the excuse for my lectures.

In 1865 I became a Proprietor of the London Institution, and from that time to this I believe I have attended something like eight-tenths of the lectures given. During this period of forty-three years I must have attended about nine hundred lectures. I therefore consider that I am a pupil of the London Institution. In the many lectures I have attended, somehow, I have felt a gap in the information given. The details were enormous, but the principles underlying the details were uniformly absent.

For nearly thirty years I have been experimenting, not for the purpose of exploiting Nature, which is nearly

uniformly the object of the physicist, but for understanding the principles of Nature, namely, those which underlie Natural phenomena and experiment. Some of these experiments I hope to show you in my subsequent lectures.

I would if I could take you all down to the seashore. Many places would suit my purpose, but far and away the best is Dorset, between Poole and Lyme Regis. This sea-coast includes the so-called Isle of Purbeck. And in Durlston Bay (fig. 18), near Swanage, I would assemble you around me, and I would preach a sermon to you. My text would be composite. It would include the story of our sun and the other suns in space—for the stars are suns—and the planets, including our earth; and the other objects in stellar space, including our moon; and the air which surrounds our earth; and the clouds which float in the air; and the waters beneath the air; and the organisms which live in the waters, and in the air, and on the earth, including man. But above all, the most important part of my text would be Nature's masonry and Nature's ruins.

I cannot, however, for want of ability preach that sermon, but I have a shrewd guess of its substance, and if I, in these lectures, can contribute something towards it, my lectures will not be in vain. Of this I am perfectly certain: the trend of scientific investigation and of scientific thought will make, in the near future, this sermon possible, and when it is possible, the man will come forth who will preach it, and then if men's brains are differentiated or attuned—and this process is going on very fast—so that they can understand the sermon, a new order of things will arise and ultimately civilization will say "Good-bye" to war, pestilence,

famine, disease, crime, and last, but not least, poverty. At least this will be the result in great part, for this is the goal the study of pure Science aims at, and if this goal did not exist, then the study of pure Science is futile.¹

But although I cannot take you to the seashore and explain what is to be seen, I can in a very poor way, by

¹ The main issue is only seen when the principles of the science of physics* and the science of biology† are understood. The late Professor Huxley clearly saw the issues when he wrote:

"Biology deals only with living beings as isolated things—treats only of the life of the individual: but there is a higher division of science still, which considers living beings as aggregates—which deals with the relation of living beings one to another—the science which *observes* men—whose *experiments* are made by nations one upon another, in battlefields—whose *general propositions* are embodied in history, morality, and religion—whose *deductions* lead to our happiness or our misery,—and whose *verifications* so often come too late, and serve only

‘To point a moral, or adorn a tale’—

I mean the science of Society or *Sociology*.

"I think it is one of the grandest features of Biology, that it occupies this central position in human knowledge. There is no side of the human mind which physiological study leaves uncultivated. Connected by innumerable ties with abstract science, Physiology‡ is yet in the most intimate relation with humanity; and by teaching us that law and order, and a definite scheme of development, regulate even the strangest and wildest manifestations of individual life, she prepares the student to look for a goal even amidst the erratic wanderings of mankind, and to believe that history offers something more than an entertaining chaos—a journal of a toilsome, tragi-comic march nowhither."

* "Physics" may be defined as the study of the ultimate particles of which *all things* (including man) are built and their reactions on each other.

† "Biology" is the study of these ultimate particles in the reactions called Life.

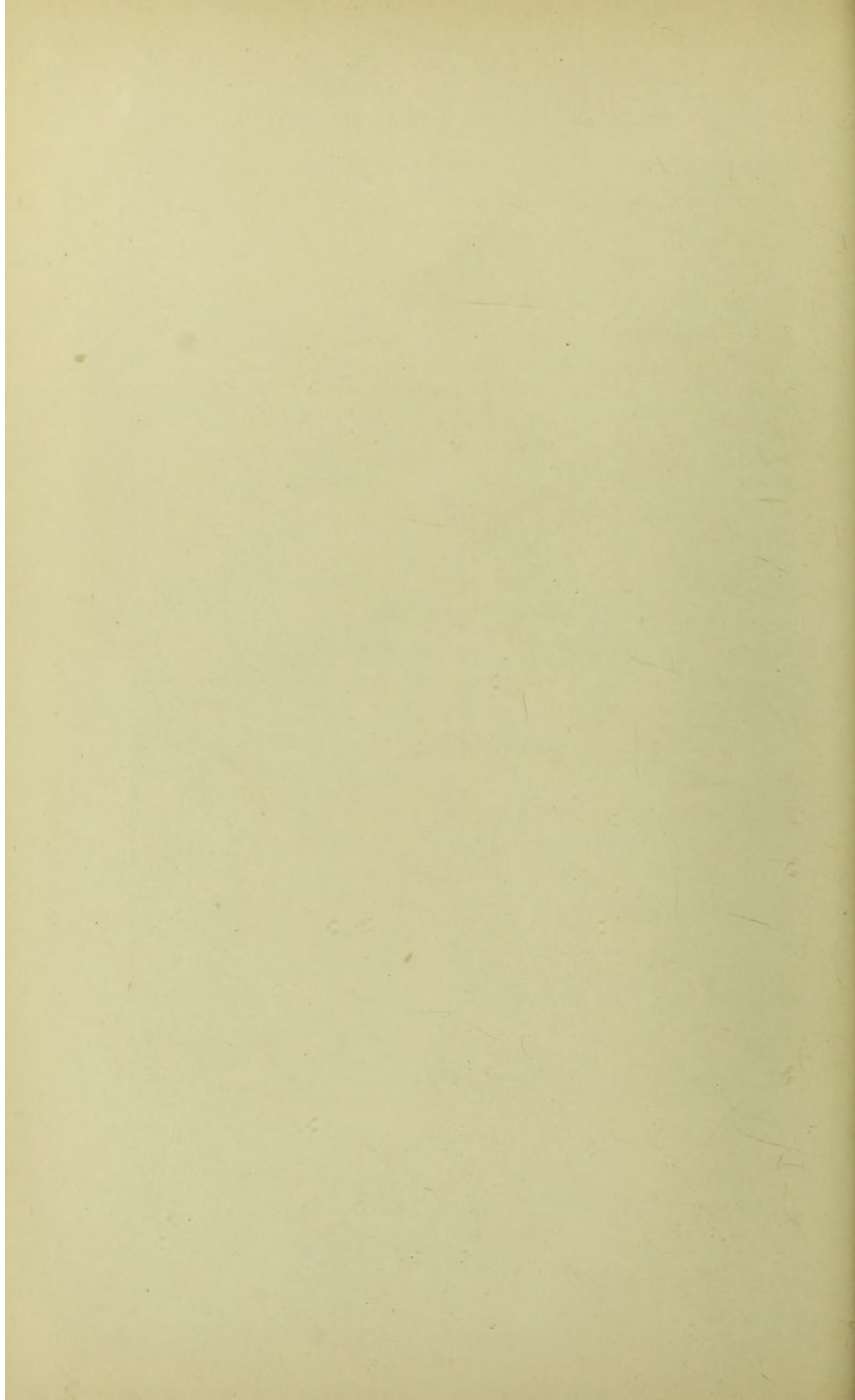
‡ Physiology is the study of the uses or functions of the parts of the organisms which are built up of ultimate particles called "molecules." These sciences are parts of a great whole called "The Science of Nature."

means of photography and the lantern, bring the sea-shore to you. Such photographs, however beautiful in themselves, are poor; they fail in showing the moving detail; they are too cramped. We want the life which surrounds the picture—the moving water and clouds, the refreshing breeze, the sunlight, the birds, and the many things which make life in the picture. My efforts must partly fail, but I do not despair in conveying some new information to you, and that information will be of the highest value, for then we can initially understand man's place in Nature, and the rôle he is playing in the totality of things; and above all, we shall understand the principles of Nature, and then we shall know how to conform to the laws of Nature instead of opposing these laws as we are doing now.

In my description I shall state many very simple truths, but you will soon find these simple truths interweave to produce complex truths of the highest order. I will commence by showing you what I mean by Nature's masonry and Nature's ruins (fig. 1). The earth's crust consists largely of layers of stone, lying layer over layer, as the photographs show, and these were always deposited horizontally, or nearly so, by means of water. Particularly I want you to notice the frequent way these are cracked, generally at right angles to the layers. These layers of stone are what I call Nature's masonry, and the fallen stones at the base of the cliff I call Nature's ruins. The first thing I want to be fully understood is, How does Nature form these layers? Those shown in the illustrations are formed of limestone. On the Dorset coast these layers are frequently filled with



FIG. 1.—A view of the coast scenery in Durlston Bay. Note the layers of limestone which form the cliff, are broken with sharp angles, while the stones which have fallen from the cliff have mostly lost the sharp angles. They are being rounded, and will ultimately become pebbles. The layers in the cliff are called "Nature's masonry"; the fallen stones are called "Nature's ruins."



fossils, so much so that there are often more fossils in volume than material in which they are embedded. At the seashore and in quickly-moving waters the stones which have fallen to the ground are pounded together by the sea and broken away into a fine powder, and the fine particles, although heavier than water, are buoyed up between the moving minute objects, called water molecules, of which the water consists, making the water cloudy or opaque. I have in this vessel some finely-divided lime suspended between the water molecules, and so long as the water is kept in motion these fine particles are held in suspension and can be carried by the water almost any distance; thus if I pour out the water into another vessel the lime particles move with it, but if the water is kept still, then these particles settle to the bottom, as is now seen in the second vessel. I have placed in the latter a shell, and you will see that the shell is nearly covered by the deposit. Now if the shell is fully covered by the deposit, and the whole sinks to the great depths of the ocean, then the pressure of the superimposed water, helped generally by chemical reaction, consolidates the layer, and in time it becomes a hard deposit, which we call stone, and the shell imbedded in the deposit becomes what is called a fossil. Not only do shells and organic matter, such as bones, wood, etc., become thus imbedded, but after the bedding, wonderful molecular alterations often take place so that the original material becomes altered into stone.

One day it occurred to me to take a mason to the seashore at Durlston Bay in order to select various layers of stone and to extract samples of these layers, also to get the mason to fashion them into paper-weights.

These paper-weights are partly the subject of my present lecture (figs. 2 and 3). Besides these which contain fossil shells, I show you one not so shaped (fig. 4). It is a piece of wood altered into stone. Notice how completely the grain of the wood and also the tracks of boring organisms are preserved.

When running water charged with these minute particles comes into deeper and relatively quiet water, as, for instance, from a stream or river into a lake, then the fine particles fall to the bottom of the lake, and any organisms imbedded become fossils. Hence the muddy water entering the lake passes away as clear water. Not only do these deposits lie at the bottom of lakes, but also at the bottom of the sea. On the seashore the waves pound stone against stone and mould them into pebbles, such as are seen at the base of the cliff (fig. 1). I show a very pretty illustration in this large pebble of limestone.¹ The original size of this stone was probably very large, comparable with the large masses of stone fallen from the cliffs as seen in the photograph, fig. 1. But let us try to conceive the vast time required to fashion a large mass of stone into the pebble you see on the table. Recollect this stone has been only occasionally submitted to the wear and tear of the sea, that is, during storms, and the difference in volume from the original to the present has been pounded up and finely divided, thrown into the bottom of the sea, and settled there, because these particles are insoluble in water. Thus new layers are being deposited which will one day—for reasons shown further on—be formed into stone, and rise to be layers on the surface of the earth like those

¹ The pebble illustrated was a white limestone pebble, egg-shaped, 7 inches long and 4 inches wide at the largest diameter.

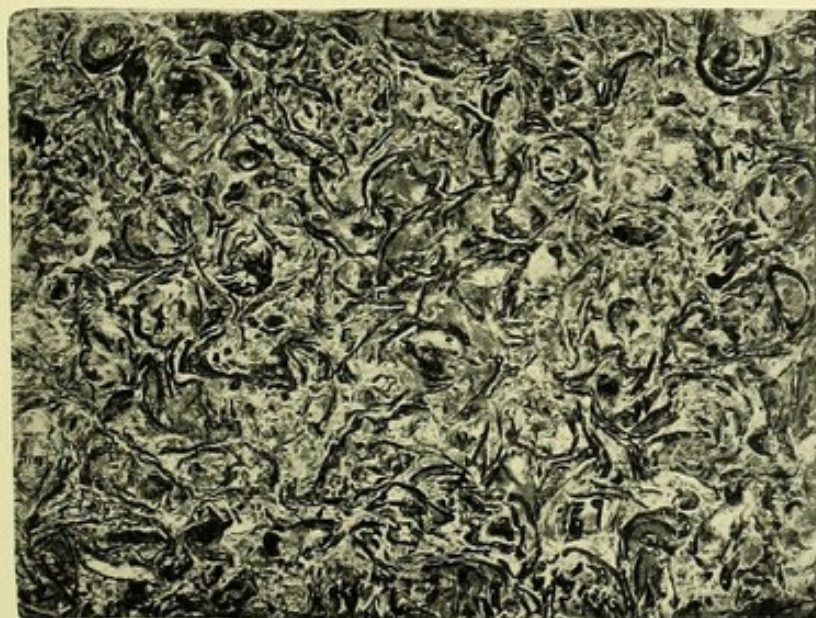
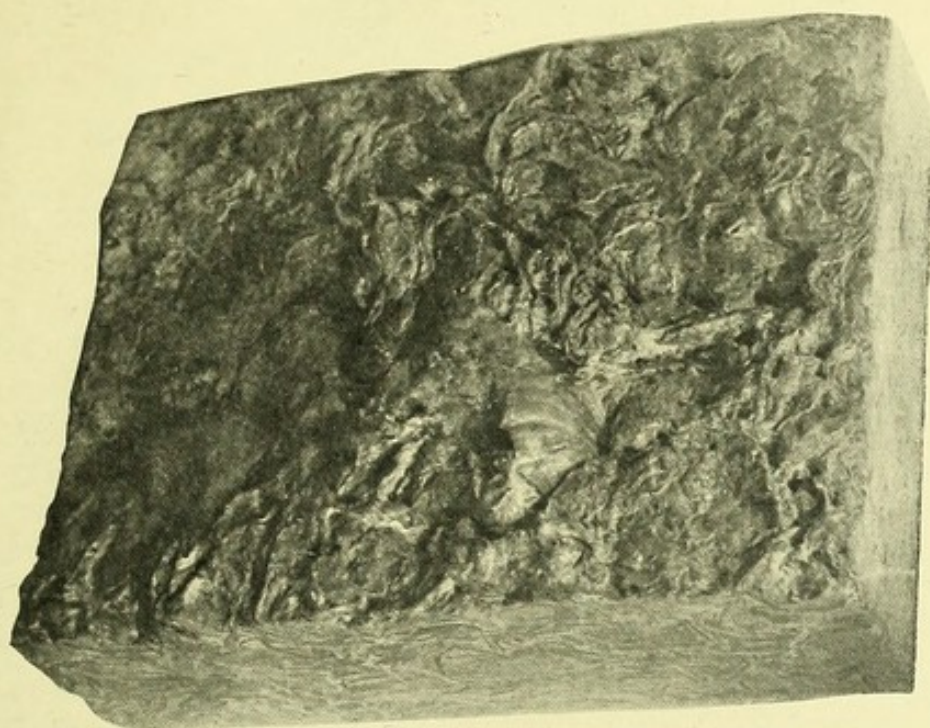
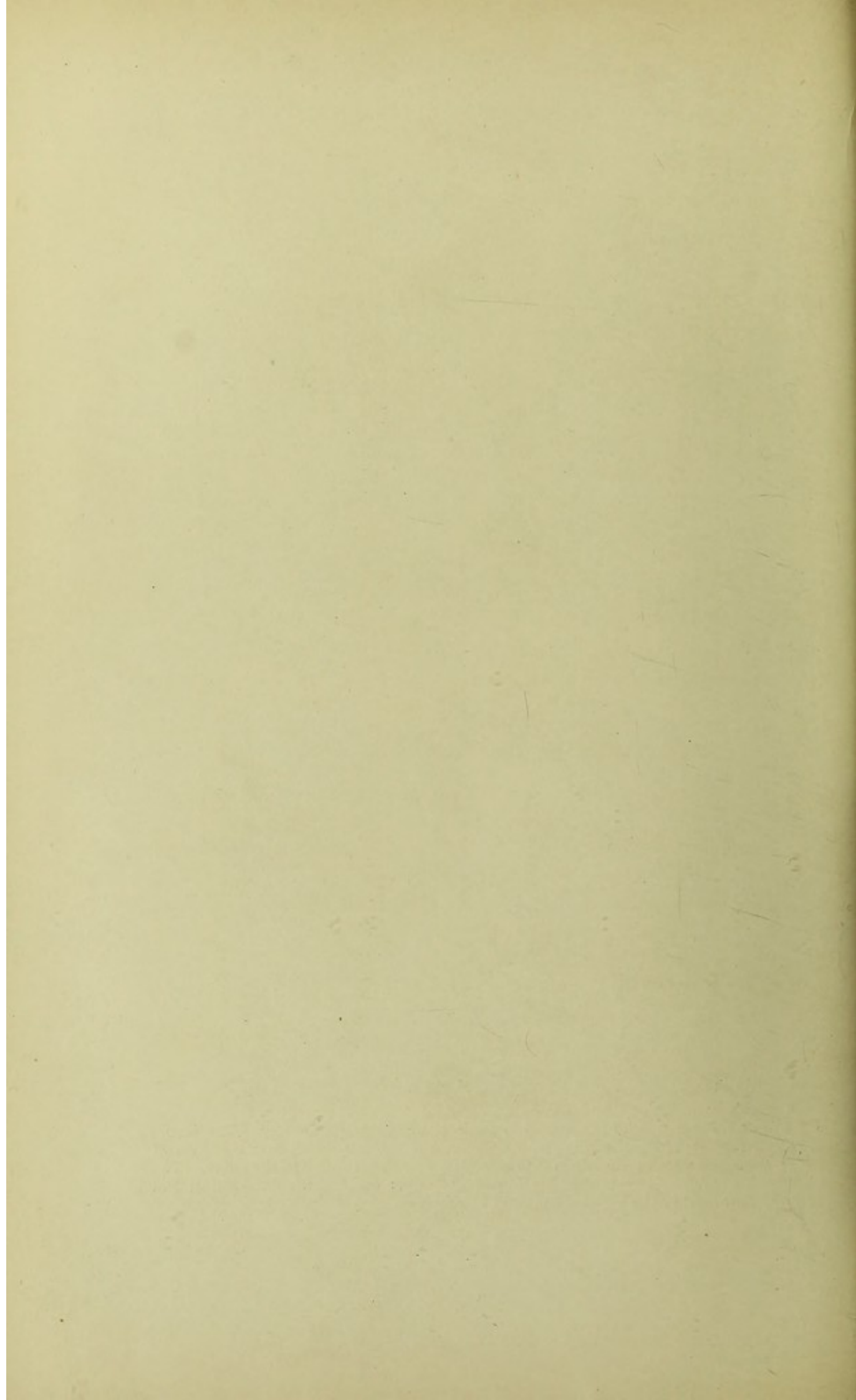
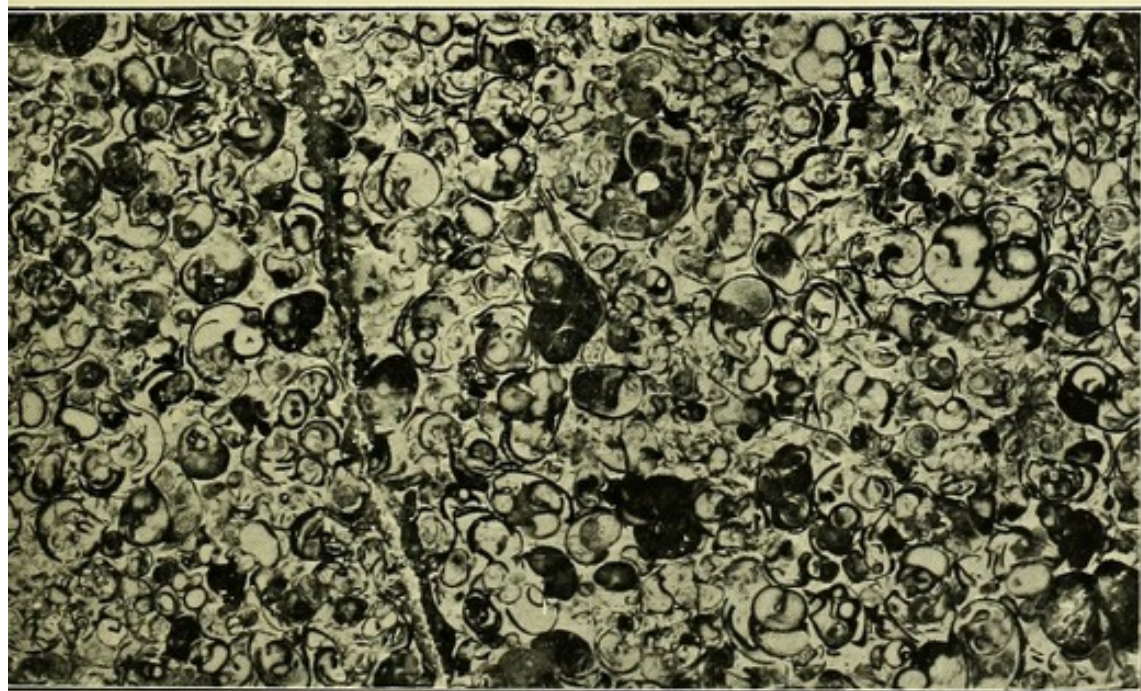
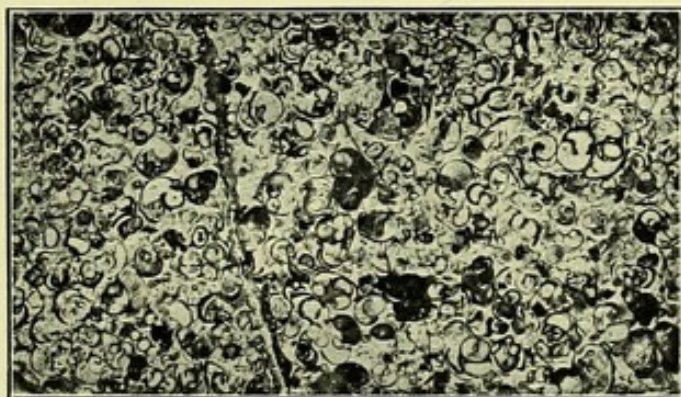
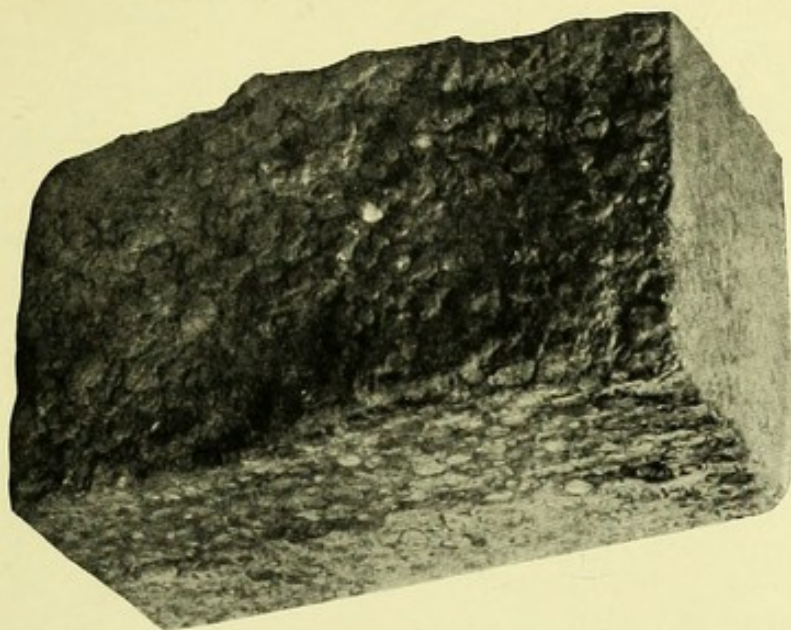


FIG. 2.—Paper-weight from the limestone layers in Durlston Bay. The layers are made of fossil shells; so closely are the shells packed, that the natural cement which forms them into stone is a very small factor in the stone. The lower figure is a polished section of the upper one, showing the detail and how thickly the shells are massed together.





3. — Paper-weight made of Purbeck marble from Durlston Bay. The middle figure is a section polished, and the lower figure is the same magnified, showing the details of the stone and the close way the perfect shells are packed together. It is a conglomeration of minute whole shells like small periwinkle shells. This fossil stone takes a high polish and is very beautiful. It is often used in cathedrals and churches.

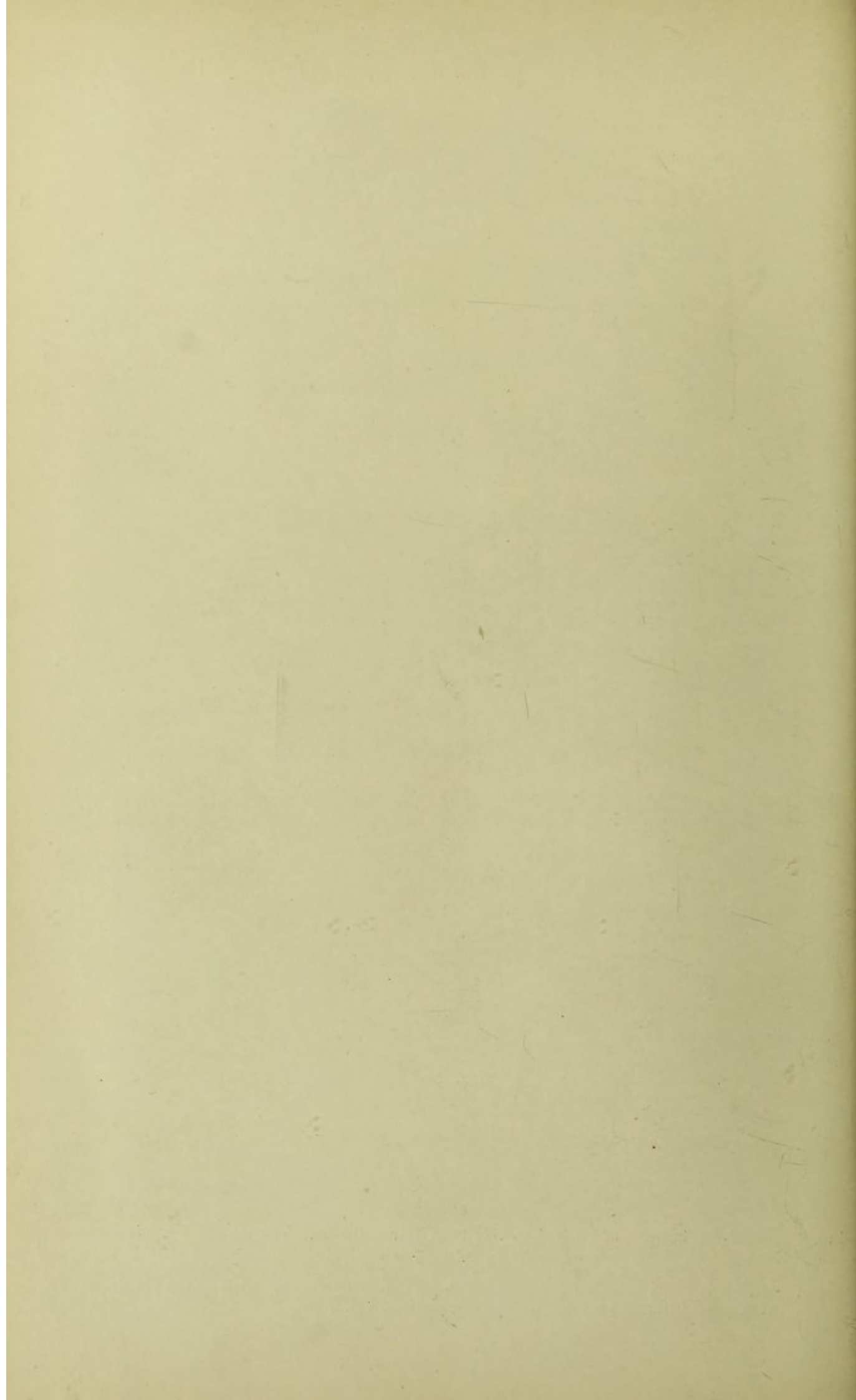
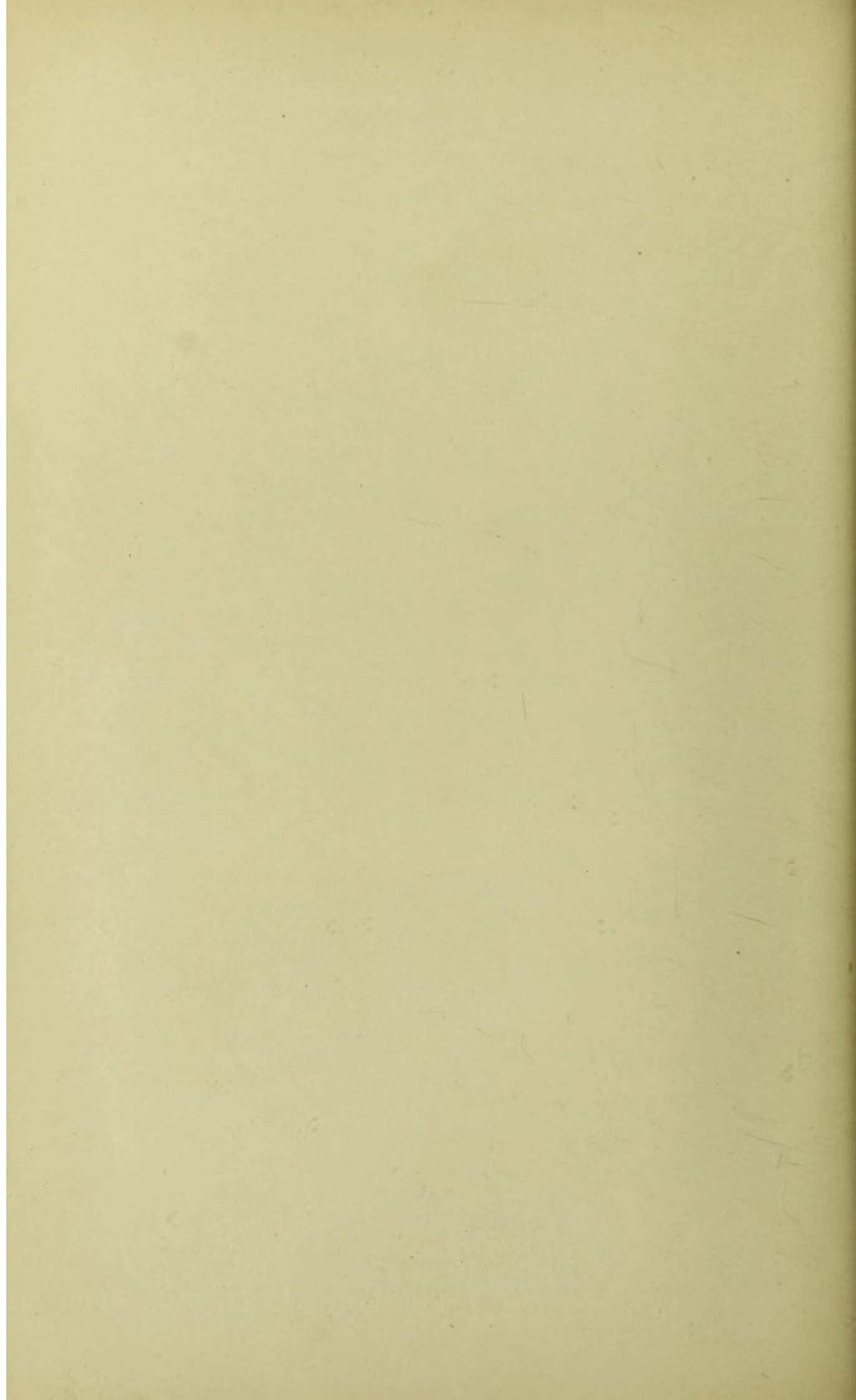




FIG. 4.—A piece of fossil wood made into a paper-weight. The lower figure, which is a section polished, shows the concentric rings in the wood. Notice the worm borings. Every particle of wood has been removed by molecular displacement. The specimen is now stone, but the alteration is so perfect that all the organic characters of the wood are preserved.



seen in the photographs. Thus Nature regenerates herself, and this regeneration in its various forms is the key to all Natural phenomena.

I have here some paper consisting of many leaves, and if I put a leaf upon the table and another leaf upon that, and then another leaf, and so on, I make a pile of paper. This is the way Nature deposits layers one above the other, but the bottom layer being the first deposited, is always the oldest. These layers are so numerous that they are beyond human description in numerical terms. But these sheets of paper are nearly uniform in thickness. Nature is never rigid: the layers are deposited in different thicknesses and differ in thickness in different parts; that is, one part of one layer is thicker than other parts. But the layers are always deposited horizontally, or nearly so, as illustrated in our receiver holding the finely-divided lime.

Now if this process were continued for all time and there were no compensating process going on, all the land would be entirely worn away by the sea and by influences in the air, such as rain.

What, then, is this compensating process? To understand this we must understand the physical constitution of our earth. If we can permit ourselves to believe that the earth is a hollow spheroid as in the illustration, everything relating to the physical conditions of the earth becomes clear. But this deduction is speculative. Very little is known about the issue—all is speculative. I have a strong feeling that this conception of our world is the truth. In the diagram fig. 5, which is an ideal section of the earth, *a* and *b* show the axis on which the earth rotates, and *c* and *d* the equatorial region; *a* is the North Pole; *b* is the South

Pole. If the shaded part were uniform in structure and density, then the earth's motion of rotation would be quite steady. But this is obviously not the condition of things; the water—*i.e.* the seas, lakes, etc.—is lighter, volume for volume, than the dry land, and the consequence of this is the balance is unstable, and the earth wobbles in its rotation. Now as the water keeps on wearing away the land, this wobbling would decrease were it not that there is a compensation like a pair of

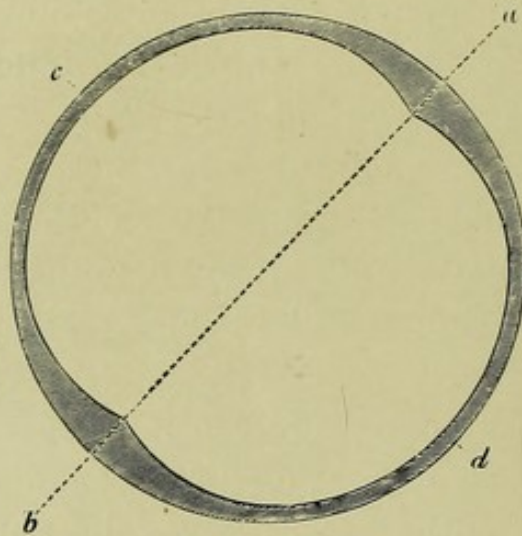


FIG. 5.

scales; when you charge one scale with a weight it falls, causing a corresponding rising of the other scale, and so in a similar way the new layers of land deposited in the bottom of the ocean press down the bottom and push up the solid land to different levels, and this pushing up takes the lines of least resistance.

Remark two important factors in this eternal process, for we have no means of ascertaining a beginning or an end of the process, but it must have been going on for millions of years, most likely millions of millions of years, a time which is to the human mind that of eternity. The deposits beneath the waters were formed in a plastic

condition, but the rising solid was in an approximate rigid state, and when the strain was at a certain pitch, then the layers of stone suddenly split into sections at right angles to the layers, and this splitting is well shown in the photograph of the chalk near the "Old Harry" Rock, near Swanage (fig. 6). The breaking of these layers produces earth tremors, which are always going on, and in extreme cases with great violence. We call the great tremors earthquakes. I think there is no doubt that the attractions of bodies in the heavens assist these reactions. Now we can understand how we have earthquakes. If, however, the cracks permit the passage of water into the solid crust and this water meets with matter which chemically combines with it, then intense heat and fire is the effect, and a volcano is born; when the material for chemical combinations is used up or the water supply is cut off, then we have an extinct volcano.

Now there is another factor which will come into operation, namely, as the balance is shifted from time to time the Poles of the earth will slowly shift, that is to say, the centre of gravity alters so that the Poles become nearer the Equator in time and the Equator will shift towards the Poles. The process is very slow, and this fact is shown in a remarkable manner in the geological record. There is the clearest evidence that temperate regions were, once or more times, polar regions, and the polar regions give evidence of organisms which lived in tropical countries.¹

¹ "That the axis of the earth's rotation has successively shifted, and consequently that the Poles have wandered to different points on the surface of the globe, has been maintained by geologists as the only possible explanation of certain remarkable conditions of climate, which

I know this is not the orthodox view of astronomers, but then what data have they? Thus Sir Robert Ball, on 5th November 1906, in this theatre, described the earth, below the crust, as an incandescent mass filling the whole interior of the earth much the same as an egg-shell is filled with a viscid mass. How does he know this? It is merely a description of a lively imagination, because no one has been very far below in the crust of the earth. And although it is stated that the temperature of the earth increases 1° F. for about every 60 feet, yet there is no evidence that this increment is a constant as it would be if heat in terms of temperature (whatever this term may mean) radiates from a homogeneous incandescent centre in an order of inverse squares, for this is the idea. Indeed, the British Association reports show that "there are indications of this rate diminishing at great depths." Temperature in the lower parts in the crust of the earth is a purely

can be proved to have formerly obtained within the Arctic Circle. Even as far north as lat. $81^{\circ} 45'$, abundant remains of a vegetation indicative of a warm climate, and including a bed of coal 25 to 30 feet, have been found *in situ*. It is contended that when these plants lived, the ground could not have been permanently frozen or covered for most of the year with thick snow. In explanation of the difficulty, it has been suggested that the North Pole did not occupy its present position, and that the locality where the plants occur lay in more southerly latitudes. . . . We can, without having recourse to any extra-mundane influence, recognize two causes which, whether or not they may suffice to produce any change in the position of the main axis of inertia, undoubtedly tend to do so. In the first place, a widespread upheaval or depression of certain unsymmetrically arranged portions of the surface to a considerable amount would tend to shift that axis. In the second place, an analogous result might arise from the denudation of continental masses of land, and the consequent filling up of sea-basins."—Sir ARCHIBALD GEIKIE, F.R.S.

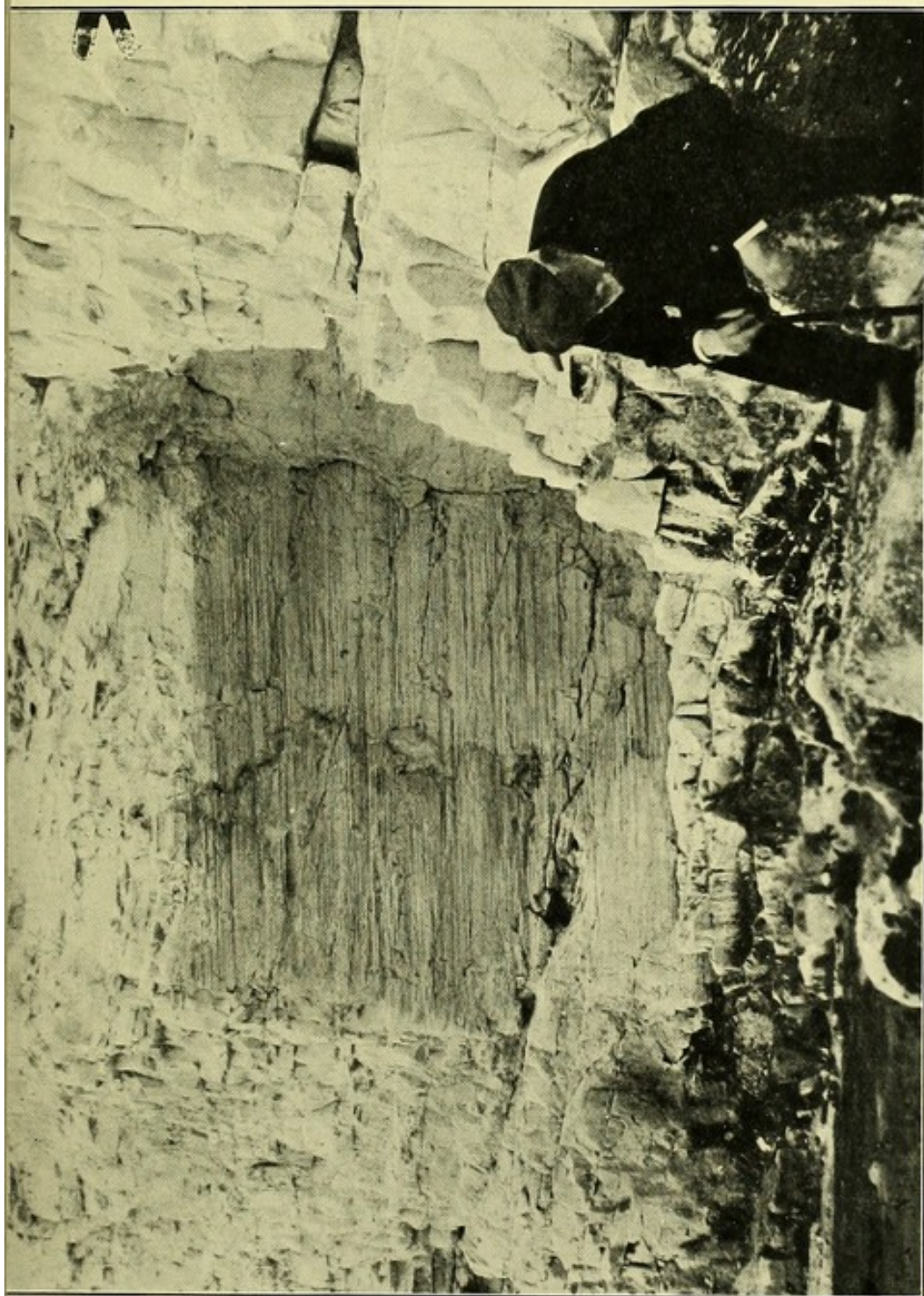
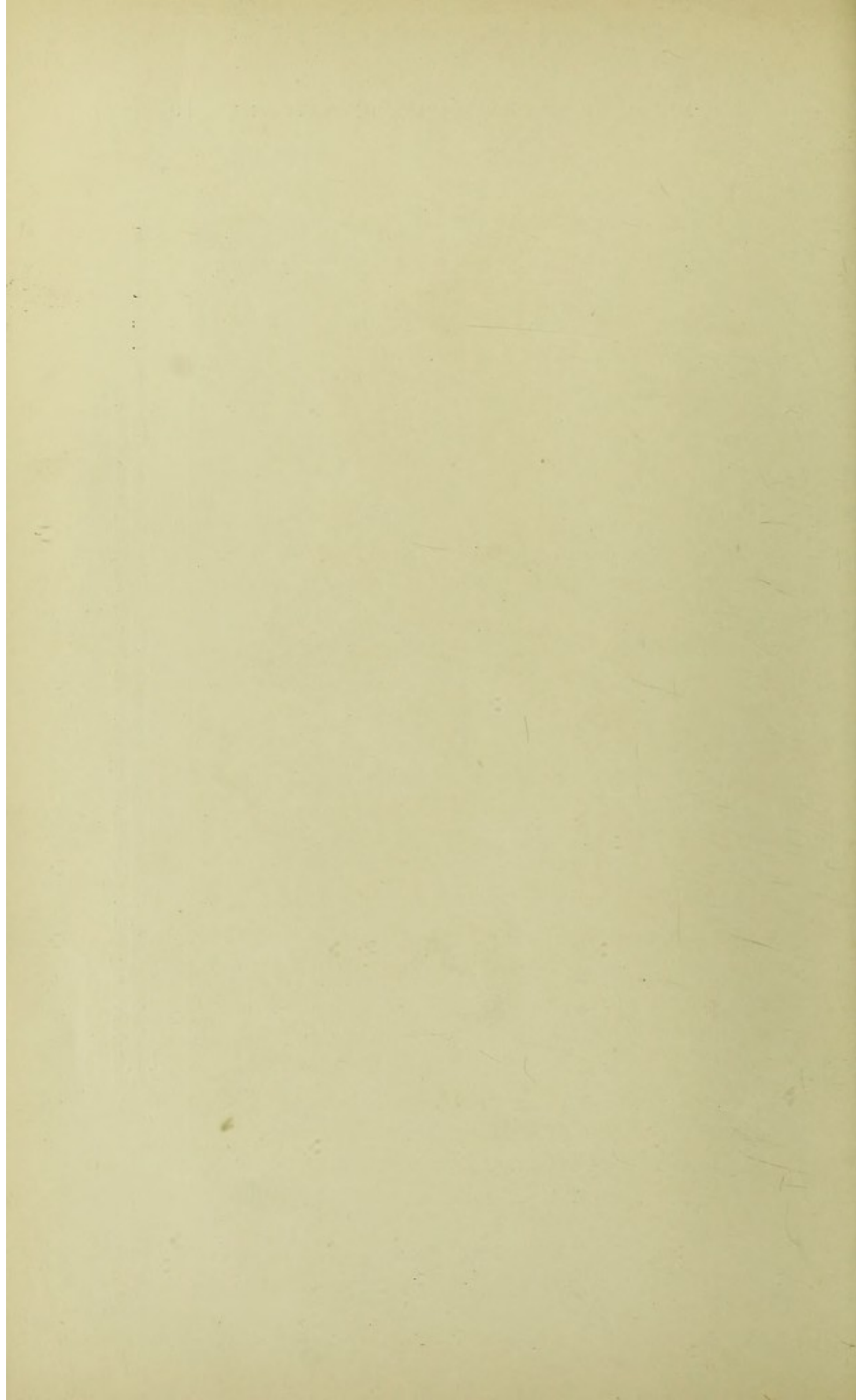


FIG. 6.—The chalk cliffs near "Old Harry" Rock, close to Swanage. On the right-hand side the splitting of the layers is clearly seen. Notice the striated appearance of the chalk in the centre. The cause of this condition is explained on page 50. The striated appearance can be well seen from the steamboats

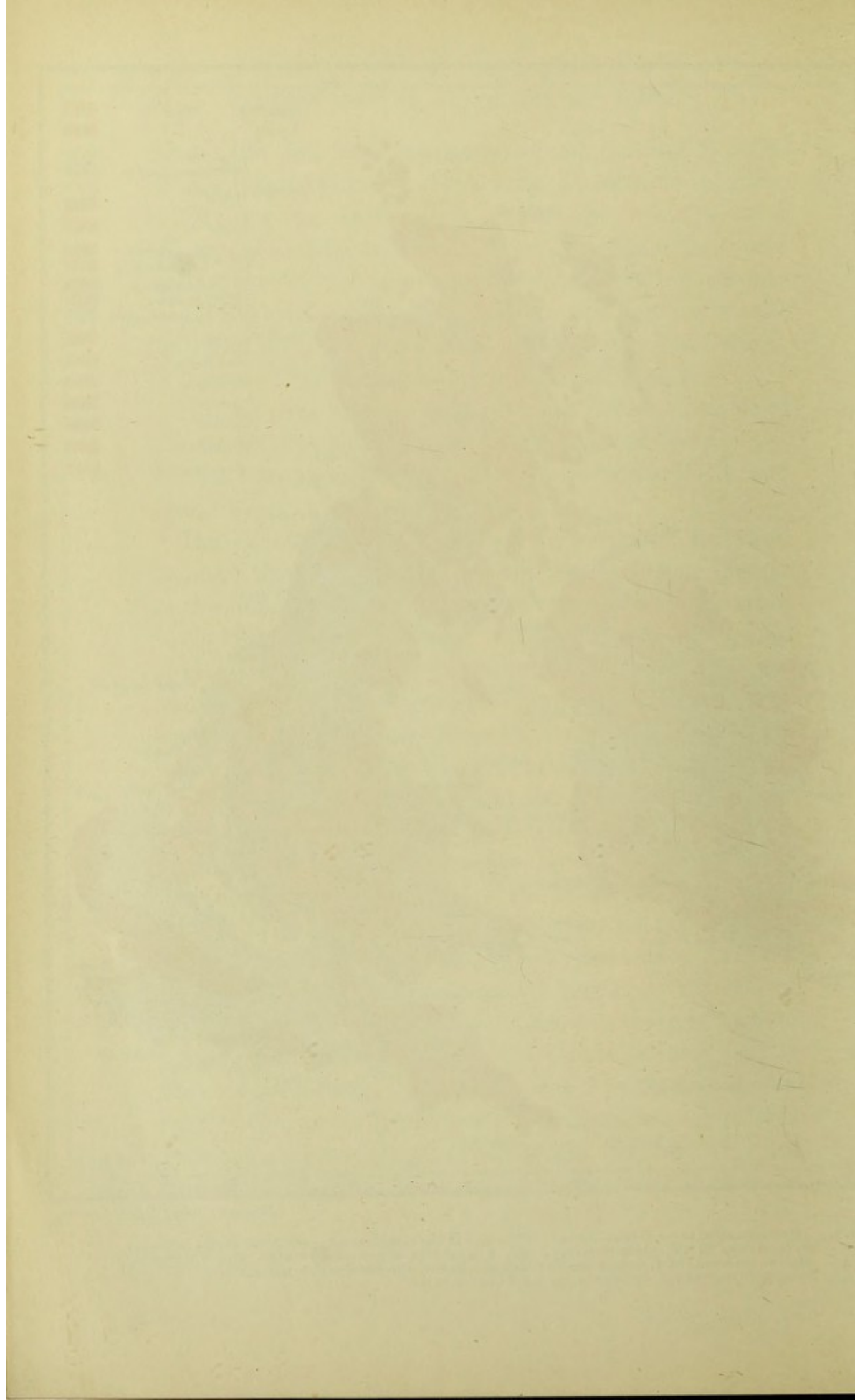


local matter. "When a tunnel is bored horizontally through a mountain, the temperature in the interior is found to be higher than corresponds to its distance from the centre of the earth." Thus temperature is high in tunnels in high altitudes. But there is a datum of great value tending to prove that the earth is a hollow spheroid, namely, the intensity of gravity. We know that gravity is more intense at the Poles than at the Equator. Gravitation, all other things equal, is proportional to mass. Let us suppose that we have on the table two weights—a 28-lb. weight and a 14-lb. weight. Assuming they are both homogeneous, which they are not, but near enough for our purpose, then the larger weight contains just twice the number of molecules than the smaller, twice the volume, and twice the intensity of attraction. Now if you look at the diagram, fig. 5, the thickness shows the mass, and this corresponds with the known facts, whereas if Sir Robert Ball were correct the inverse should be the fact, because the diameter of the world is greater at the Equator than at the Poles; hence the mass and gravity should be greater. This is not the case. Moreover, Sir Robert Ball stated that volcanoes were vents for the incandescent interior. This view is abandoned by geologists. It is not tenable, because volcanoes become extinct; this could not be the case if they were vents of a nature Sir Robert Ball describes. The chief factor in volcanoes is water. Moreover, a body rotating at such a speed as the earth does, would naturally assume the shape of a hollow spheroid, and specialists estimate that if the earth were to rotate at a speed of one rotation in three hours, centrifugal force would be so great that it would fly to pieces. We have then two forces opposing each

other : the first force being centrifugal, tending to make the earth fly to pieces, and molecular attraction—in mass, called gravity, tending to make the world a solid sphere—a centripetal force. Thus centrifugal force acts against that of molecular attraction, but does not conquer it. The earth's speed of rotation at the Equator is estimated at 507 yards per second. The evidence is, I think, in favour of the earth's being a hollow spheroid.

Having thus briefly shown you the main principles of Nature in geological phenomena, I will now describe the various formations to be met with between Poole and Lyme Regis.

The various layers of stone have local and technical names. Now I want to show you how geologists picture to the mind the various layers of which the known crust of the earth largely consists. Fig. 7 is a geological map of Great Britain. If we bear in mind the fact that all the numbered layers were deposited horizontally by means of running water, the map shows the marvellous distortions which must have taken place to bring the various layers to the surface of the earth, and the vast wearing away of these layers in order to show the sections. The various layers in the map only show the layers in sections (see fig. 10). In this map No. 1 is the lowest and the oldest layer containing fossils, and No. 16 is the newest—the deposits, geologically speaking, of yesterday. At the Jermyn Street Museum there is a model of the Isle of Purbeck which everyone should see, and there is a guide published by order of the Lords Commissioners of His Majesty's Treasury—price 6*d.*—which every one should read. The guide is written by Mr Strahan. You will notice in the photograph of the model (fig. 8) two lines which divide it into three sections, and by pulling them



ISLE OF PURBECK

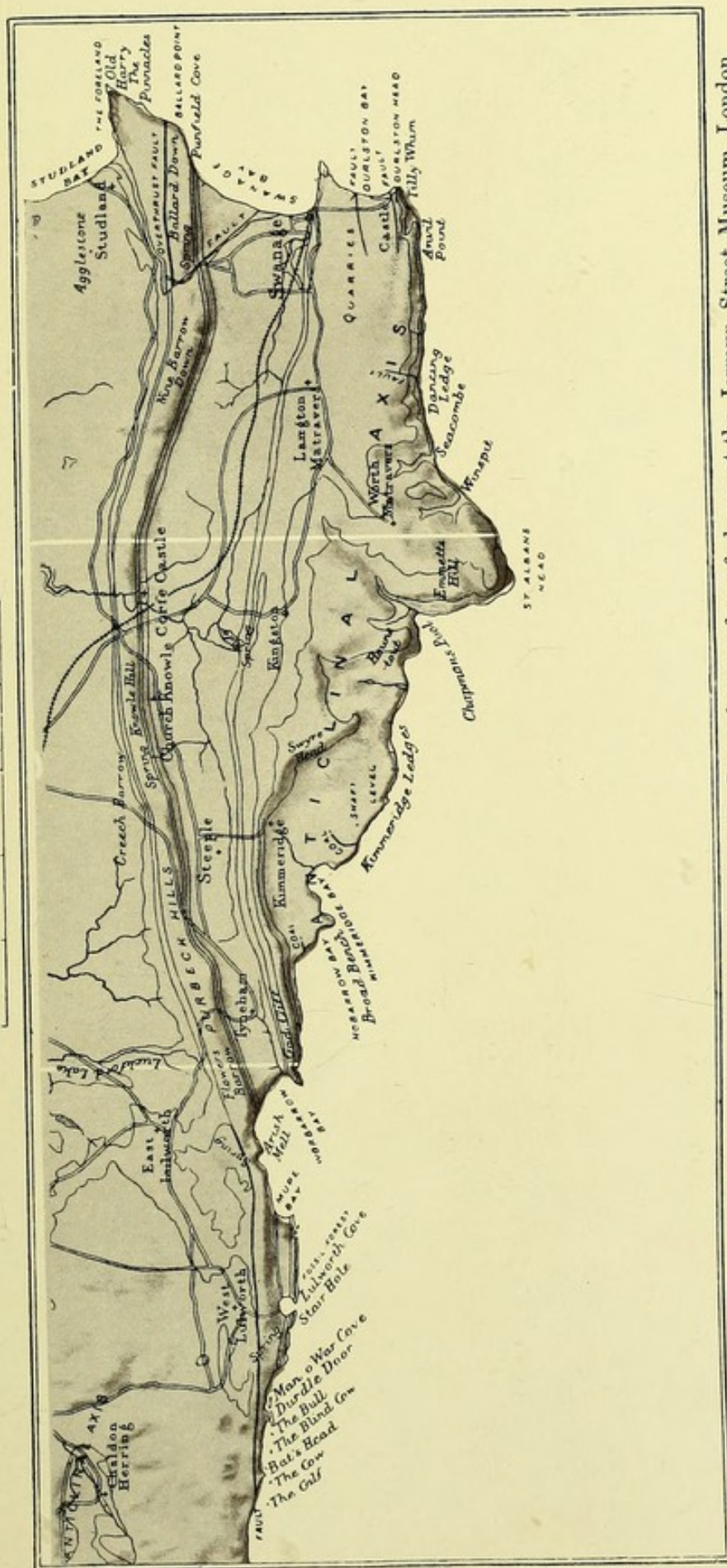
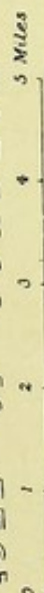
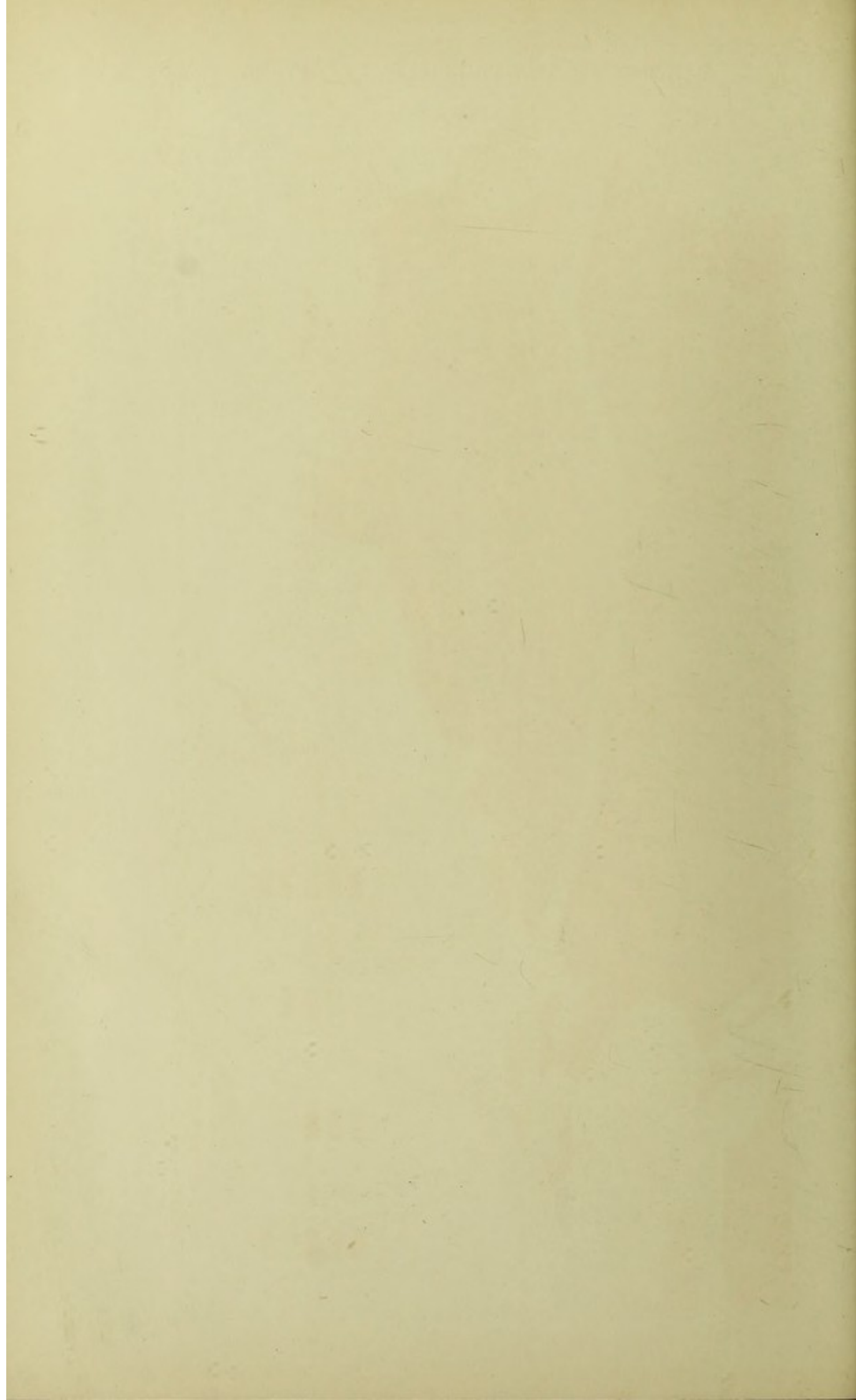
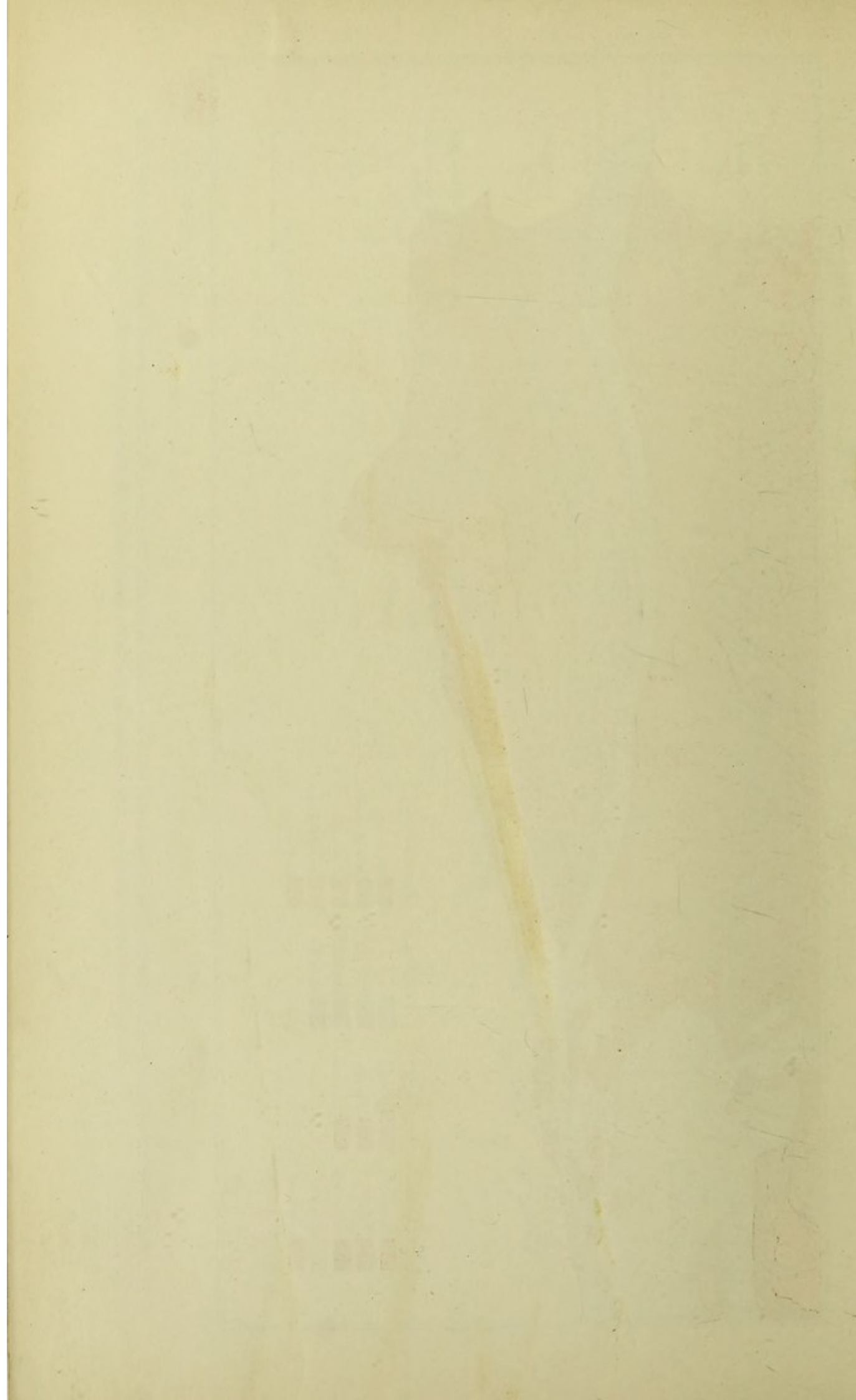


FIG. 8.—Photograph of the model of the so-called “Isle of Purbeck.” It can be seen free of charge at the Jermyn Street Museum, London. Notice the line of the Ballard Down Fault, reaching to “The Calf” on the west. The face of the fault at Ballard Down is shown in fig. 14.





apart we obtain views of the substratum of the earth's surface here (fig. 10). I also show you a coloured photograph on which there is an index explaining the various formations which crop up to the surface of the earth in this region (fig. 9). These layers are coloured to correspond with the index. The lowest layer in this district is known as the Kimmeridge clay, the next as the Portland sand, the next higher the Portland stone, and so on until we get the deposit of to-day, the alluvium deposit, which does not exist in the Isle of Purbeck.

I now show a copy of these sections (fig. 10). You will notice how wonderfully the layers are disturbed from the horizontal. I want to fix your attention on various parts of the Isle of Purbeck (fig. 9). First, Ballard Point, next Durlston Bay, Tilly Whim, then Worbarrow Bay, Mupe Bay, the Fossil Forest, Lulworth Cove, Man-o'-War Cove, and Durdle Door. I draw particular attention to the line from Ballard Point to the Calf in fig. 9, which is in the chalk formation. This line represents what is known by geologists as a fault, and a very remarkable one it is. Now I shall revert to our layers of paper. Nature always lays these geological layers horizontally (or nearly so), as if deposited with a spirit-level, somewhat as a mason lays his stone. But immediately after the deposit and during the deposit, Nature, always on the move, is constantly altering the position of the layers, and thus with our paper model there is not a position I can place the paper layers but what Nature has a counterpart. We tilt the paper in one direction, say, below or upwards, and then we may have a drop, as if I cut the mass of folds and altered the levels—this is a fault (fig. 11); or we may

twist the paper into folds so that the layers assume the form of the letter "S" (fig. 15). Or we may cut off the tops of the inclined folds and deposit thereon fresh horizontal layers. And thus we find that Nature alters or contorts the surface of the earth, and these folds and faults are lines of least resistance. So we have two distinct processes going on: the deposition of the finely-grained matter in the water, with the entrapping of the organic matter in it and the consolidation of the plastic into the rigid to form stone; and then, secondly, the distortion and upheaval of these layers of stone into any conceivable and every conceivable form.

Besides the deposits illustrating the regeneration to which I have drawn your attention, there is a second form of deposit, and this is shown in the chalk formation (see model, fig. 9). It is essentially a deposit formed by what is being now recognized by biologists as chemical reaction. It is a unique deposit. All life is a phase of chemical reaction so complex as to defy the human being to describe the detail. Amongst the various forms of life there are organisms very minute in size whose shells are built up of carbonate of lime, and which fully illustrate this process. The carbonate of lime is extracted from the water by the living organisms just as we extract the carbonate of lime in our kettles, and we call it furring of the kettle, only in these organisms it is not necessary to have a high temperature to produce the solid shell. The living bodies are inconstant in form, now assuming one form and then another: objects without permanent limbs as we have, but whose bodies become temporary limbs, the plastic matter becoming a temporary mouth and thus absorbing food which is digested in this what is called protoplasm, and having absorbed the

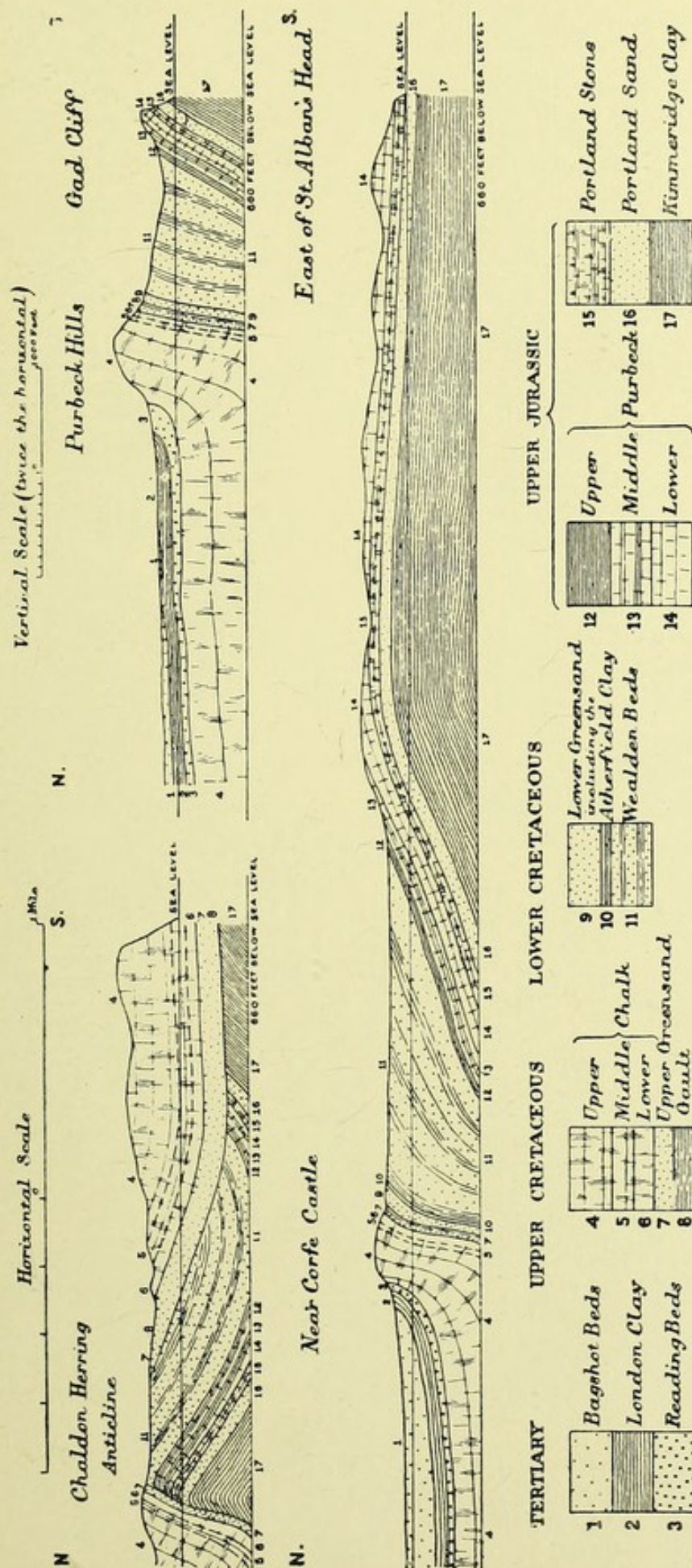
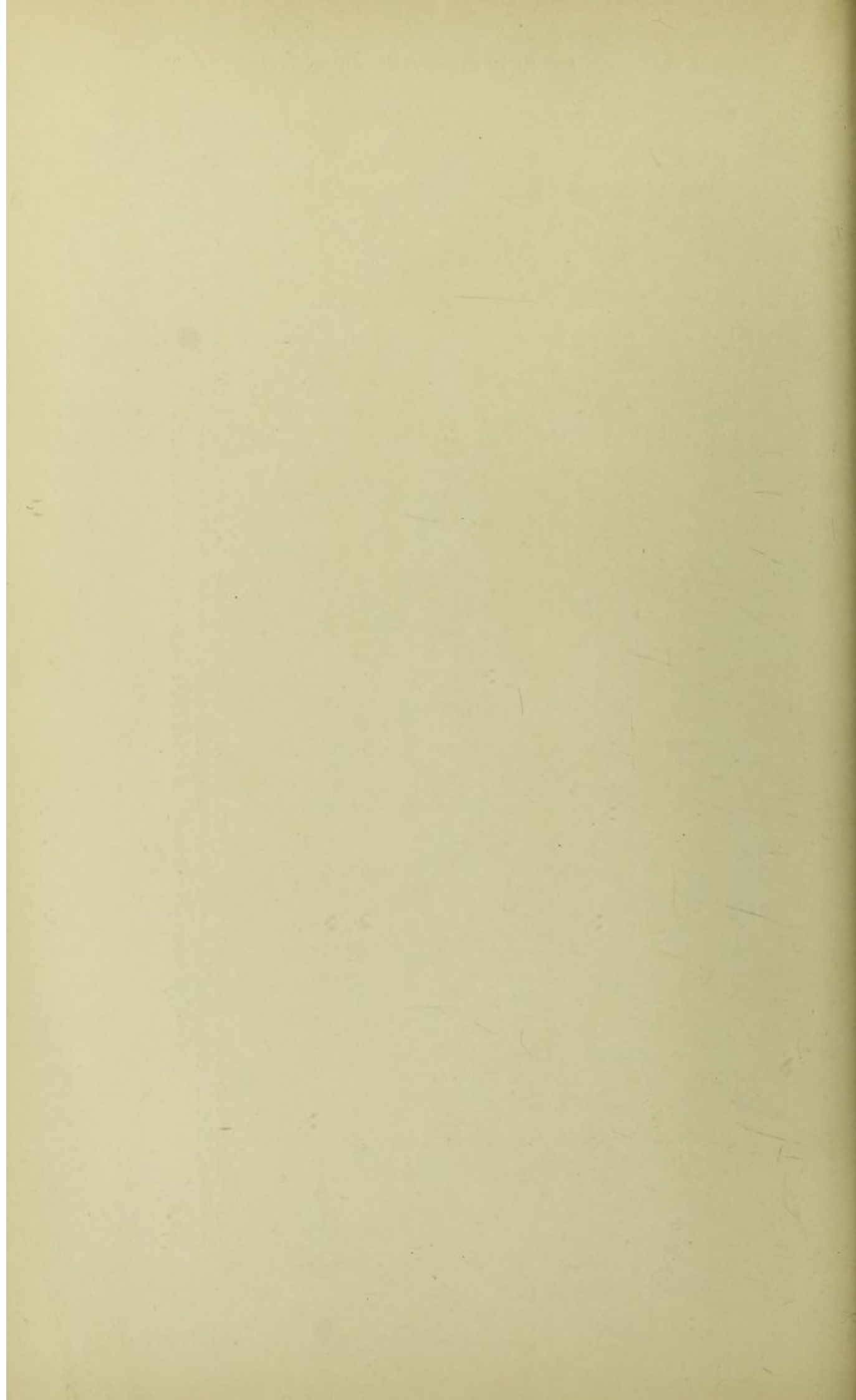


FIG. 10.—When the model of the Isle of Purbeck (fig. 8) is pulled apart at the lines dividing the model, each section shows the above layers and how they have been distorted. Notice that the parts of the layers exposed at the surface are nearly uniformly sections of the layers.

(From the *Guide to the Geological Model of the Isle of Purbeck*, by Aubrey Strahan, M.A., F.R.S.)



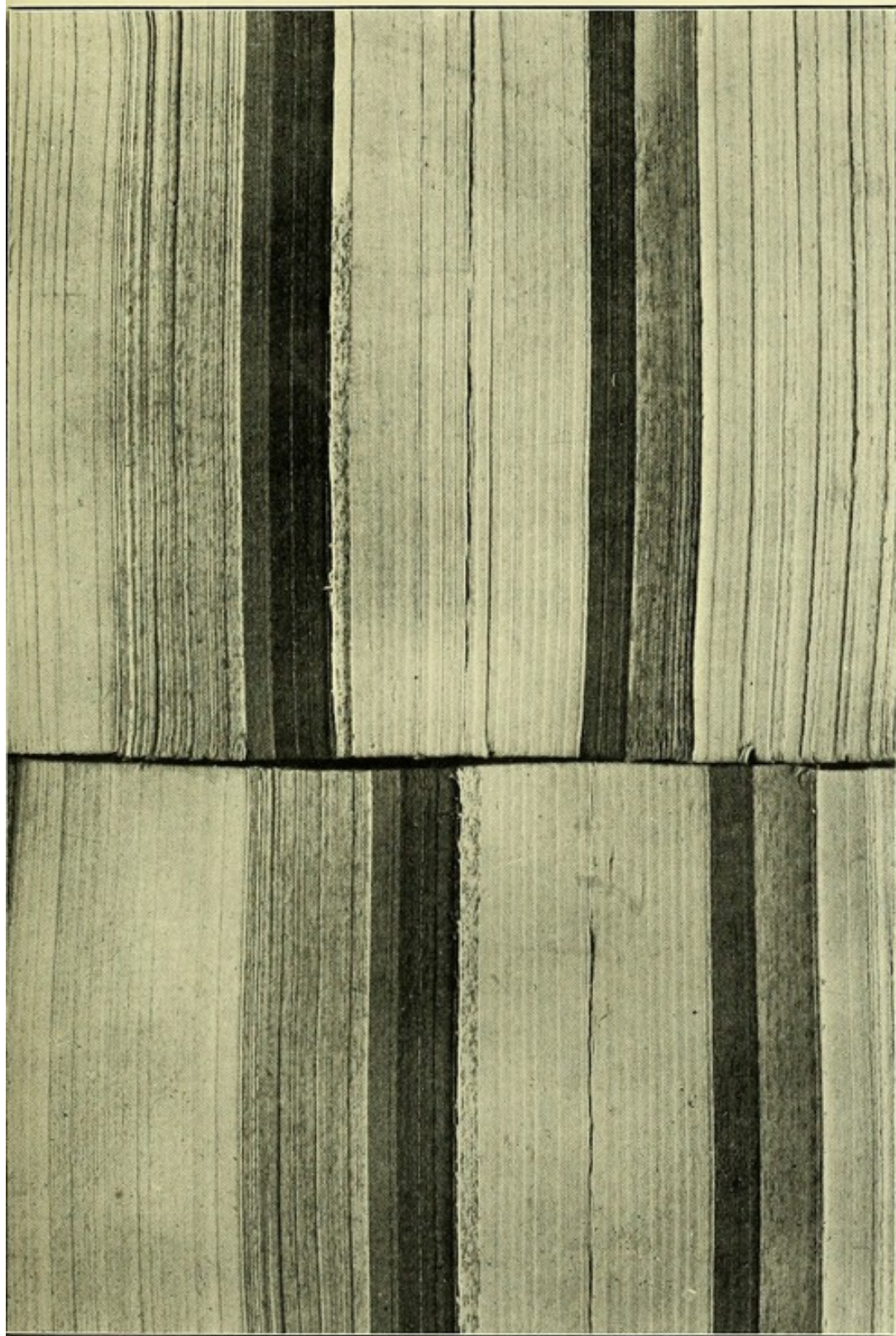
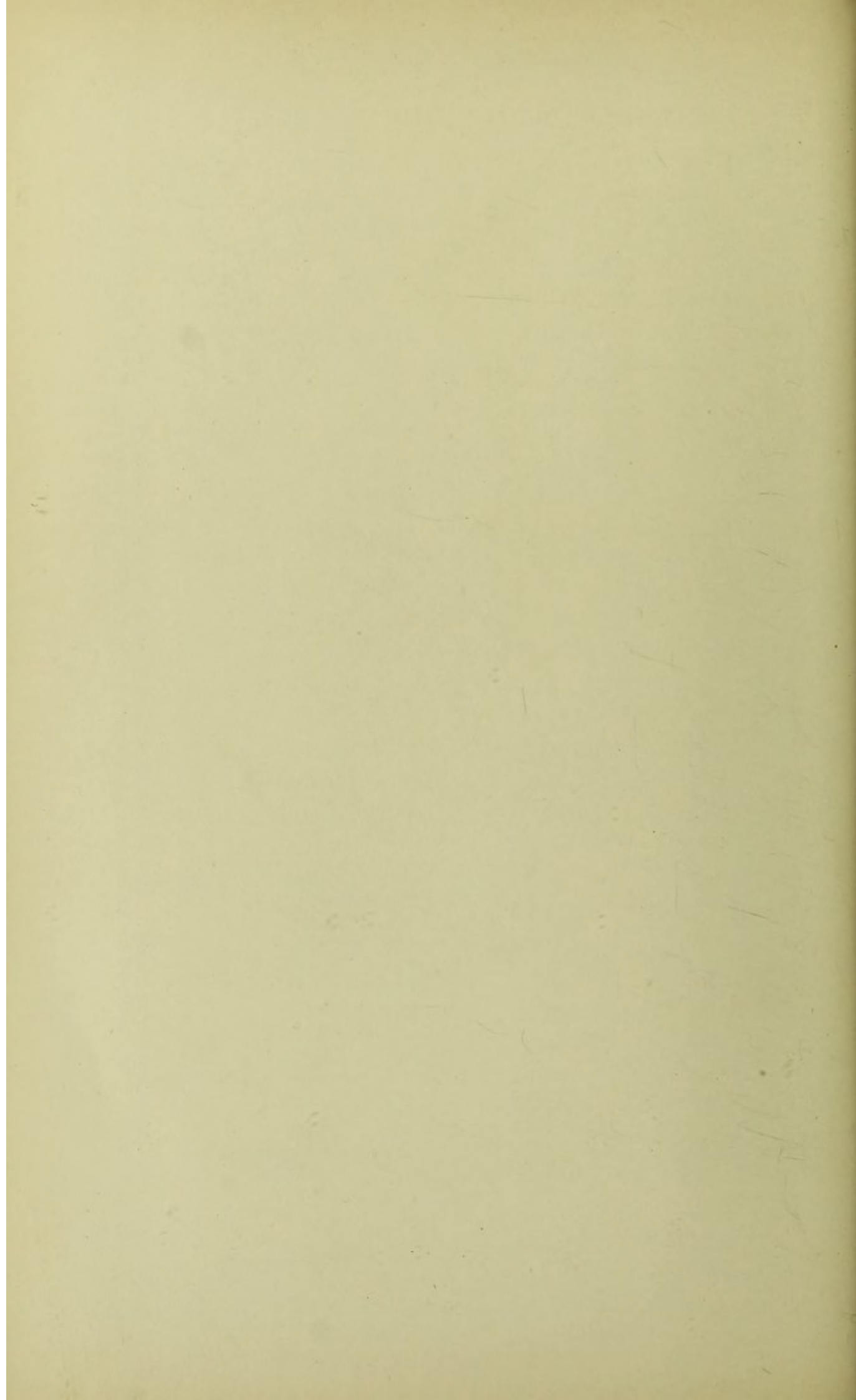


FIG. 11.—Copy of paper model consisting of layers of different coloured sheets of paper. The mass has been cut into two parts and the levels altered. This alteration of level is called by geologists a "fault."



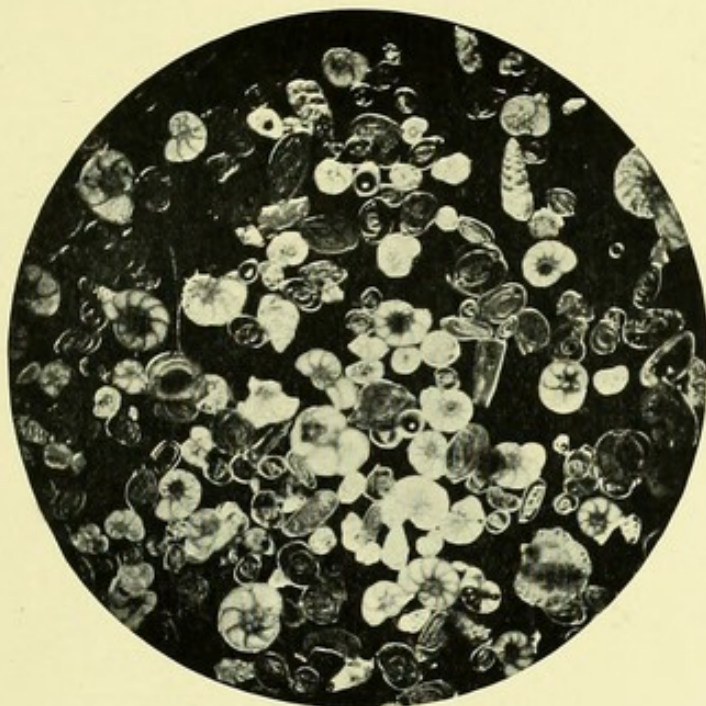
nourishment, the indigestible food is ejected at any part of the body. This process is a true chemical reaction.¹

In fig. 12 we have photographs of some of these shells from the bed and the upper part of the Atlantic Ocean. The creatures forming these shells lived in the upper part of the seas, had a life-history, died, and then the shells slowly fell to the bottom and are forming a layer. The process is, in principle, the same as the fine grains of solid matter which have been taken from the stone, which I have called Nature's ruins, and which ultimately forms the pebble. And this process is going on to-day in our seas, and the evidence shows that the process has gone on for an eternal time—that is to say, *to our minds*, an eternal time—and by-and-by this bed of the ocean will be raised to form a chalk down, the same as the present chalk downs were once the bed of an ocean. Fig. 13 is a photograph of some chalk which consists almost wholly of fossil shells, and notice how these shells compare with those which are being deposited in our seas at the present time. But there is one thing I want to impress you with. To-day our ships are being wrecked and are falling to the bottom of the ocean just as the shells do and did, and one very, very distant day these ships, the ironclads, with the bones of our sailors, the cannons and shots, the anchors, the masts, the machinery and so forth, will appear as fossils to be dug out of the chalk downs! Try to conceive these truths, try to conceive the vast time required for such changes in the past. Consider that these shells are so small as to be fully seen only by the microscope—that each shell

¹ "Chemical reactions" may be defined as the definite grouping and regrouping of the molecules of which all visible and invisible matter consists. Hence all chemical reactions are physical reactions.

tells a life-history, and then we shall be able to appreciate what has taken place to form our chalk downs. The chalk downs in the Isle of Purbeck measure in thickness over 600 feet, more than one and a half times higher than St Paul's Cathedral. But in the chalk there is no evidence of the remains of man nor his handiwork. Fig. 14 is a photograph of the front of Ballard Down. It shows the section of the fault. This fault runs approximately with the black line I have shown you on the photograph, and appears again to the west of Durdle Door (fig. 9, and model, fig. 8). You will notice the chalk has layers of flint nodules which were deposited horizontally—they are seen on the right-hand side of the photograph in their normal position,—but on the left these layers of flint have in some mysterious way become vertical, and in process of this alteration the vertical layers have pushed up the horizontal ones with such a power as to bend up the horizontal layers, showing the curve, as illustrated in our photograph. Such has been the force exercised that the flint nodules have been broken into fragments, and in some parts on the coast in the line of this fault the flints have been reduced to a black powder and drawn out, says Mr Strahan, "into black streaks like so much coal-dust." Now the problem comes: Has all this been done suddenly as by tremendous earthquakes? The consensus of opinion of geologists leads to the answer "No." It is a slow upheaval, and is going on now, and probably it is so slow in action that a thousand years or more will not make a visible alteration.

Fig. 15 is a photograph of Lulworth Cove. It is one of the most interesting scenes in the world. Notice that east and west of the entrance to the cove the layers,

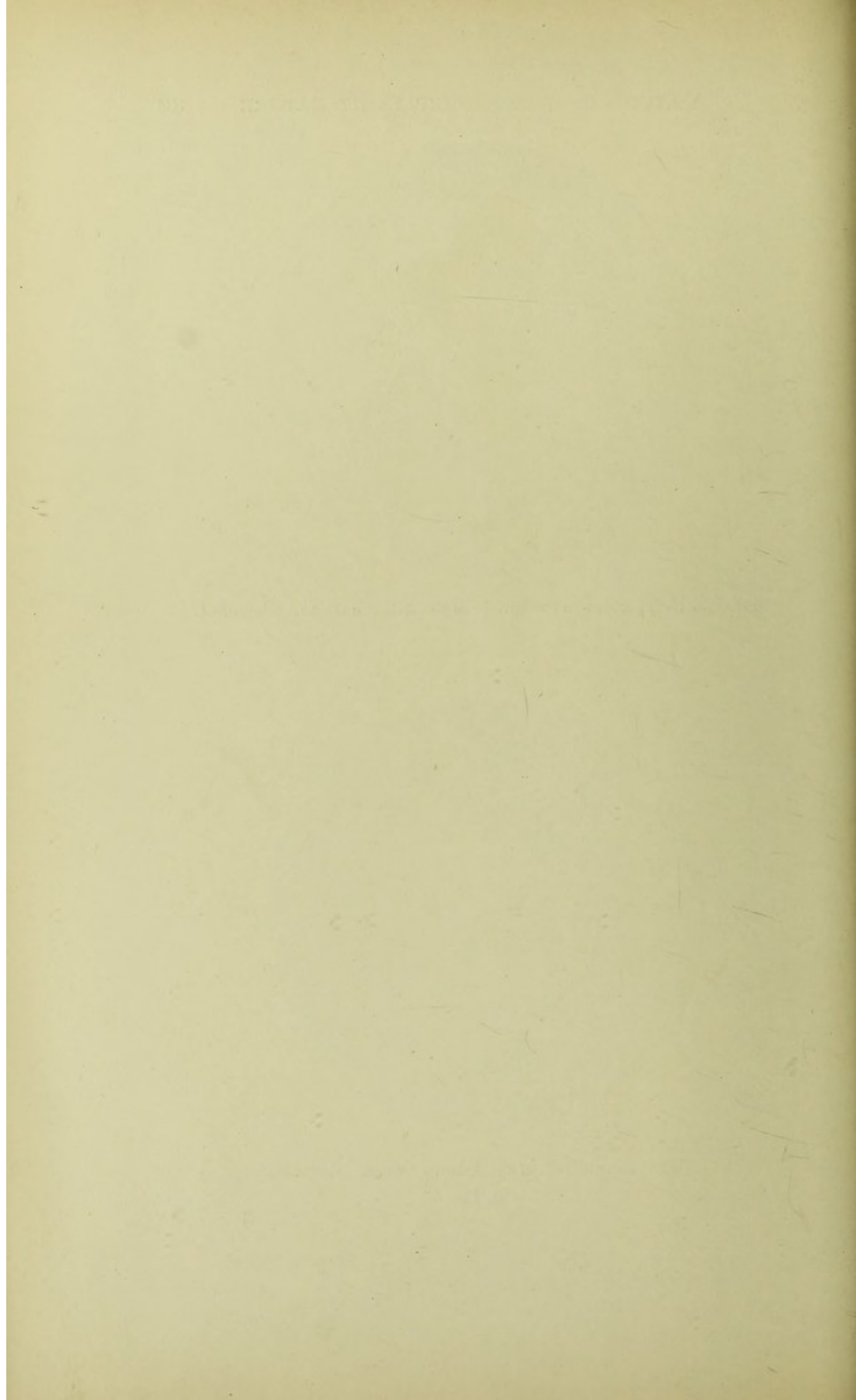


Shells floating near and on the surface of the Atlantic Ocean. Magnified.



Shells from the bottom of the Atlantic Ocean. Magnified.

FIG. 12.



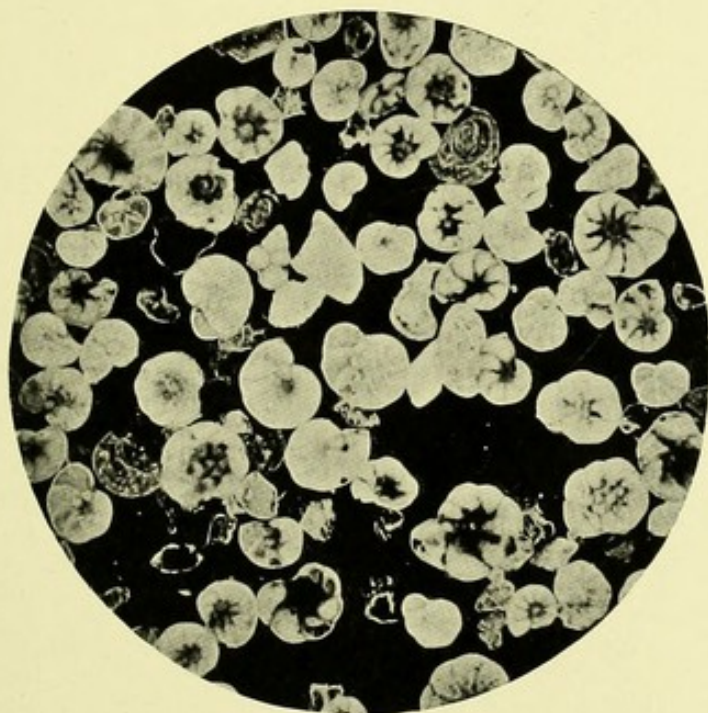
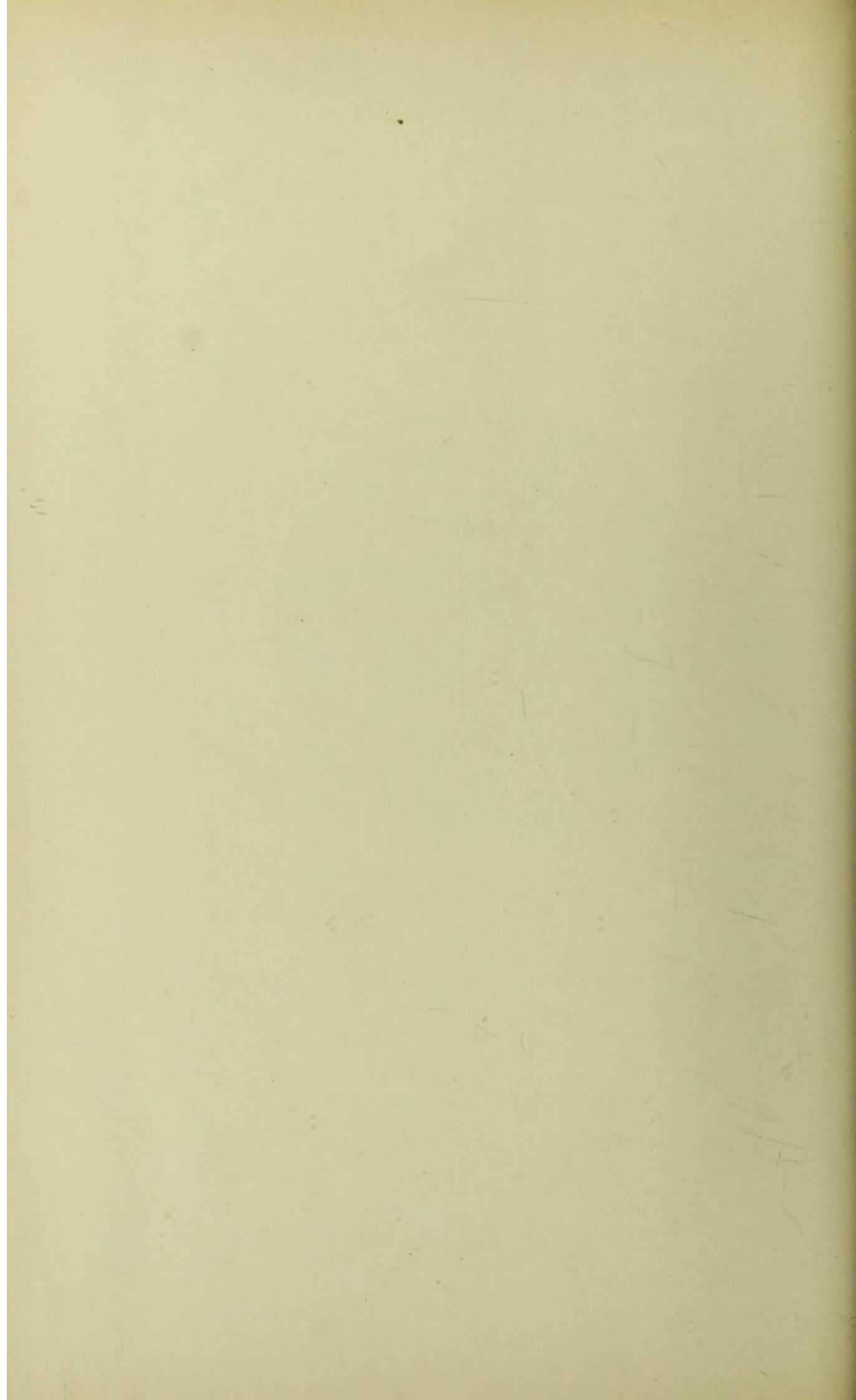


FIG. 13.—Fossil shells from chalk. Chalk consists almost entirely of these minute shells. Magnified



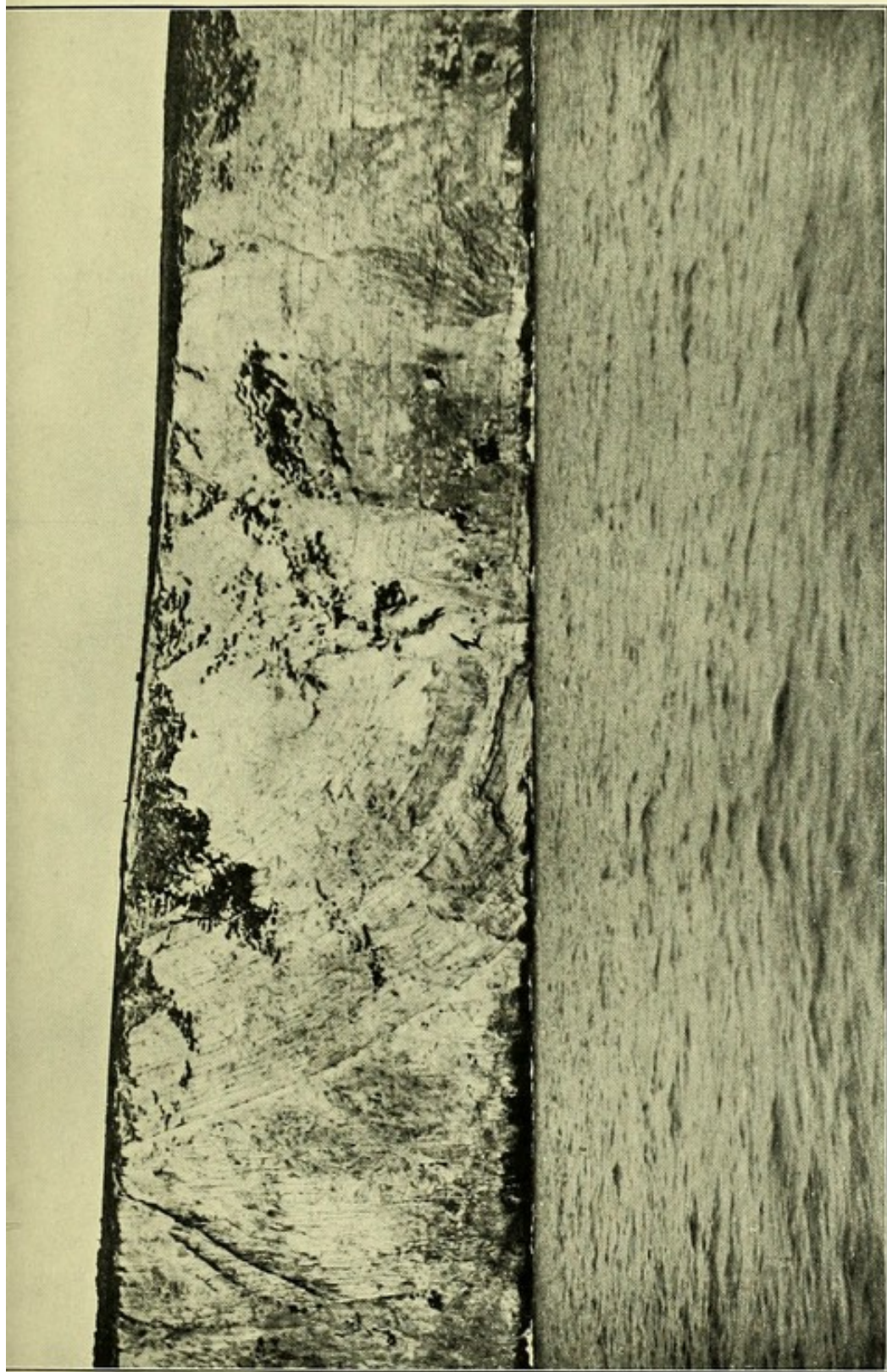
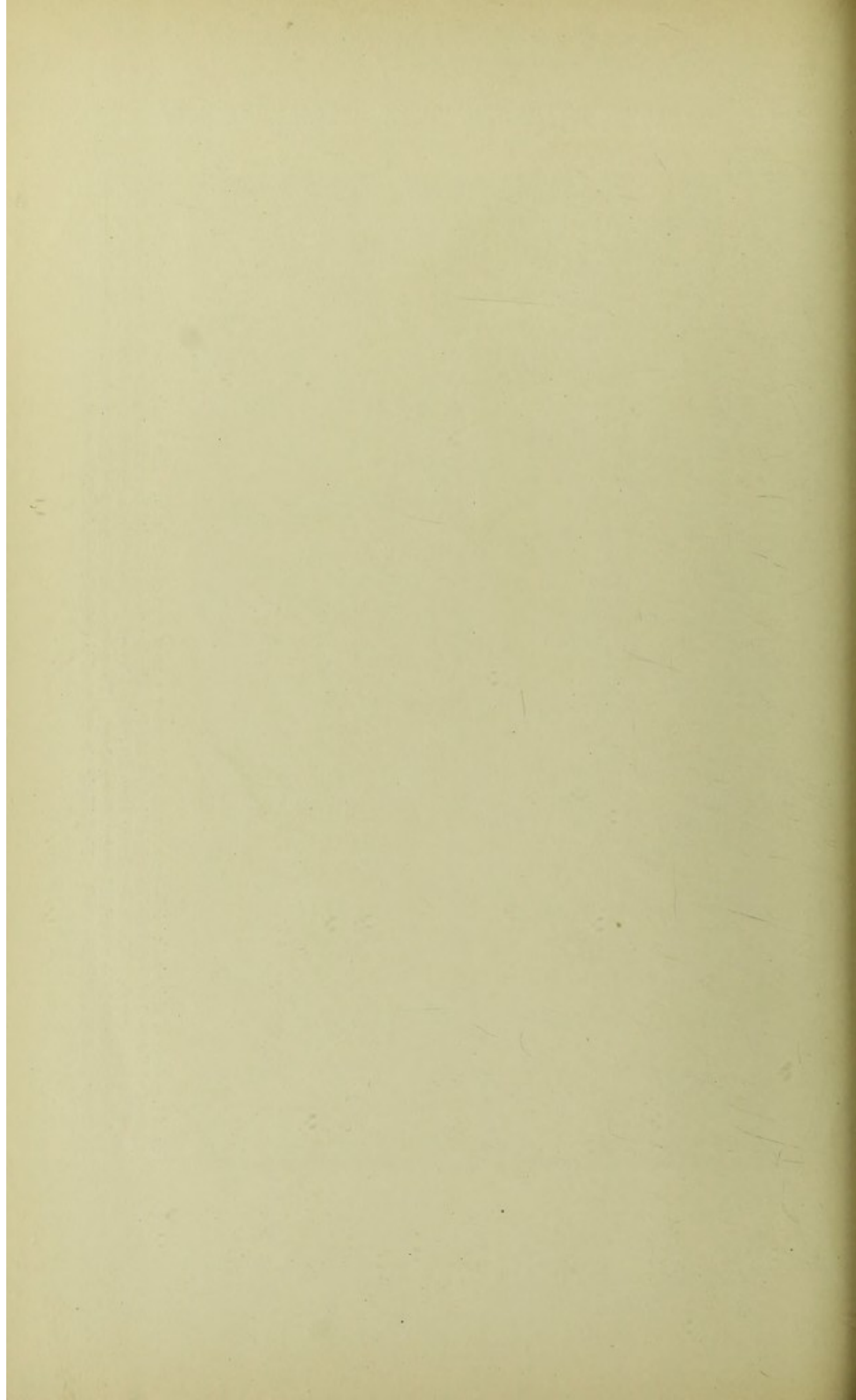


FIG. 14.—Face of the chalk cliffs near Swanage, showing a most remarkable fault. The chalk layers to the left are quite vertical (instead of horizontal as originally deposited). The layers are seen in the normal position in the right-hand side of the photograph. We do not know how the vertical layers got below the horizontal layers, but they pushed up the latter and formed the remarkable curve shown above. The pressure has been so powerful as to break into small fragments the nodules of flint in the chalk. Most likely the upheaval is now going on, but it is very slow.



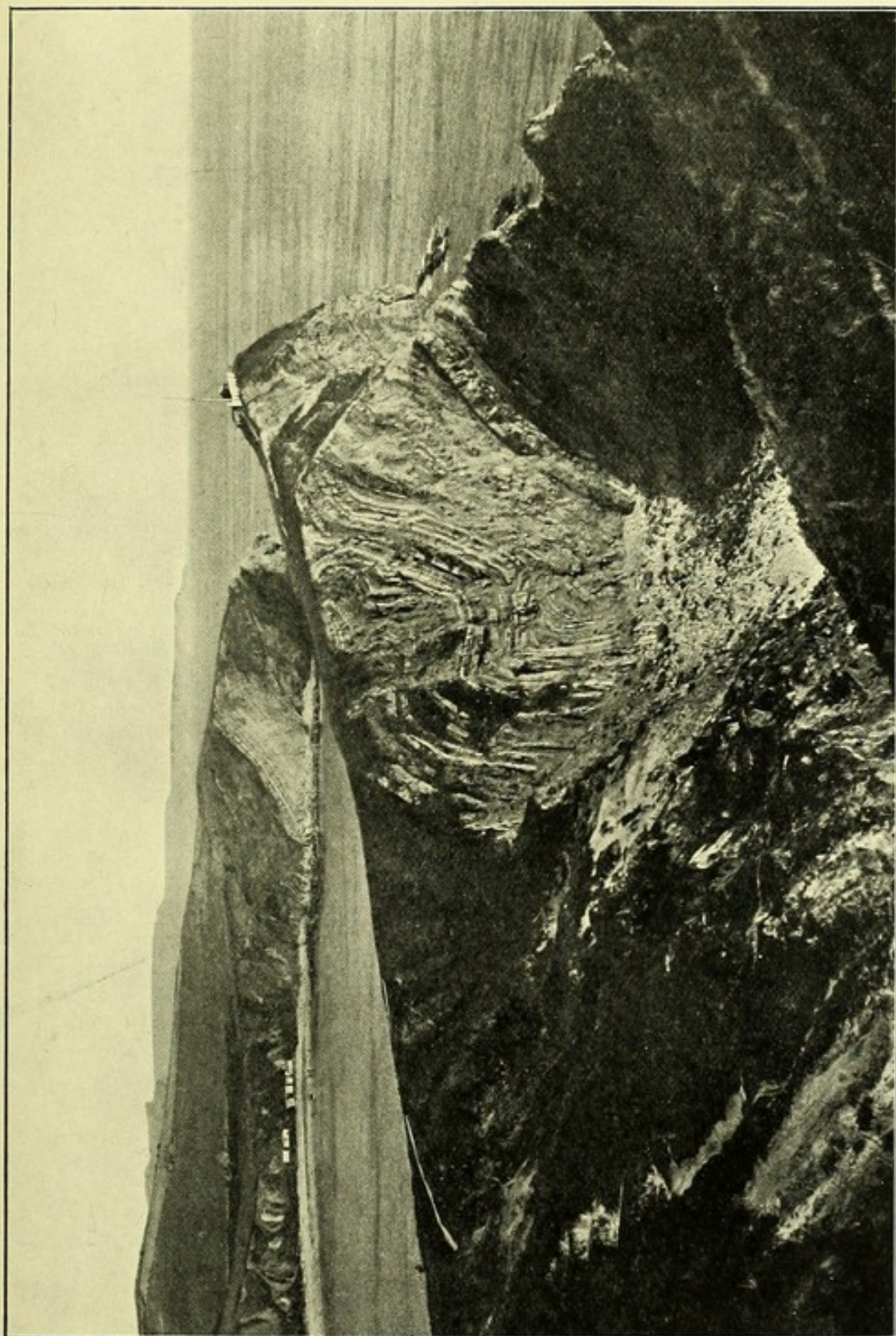
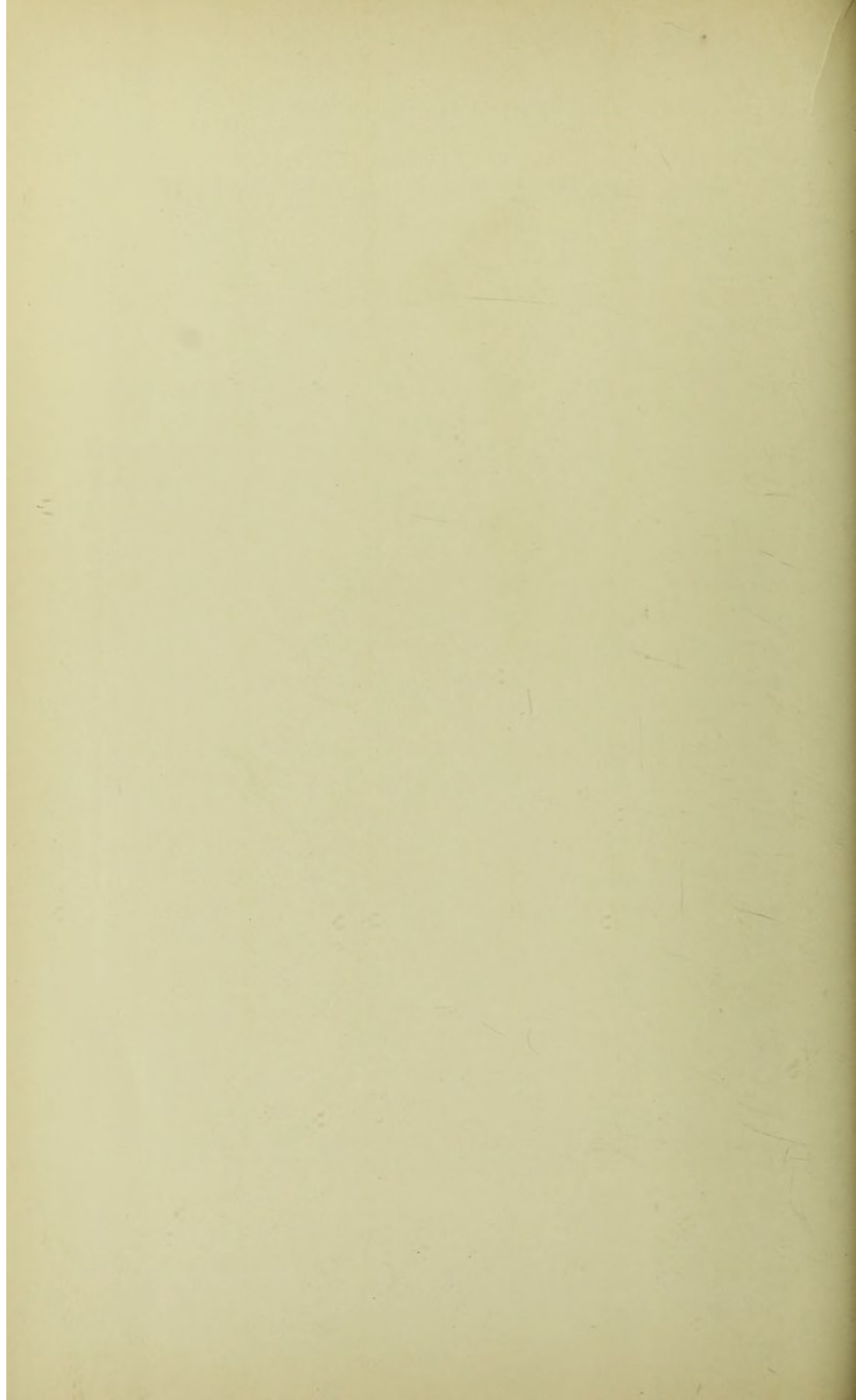


FIG. 15.—Lulworth Cove, a natural harbour sufficiently deep to allow a steamboat to enter. Notice the remarkable way the layers have been twisted and altered from the horizontal.



which were deposited horizontally, have been distorted to nearly a vertical position ;¹ and in Stair Cove especially the layers have been distorted in a most remarkable way (fig. 15, zigzag formation). In these vertical layers there is one I want particularly to draw your attention to. It is built up of broken oyster shells packed so closely together that there is absolutely more oyster shells than material which cements them together. Fig. 17 shows this formation well weathered,² and this is the structure: picture to your minds breaking oyster shells with a hammer and pitching the broken parts into a box, getting them as close together as possible, and then cementing them together by pouring in between the broken shells thin cement. This is what is seen. Every piece of shell is as sharp as if it had been broken yesterday. These shells have never been subjected to friction like the pebble, for in that case the edges would be rounded. We must recollect that this deposit is vastly older than the chalk formation—which is the bed of an ancient ocean—as it lies a long way below it.

In other parts the layers between the chalk and the formation holding these fossil oyster shells measure about 2500 feet, a thickness equal to nearly half a mile. Here they are squeezed out into a few hundred feet. This deposit of oyster shells is known by the quarrymen in this district as the “cinder bed” (fig. 19). It varies in thickness from 15 to 16 feet to a few inches. In Lulworth Cove on the east side there seem to be three

¹ The illustration fig. 16 shows the nearly vertical layers on the western entrance to the Lulworth Cove.

² The effect of weathering is to bring the shells in relief. It is Nature's carving.

deposits, but they are really one folded like the letter "N." This cinder bed can be traced from Durlston Bay to a place called Greenhill Barton, just outside Weymouth, a distance of about 22 miles as the crow flies. Then I show you a picture of Durlston Bay (fig. 18). The extreme end of the bay is Peveril Point. Here crops out the celebrated Purbeck marble¹—one of the paper-weights is made of this marble (fig. 3)—consisting of small freshwater shells. Remember this was deposited far below the ancient bed of an ocean (the chalk). Nearly every shell is perfect, and they are packed close together. Imagine putting such shells into a box as closely as possible without destroying them, and then pouring into this box thin cement to make a concretion, and you have a clear idea of what this formation is like. Recollect that each organism forming each shell had a life-history, for which we must allow time.

Fig. 19 shows a section of this district. The cinder bed first appears near the north end of Durlston Bay. It runs at an acute angle from the shore to the top of the cliff, and then it is broken by a fault. When the fault is passed it appears again on the shore, and again rises to the top of the cliff. At the west end of Worbarrow Bay the cinder bed is nearly vertical. In the "Man-o'-War Cove," again, the layers are vertical, and the cinder bed is found in these vertical layers. East of Mupe Bay the cinder bed is horizontal, forming a ledge on the seashore. In the Man-o'-War Cove is the Man-o'-War Island, which is built entirely of vertical layers,

¹ Many of our cathedrals and churches are ornamented with the Purbeck marble, so that this marble preaches a silent sermon in the sacred buildings.

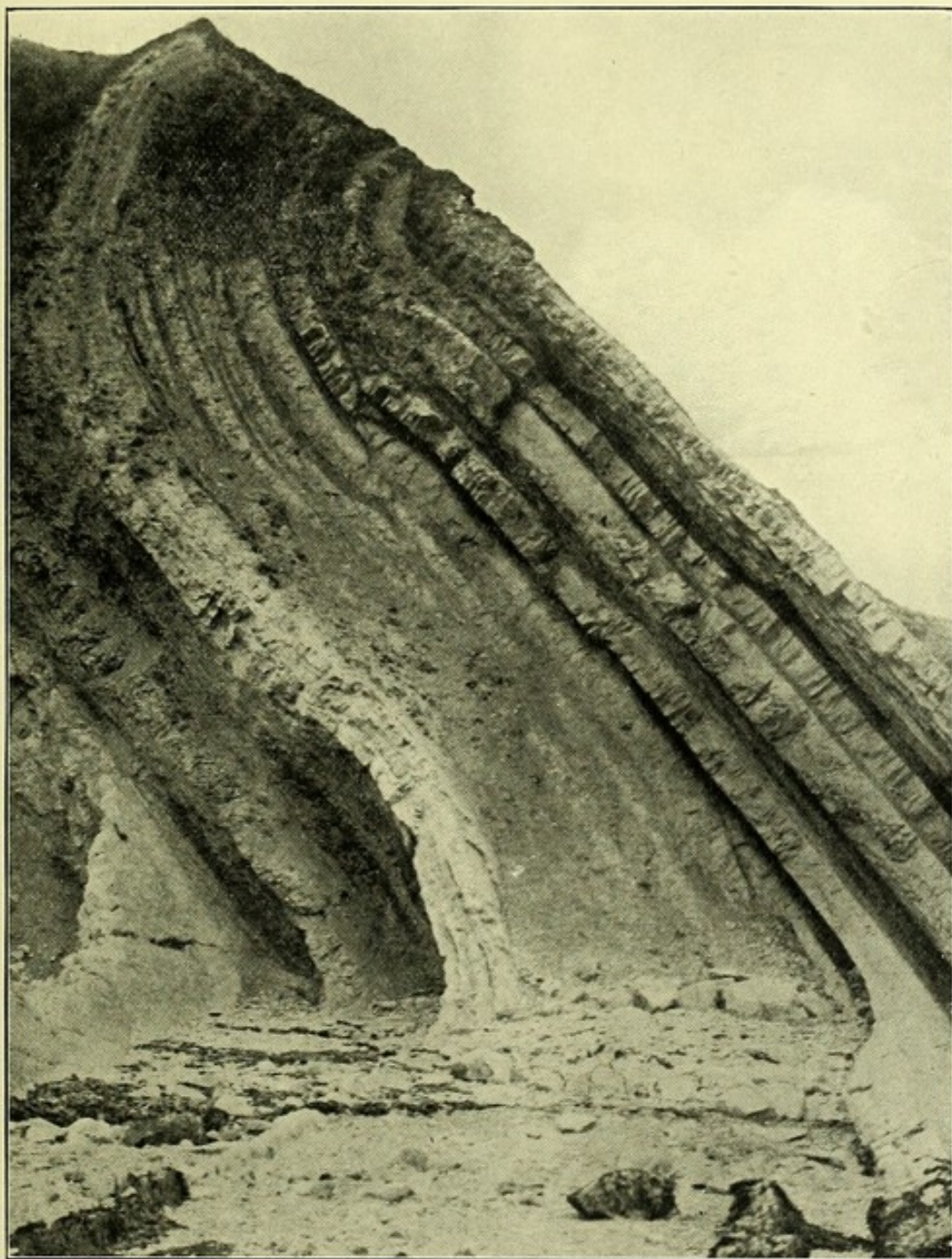


FIG. 16.—Layers of stone which were deposited by water in a horizontal manner, but which have been twisted into the above shapes. The west entrance to Lulworth Cove.

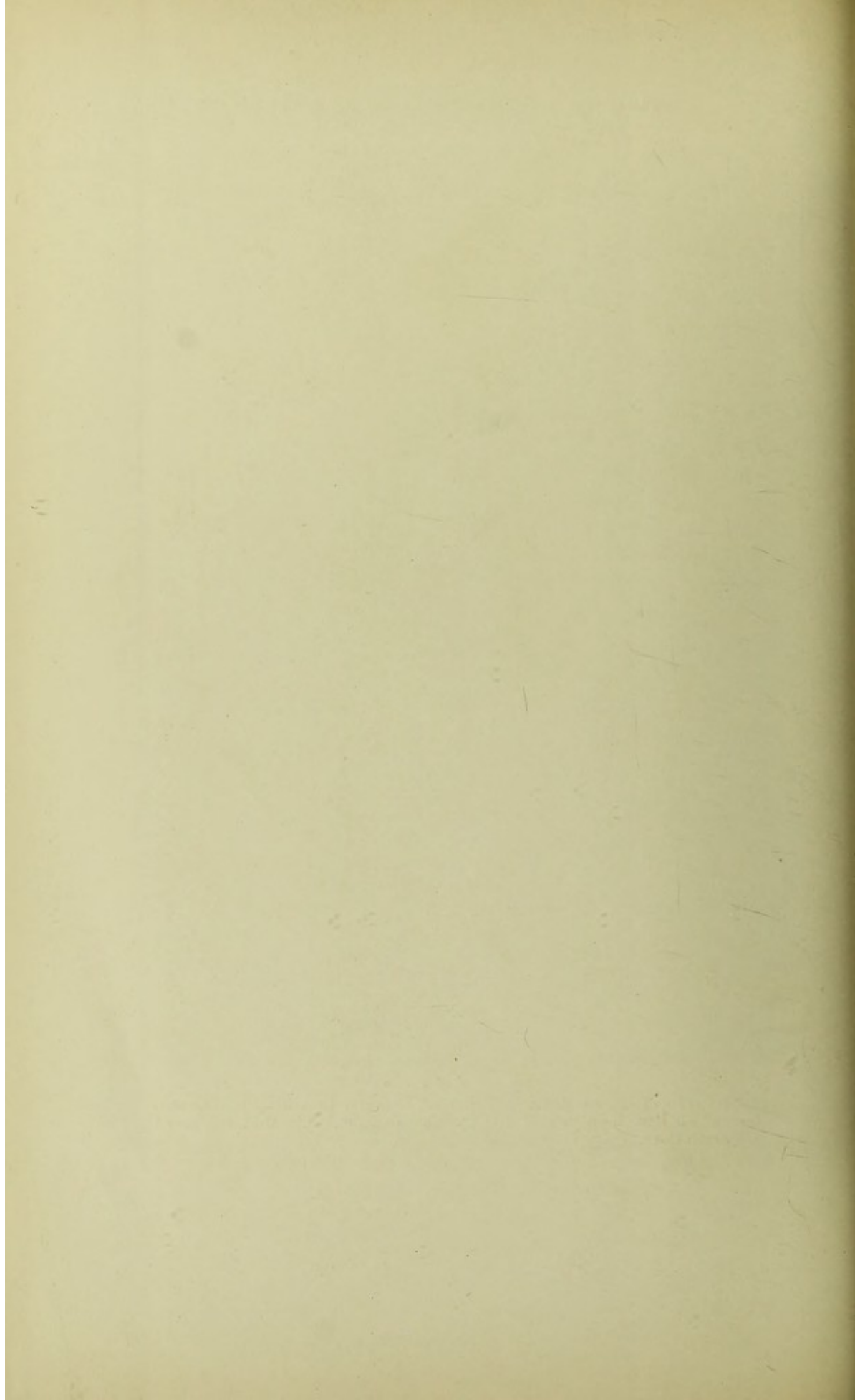
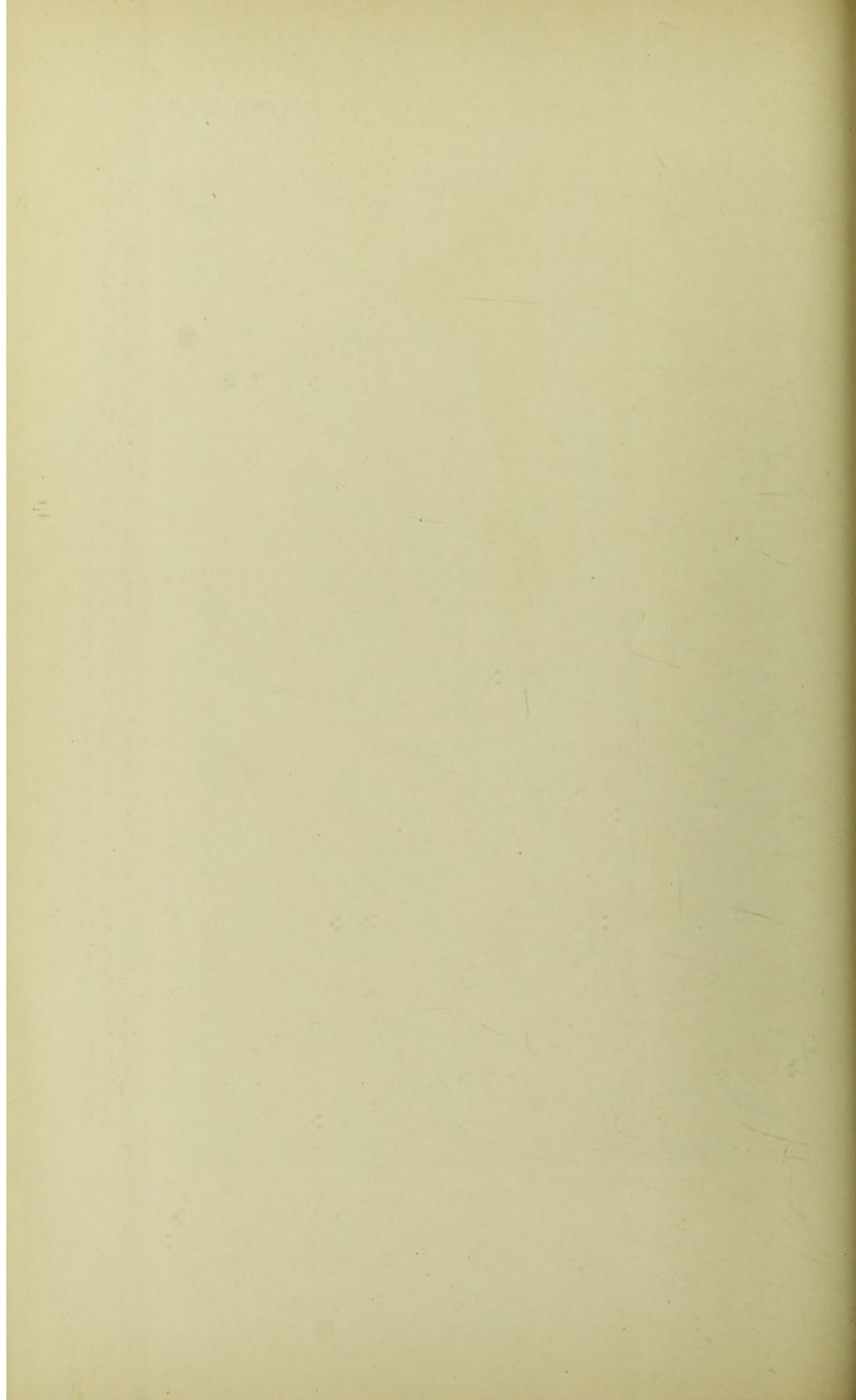




FIG. 17.—Photograph of a part of the "cinder bed." It consists of broken oyster shells lying as compact as possible. All the shells have the broken edges quite sharp as if they had been recently broken. This deposit is about 16 feet thick in Durliston Bay. It appears twice on the shore. See section, fig. 19.



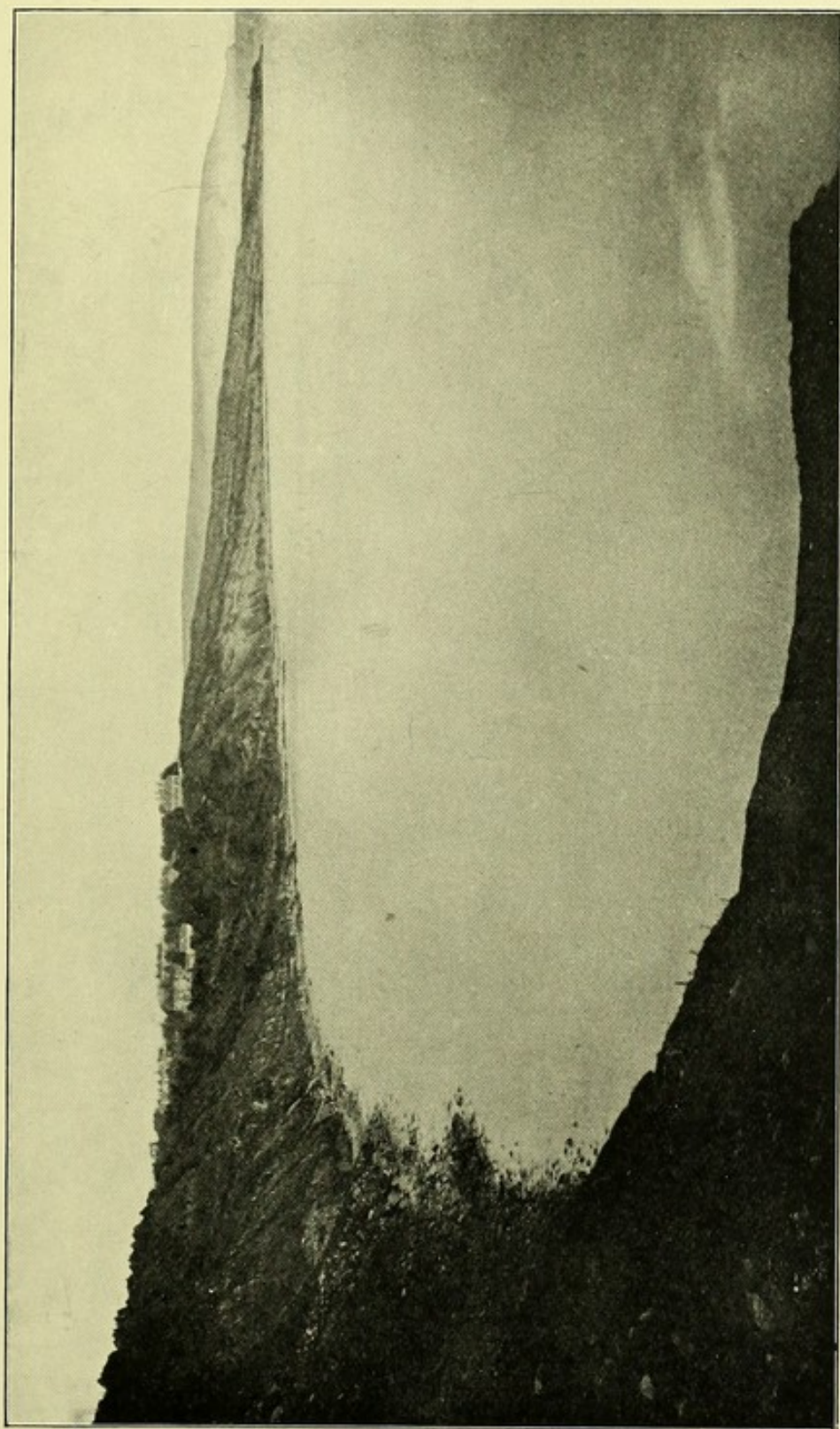
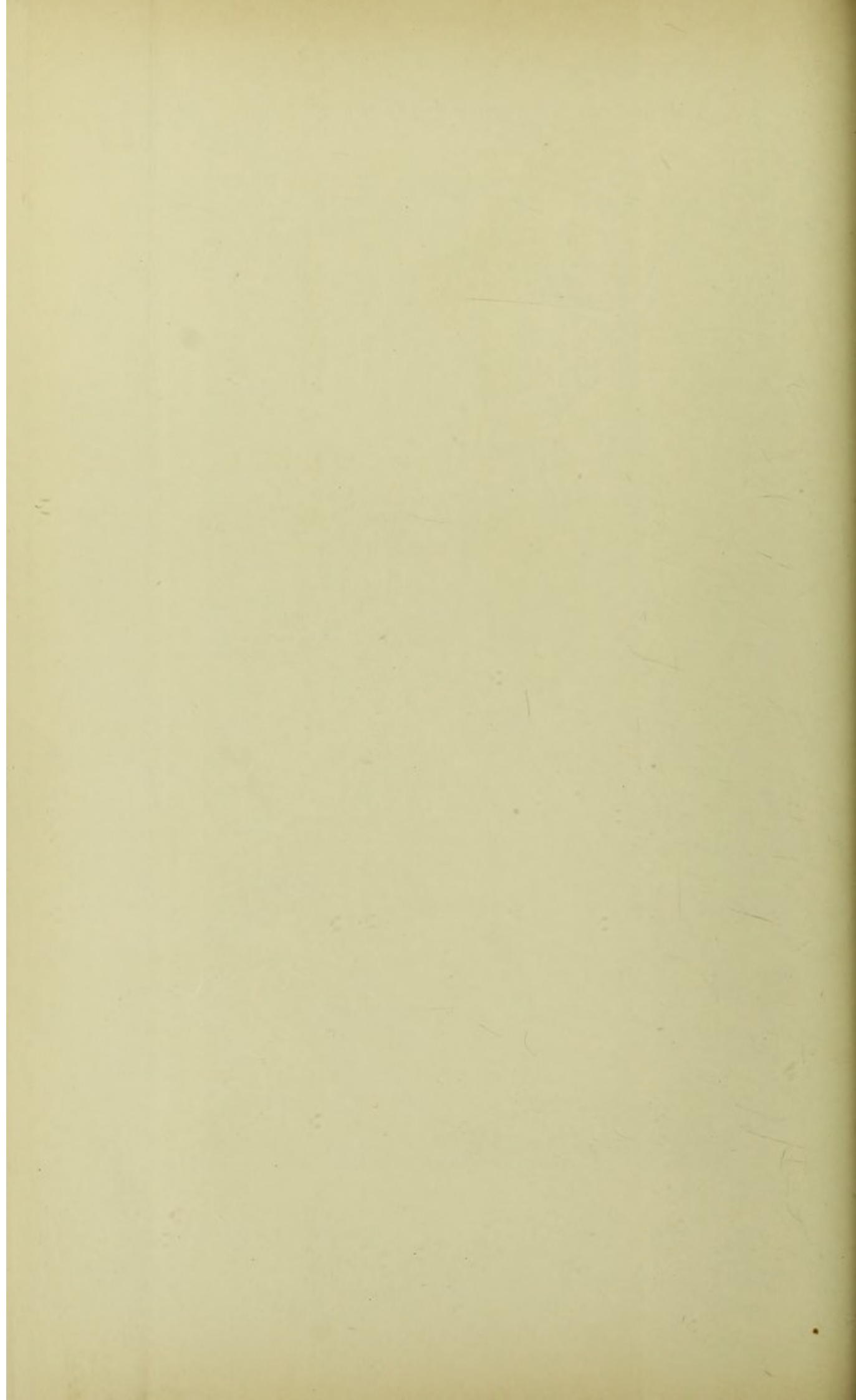
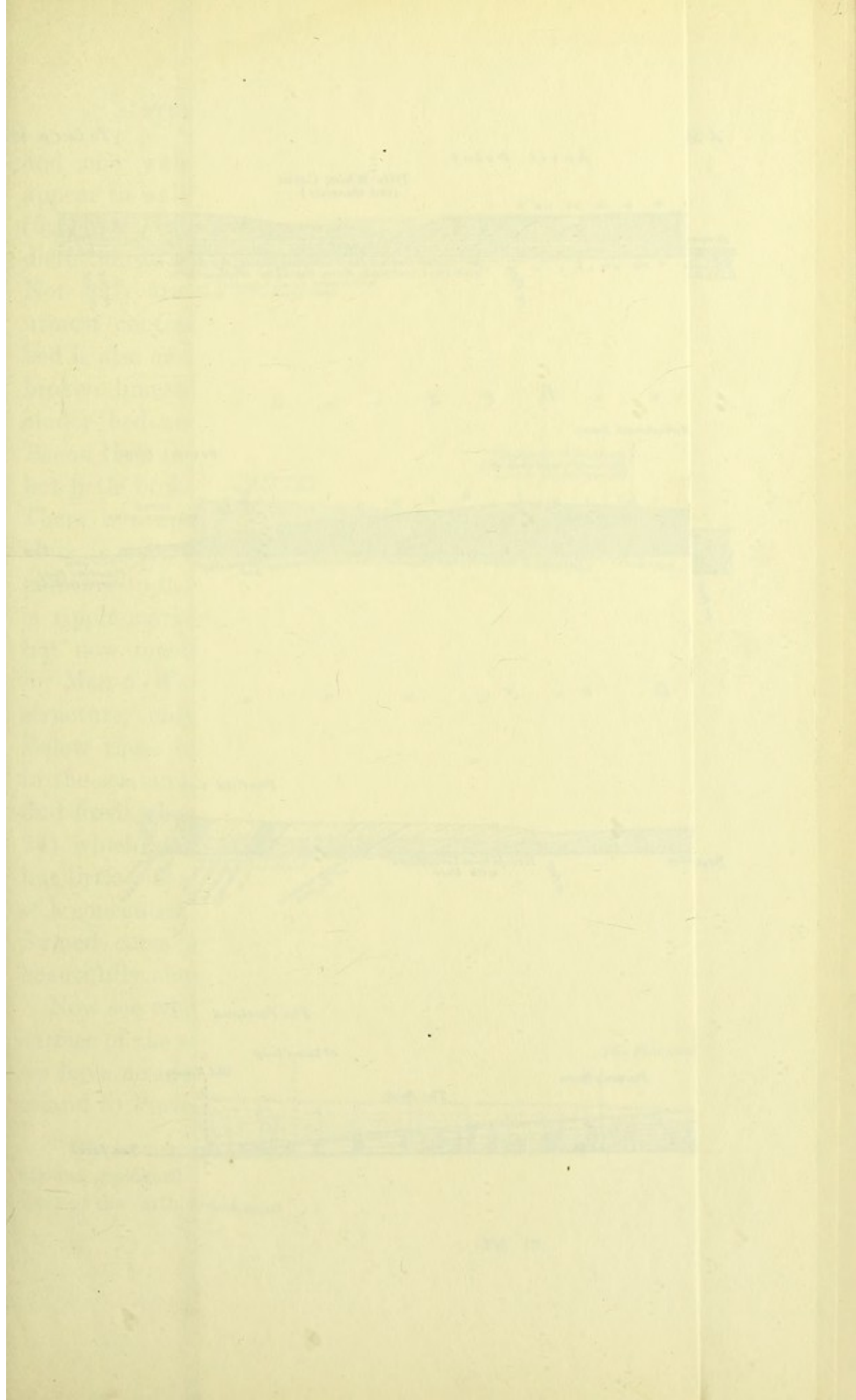


FIG. 18.—View of Durlston Bay, showing how the layers have been altered from the horizontal. One of these layers is the "cinder bed." It is twice shown, the layers altered by "faults" as seen in fig. 19.





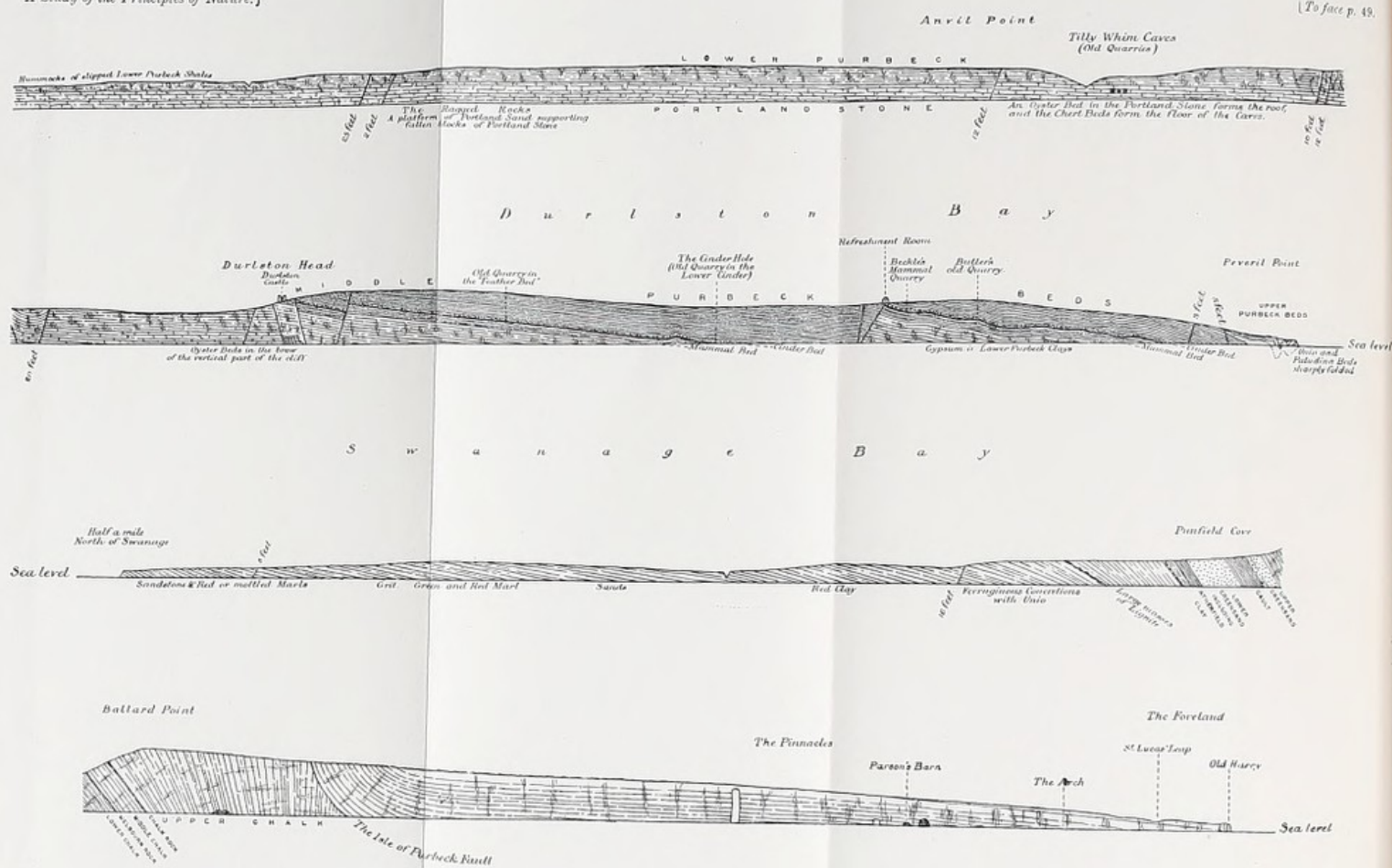


FIG. 19.

and one walks upon the edges of these as one may appear to walk upon the edges of these sheets of paper (fig. 11). Durdle Door is an interesting view of this distortion of layers—here again we find the cinder bed. Not only are the oysters crushed and mixed in the utmost confusion, but the limestone beneath the cinder bed is also crushed and mixed in the same manner. The broken limestone is, however, a long way beneath the cinder bed and therefore much older (fig. 20). Near Bacon Hole in Mupe Bay there is a layer of fossil oysters, but little broken, and lying nearly horizontally (fig. 21). There is a specimen of these oyster shells on the table. Here is a cast of a large ammonite shell. The man is pointing to it. On a higher layer the surface of the rock is ripple-marked, giving evidence of an old seashore, but now much above high-water mark (fig. 22). And in Man-o'-War Cove there is the same ripple-mark structure, only the layer is quite vertical (fig. 23).¹ Below these oysters, which were born, lived, and died in the sea, and which left the remains of shells we now find fossil, there are the remains of a fossil forest (fig. 24) which shows a view of the fossil trees. There is but little left of the trees, but there are casts consisting of a concentric deposit of carbonate of lime. The trees formed cores to these deposits, and one cast is very beautifully shown in the photograph.

Now see what all this teaches. Once upon a time the surface of the earth here was a forest, the extent of which we have no idea, but the same forest remains are traced inland to Portisham, about seventeen miles away as the

¹ Ripple marks, sun-cracks, and rain prints may be seen in the earliest geological formations, thus proving that the physical conditions of the earth were the same as now.

crow flies. Then this forest was submerged below the sea to permit the oysters to live, and then the oysters sank below the bottom of the ocean to permit the deposit of the shells of the microscopical creatures which form the chalk downs surrounding the beautiful Lulworth Cove. And then the whole of the chalk downs with the fossil oysters and the forest came out of the sea to become what is visible at the present day. The process is not simple as I have described it, but it was very, very slow in its action. I have only attempted to sketch an outline, but an outline of great value. The evidence shows that the surface of the solid earth in this district was once dry land to permit a forest to grow, then an estuary of a river, then the bottom of an ocean, and these processes have been repeated many and many times; for instance, below all I have described is another layer of broken oyster shells at Tilly Whim, all broken as the cinder bed, and the evidence shows that the process has been very slow—in fact, a repeat of what is going on at the present day.

These broken oyster shells tell a very important tale. They have evidently never been subject to moving water, as if that were the case the broken edges would be rounded after the fashion of the pebbles. We cannot say positively how they came into their present condition. But in this coast there is evidence of the layers having rubbed against each other. Fig. 6 is a photograph showing the markings—furrows—resulting from the rubbing of rock against rock. These markings are distinctly seen from the steamboats. It would seem, then, that these shells have been pounded much as they would be if smashed to pieces by means of the grinding action of a pestle and mortar. This, coupled

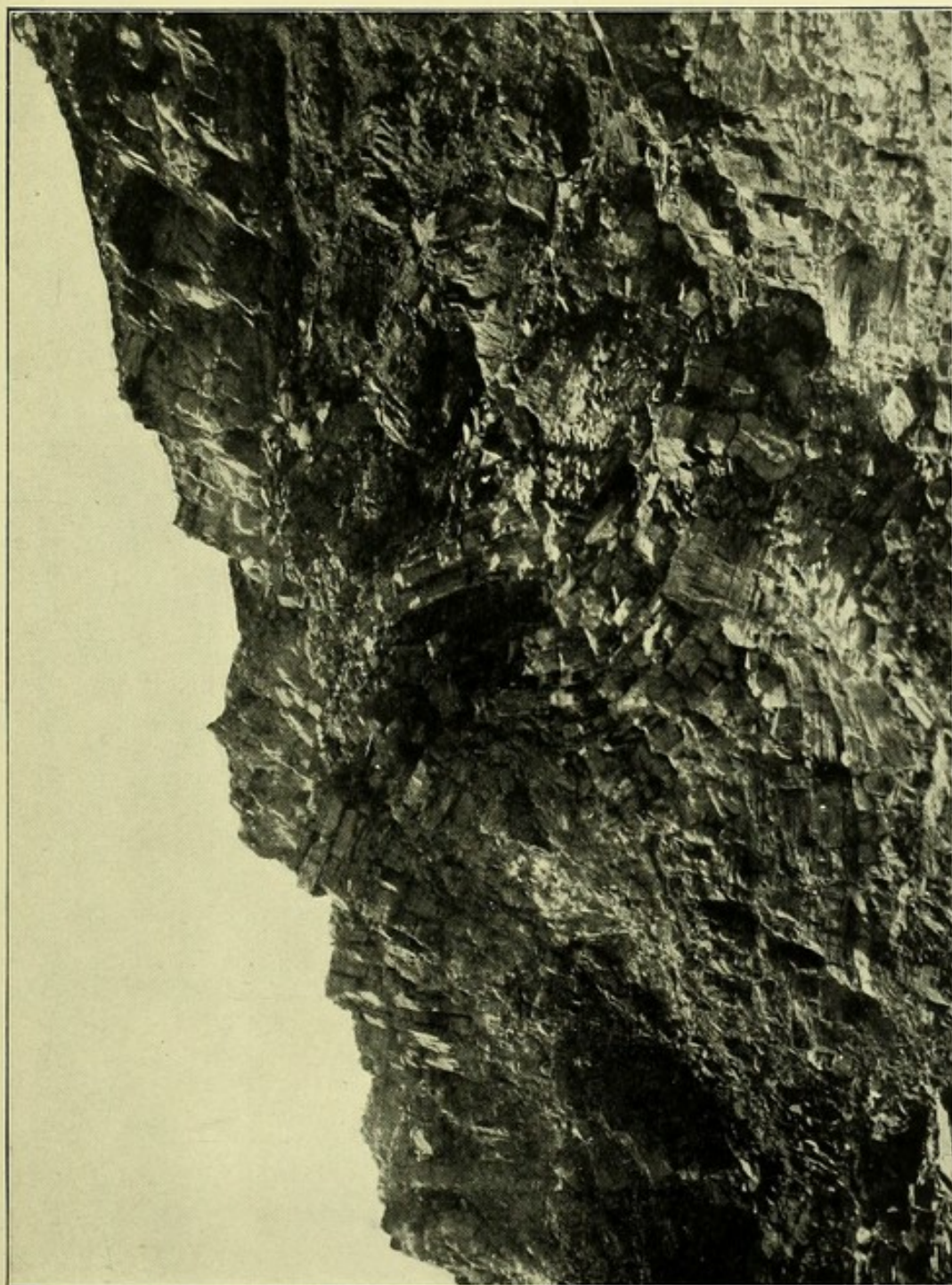
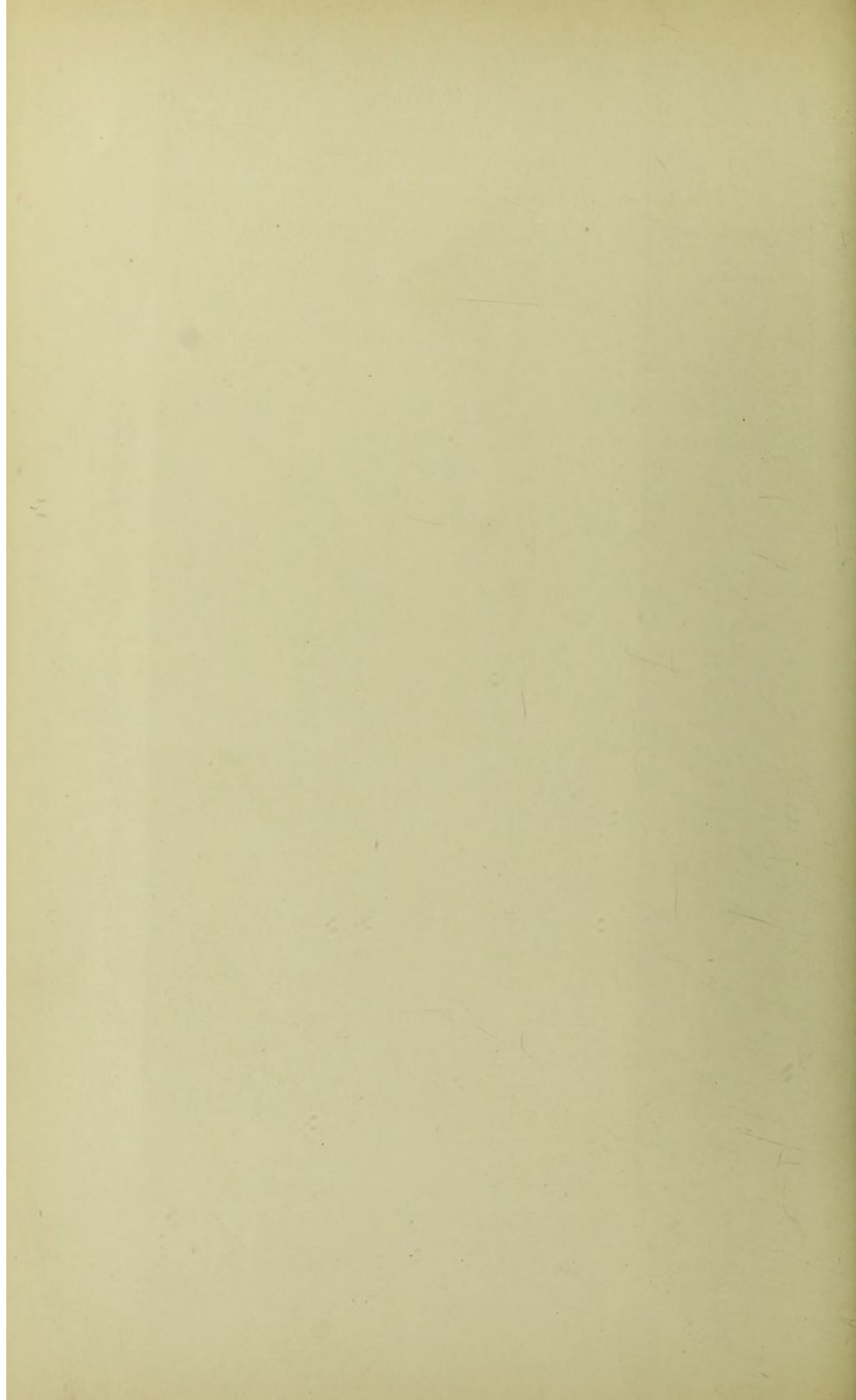


FIG. 20.—Crushed rocks forming the upper parts of the cliff near Lulworth Cove.



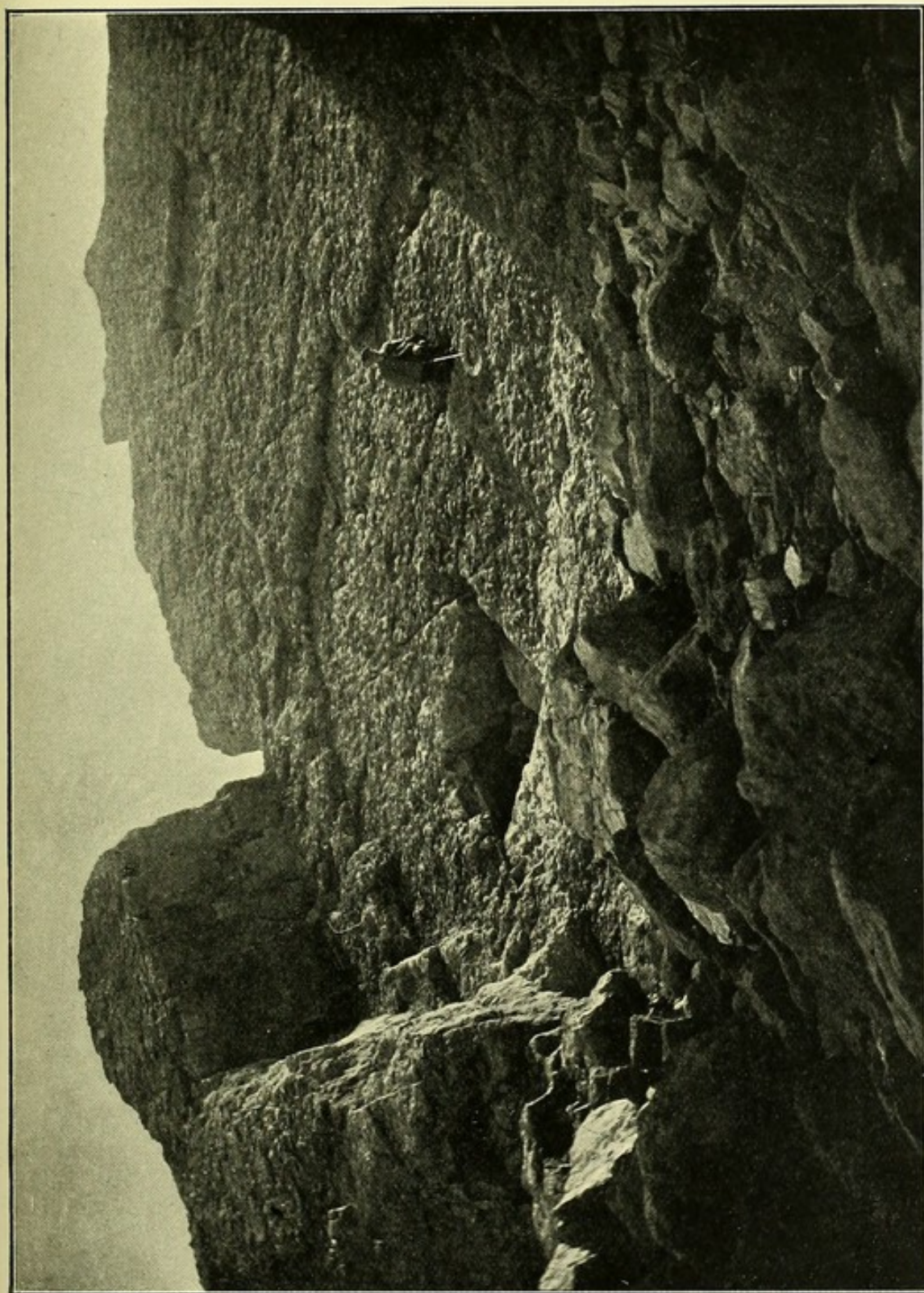
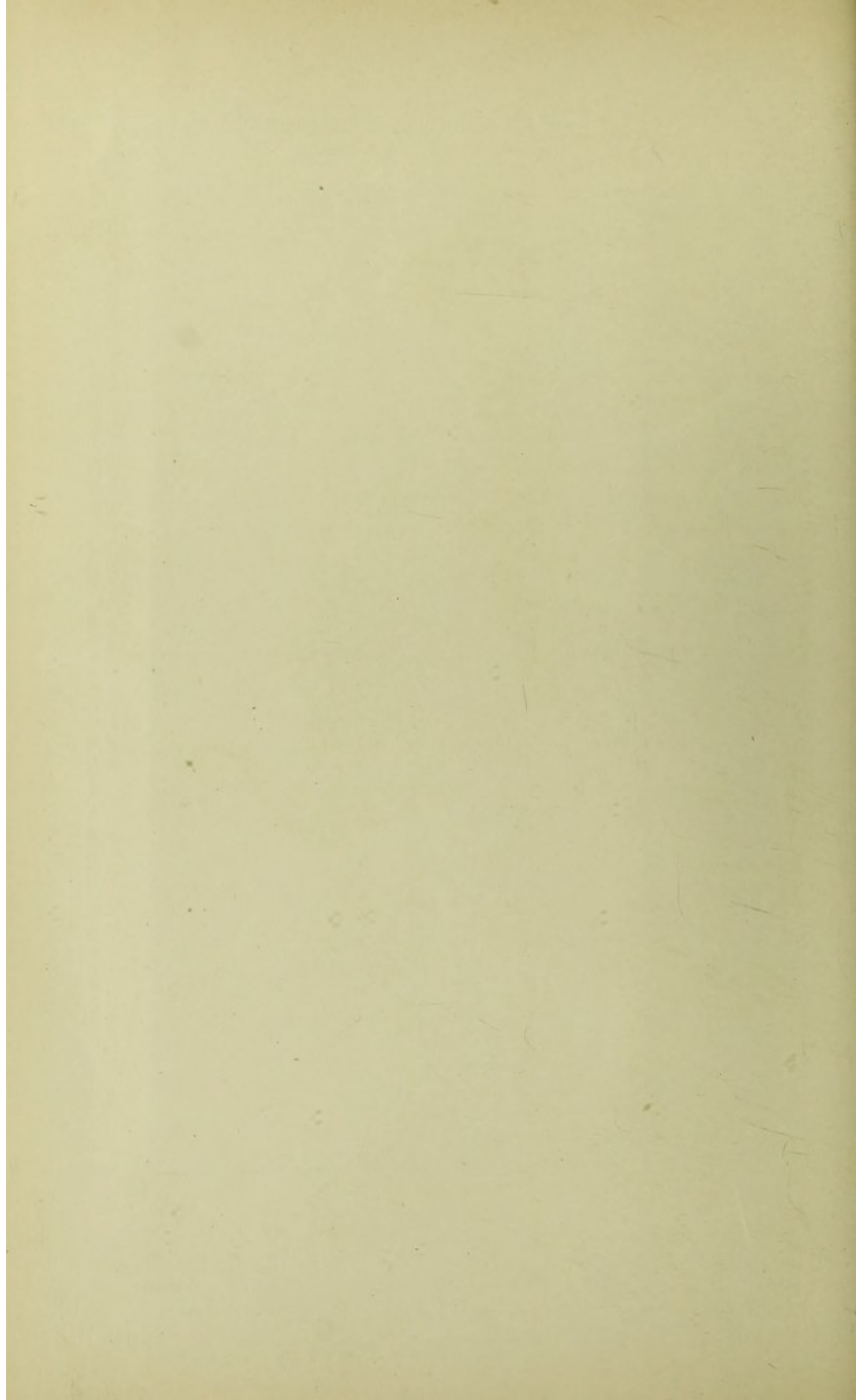


FIG. 21.—Ledge consisting of fossil oyster shells, almost whole, lying on a nearly horizontal platform. The man is pointing to a fine cast of ammonite, an animal allied to the Nautilus. Near Lulworth Cove.



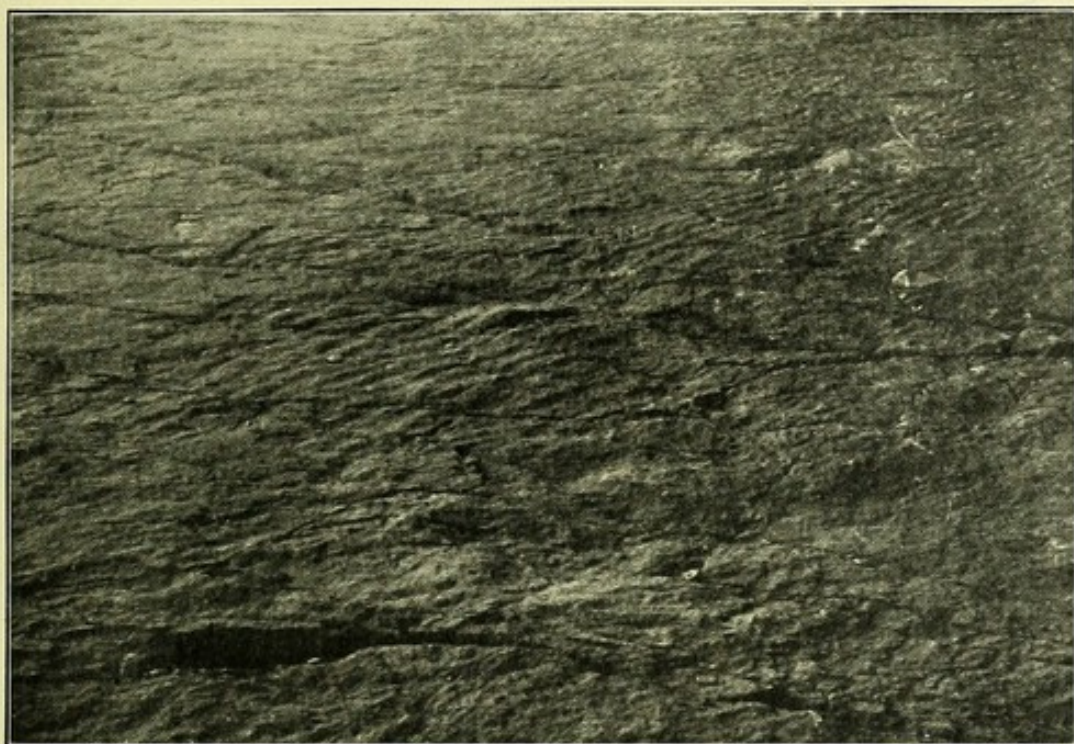
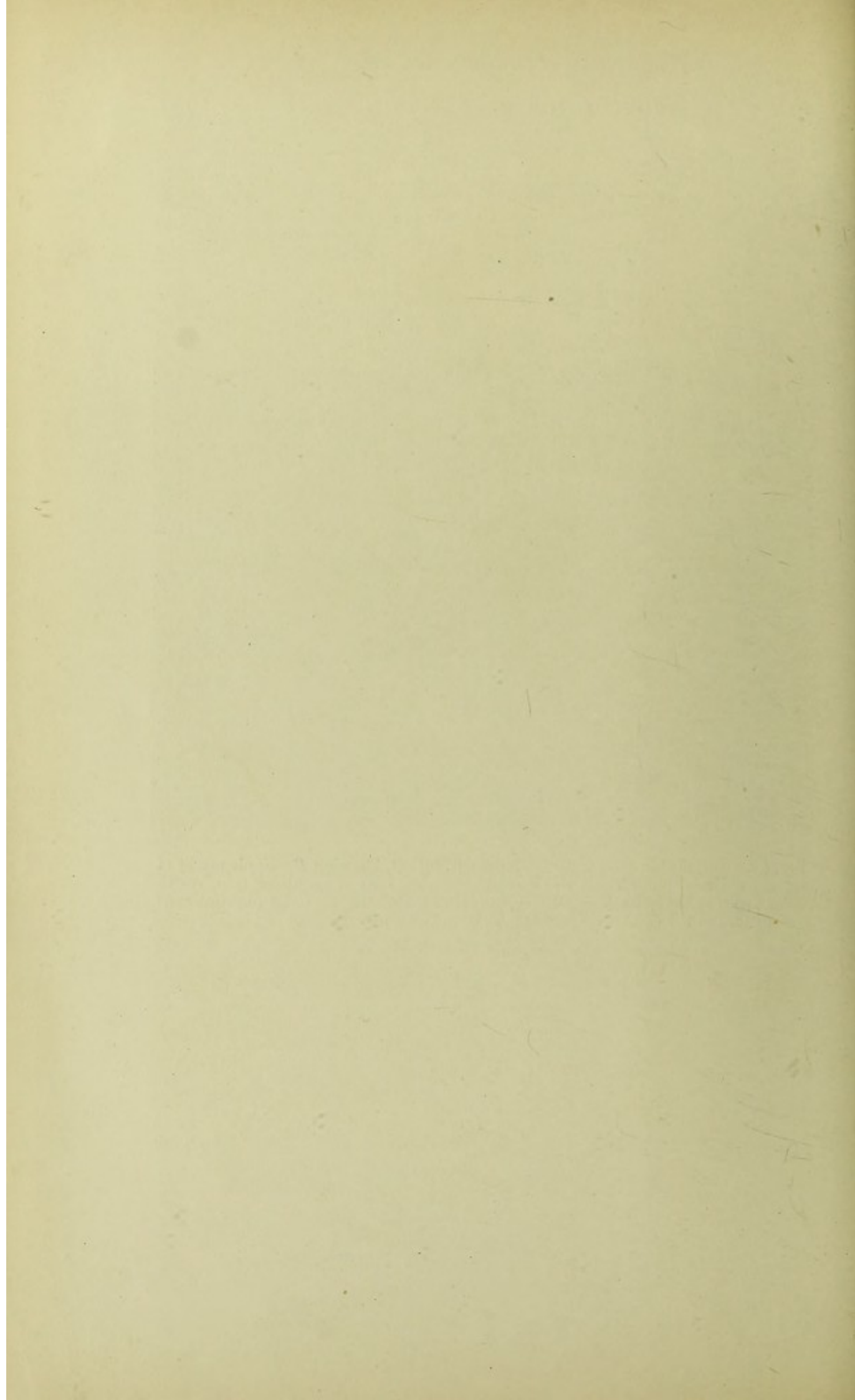


FIG. 22.—Ledge above the fossil oyster shells, fig. 21, showing the ripple marks of an old seashore. These ripple marks and pits, formed by falling rain, are to be seen in the oldest sedimentary formations, showing that the physical conditions of the earth were the same as in the present day.



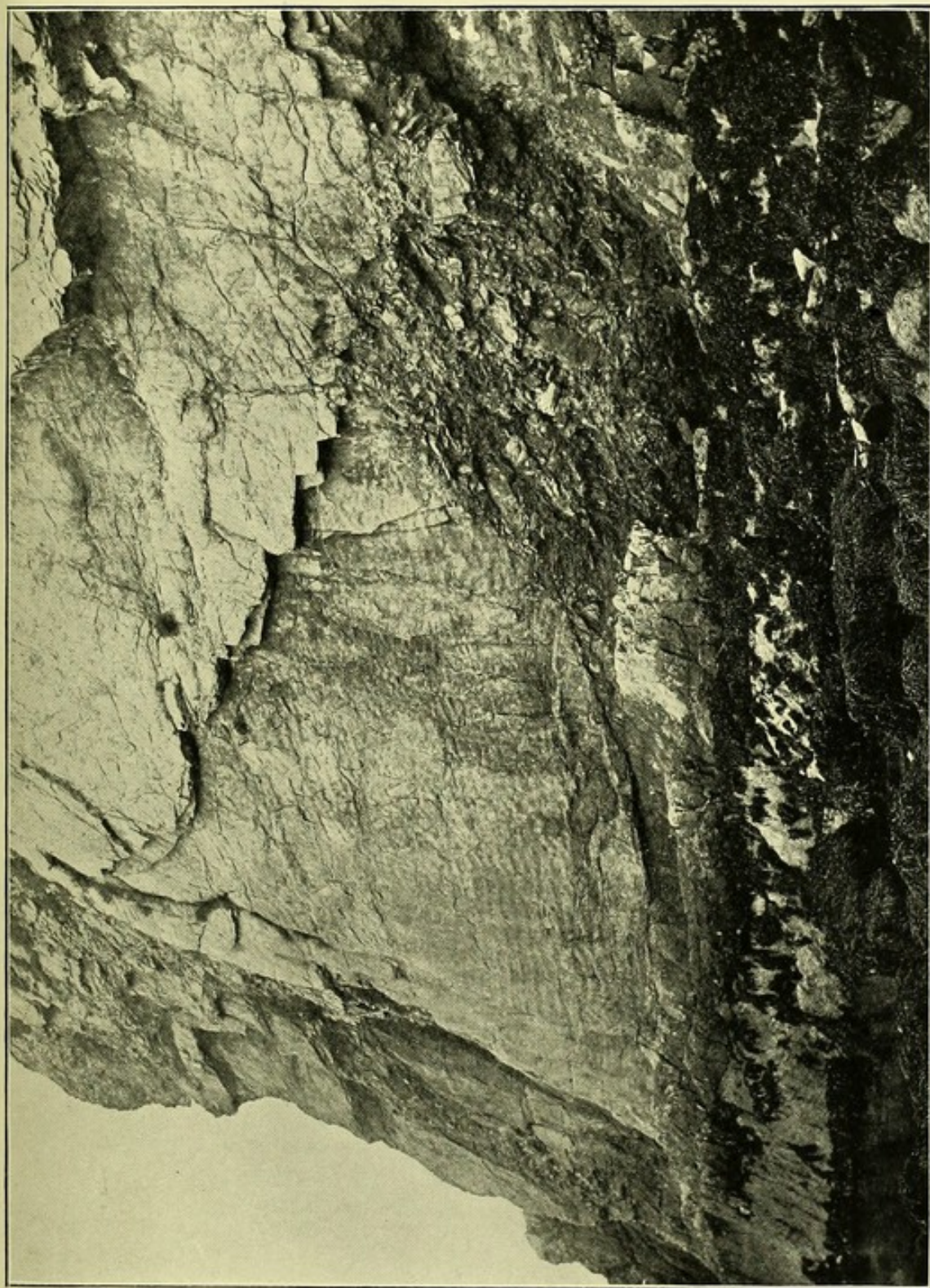


FIG. 23.—Remarkable instance of ripple-marked stone, the remains of an old seashore, but now quite vertical. Man-o'-War Cove, near Lulworth Cove.

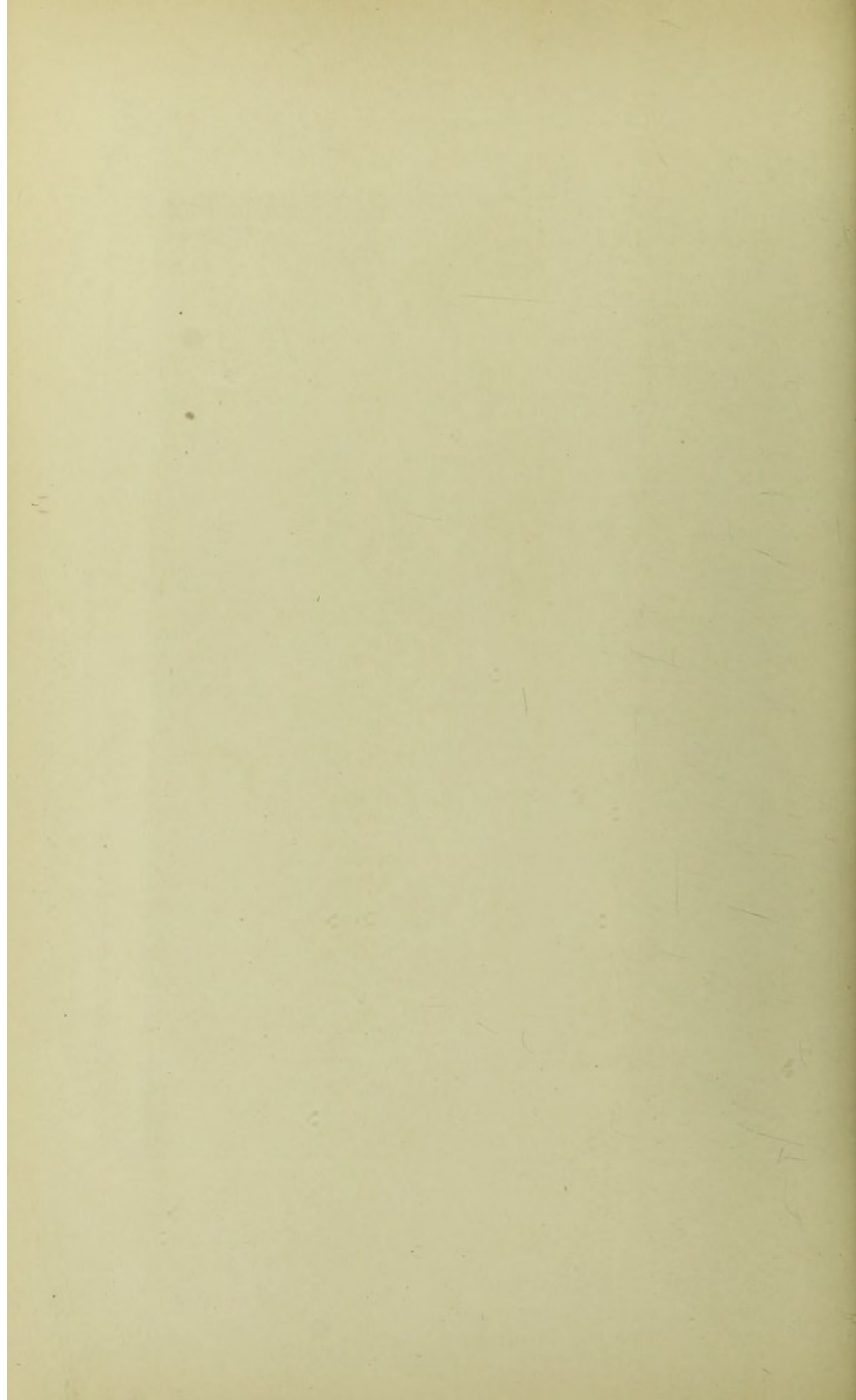
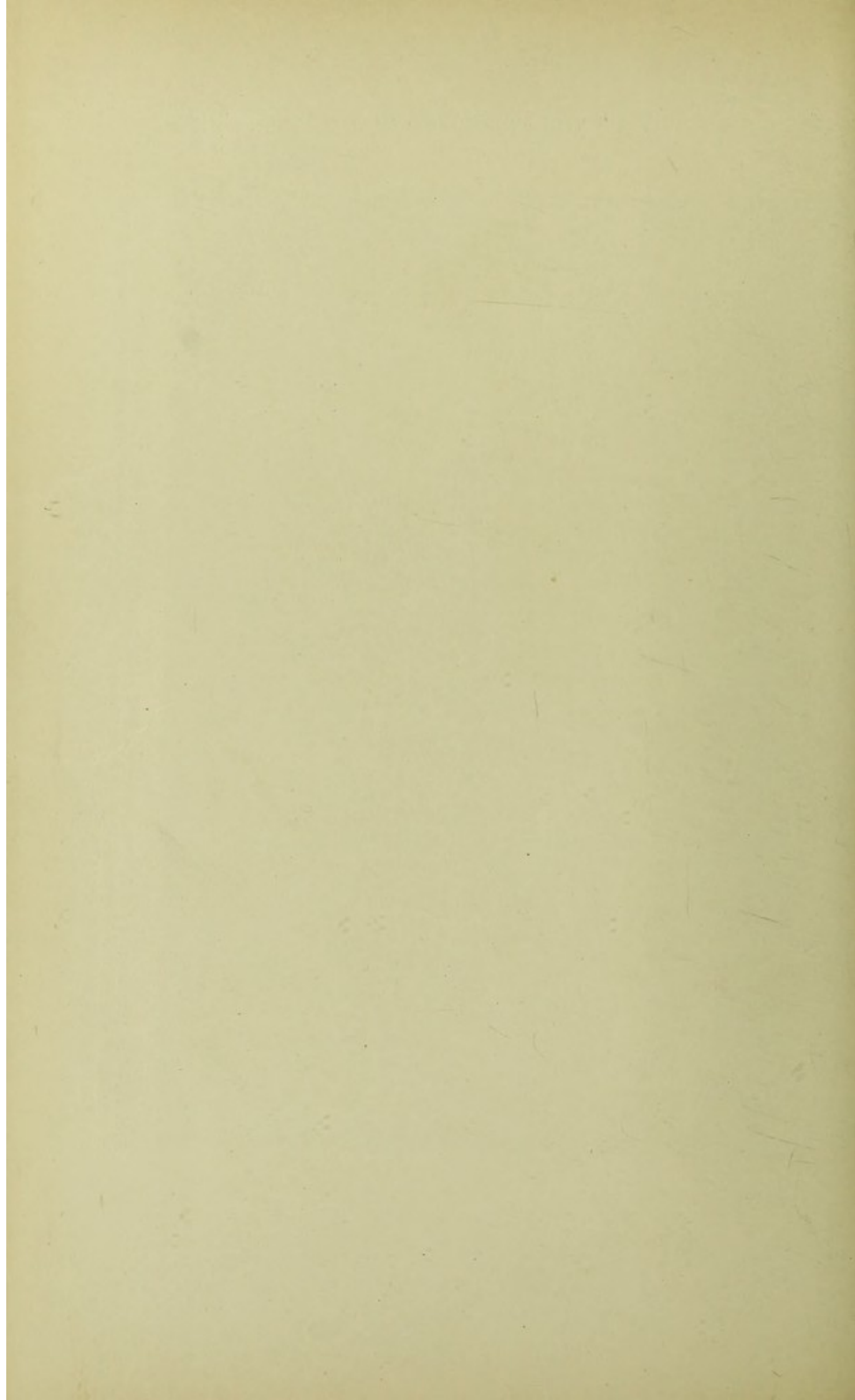




FIG. 24.—The remains of a fossil forest, a few minutes' walk from Lulworth Cove. The concentric formations are of carbonate of lime, which surrounded the trees. The cast of one of the trees is well shown in the foreground. The position of the forest is shown in fig. 8 and fig. 9.



with the fact that the flints are likewise broken into small fragments by the enormous pressure, leads one to believe that this is the cause. Whether earthquakes in the past have been a factor we cannot tell.

We must recollect that I have only explained a small portion of the earth's crust. To go and see this district makes a most interesting and enjoyable week-end holiday. It is only about four hours by rail from London. Swanage is the best centre. Geologists estimate that the maximum thickness of the layers beneath the region I have described is 71,610 feet, all giving evidence of life as fossils, or a total thickness of over thirteen miles, while the layers of rock above the region I have described are about a mile thick. That is to say, if we were to add together the layers of paper, and the paper were of proportional thickness to the layers of Nature, they would total up to these enormous figures. The whole is studded with the remains of life as fossils, and to every organic creature we must give a time for growth, and this does not end the tale, for we must give enormous time for the formation of hills and valleys, and a still greater time for that which has been wholly destroyed by the wear of the sea, an item of which we have not the slightest idea. We only know that this process is now going on. In the sketch I have given I have endeavoured to expand our minds to understand the wonderful and powerful factors which have produced the condition of the earth's surface as we know it now. I have endeavoured to give some idea of the, to our minds, eternal time required to produce the condition of things. I might have amplified all this by trying to explain the formation of the miles of layers of which we know the surface of the world to consist, but I have given sufficient for my purpose.

Perhaps the fundamental issue will be better understood by the following statement. If a shaft were made in the earth at London, about fourteen miles deep,¹ we would find in the layers at the bottom, ripple marks, marks giving evidence of rain drops, sun-cracked clay, shores of former seas and the remains of life, giving distinct evidence that once upon a time the ground at this great depth was at the surface and that the physical conditions of the earth were the same as now.

My next lectures will have for their object the experimental proof of the existence of a force or power which is the factor and the cause of these wonderful changes which I have, I hope successfully, described: a power by which you and I and every living creature were brought into existence; a power by which I speak and you hear; a power by which you speak and I hear; a power which is omnipresent and omnipotent; and I count it the greatest victory in Science that this power can be proved and *seen*.

¹ The depth must be taken as only approximately true. We are supposing that the various layers are of the thickness they appear when exposed at the surface of the earth, and that the layers lie over each other in the order in which they are exposed on the surface—that is, that no layers are missing. This is most improbable, but the statement in a powerful way conveys to the mind the enormous alterations and the vast time required to explain the geological alterations which have undoubtedly taken place.

LECTURE II

ANYONE who thinks must be convinced that the human being is part of a vast and very complex and very wonderful system. For instance, the earth rotates on its axis once in about twenty-four hours. The surface of the earth, beneath a gaseous envelope, is the habitation of man. And man rotates with the earth. He is, as it were, pinned to his planet, and although we are mostly unconscious of this motion, yet we are aware of it by seeing the sun and the stars apparently rotate in an opposite direction to the rotation of the earth.

Now, the laws which regulate ourselves and our environment are very complex, and in detail most perfect and exact. Nature is no respecter of the artificial condition of things we so much value and so persistently adhere to.

The sciences—*anatomy* (the study of the structure of the organism), *physiology* (the study of the functions of the structure), and *biology* (the study of the life of the organism)—teach us that a king's life-history springs from a little mass of so-called protoplasm, too minute to be seen except by the highest powers of the microscope. This little object, in the struggle for existence, is the survival of thousands of like objects which die; and this object, under certain fixed conditions, adds to itself matter to become a human being, subject to the same

laws of growth, of disease, and of death as the meanest of the king's subjects. Hence we are, as it were, all in the same boat, where floating or sinking is a lot common to us all.

The human body is a very complex machine, framed by Nature for its external conditions. We could not breathe were it not for the pressure of the atmosphere.

The only way we can understand these fixed and complex laws is by the closest study of them, and by experiment.

We are going to make experiments, not with the object of exploiting Nature as a business—as it is generally with the professional man—but with the object of understanding the principles of Nature; hence we approach Nature in the religious sense.

Experiments are operations of Nature artificially produced on a small scale, so that we can, by studying them, better understand the laws of Nature. We all make experiments, but we are not always conscious of making them. One of the most common of experiments, as also one of the most instructive, is the act of writing. We dip our pen into a mass of ink, and the pen takes from the mass a small but definite quantity of the ink by virtue of the attractive power of the finite compound particles—the molecules—of which the pen is made and of which the ink is formed. And then, largely by means of the split in the pen, the ink is urged downwards upon the paper. This is the whole of the human operation; and now steps in Nature. The wet ink gradually becomes dry.

I will show you a rough and exaggerated diagram explaining what experiments prove is taking place during the time the ink is drying (fig. 25). Water

molecules, in the liquid state, are very minute hollow spheres lying on each other, just as these small shot lie one over the other in this vessel. They are too minute to be seen by any power of the microscope. A bold downstroke of the pen, or a blot, puts on the paper a mass of ink, which when seen in section assumes a domed shape. Between the water molecules, of which the ink mostly consists, lie the minute pig-

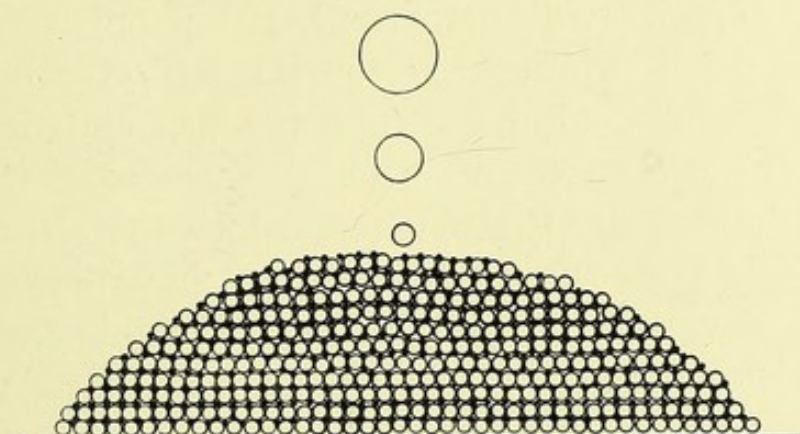


FIG. 25.—The drying of ink. The ink molecules (black dots) are held buoyed up between the water molecules (hollow spheres with colourless centres). The water molecules dart off the mass of ink, and as they do so increase in volume—that is, become gaseous—as illustrated, until they become of the same dimensions as the gaseous molecules of which the air consists; these are normally invisible. When all the water molecules have darted off into the air (evaporation) the black dots representing the ink molecules are left behind on the paper and the ink is said to be dry.

ment objects which colour the water, and we call the whole “ink.” These pigment objects are also so minute as to be beyond the highest powers of the microscope. After the ink has been deposited on the paper, and even during the time the writing is taking place, the outside molecules suddenly increase in volume, rise from the surface, and thus enlarged, they spring up into the air, one by one; and as they rise from the surface they keep on increasing in volume, as the diagram shows (fig. 25), and become mixed with the

air, which consists of hollow spheres, much the same as the now gaseous molecules of water, and approximately of the same volume. As they rise from the mass they cool the liquid and the air. The gaseous water molecules as well as the air molecules may be compared to very minute *invisible* objects like soap bubbles. These gaseous molecules are highly elastic. When all these water objects—molecules—have sprung off the liquid ink (the writing), the pigment remains on the paper, and we say the ink is dry. Not only does this process go on, from the pen and from the paper, but it also goes on in the inkpot; so that if we leave the ink in the pot exposed to the air, a time comes when all the water molecules have darted into the air, and we say the ink is dry in the inkpot. Thus every molecule is alive—there is no molecular death in Nature. We add water to the dry ink, and we get ink back again, but it is not the same ink, as the water molecules are all different—that is, fresh ink is made. I have dwelt upon this simple experiment because it illustrates one of the most powerful forces in Nature, the value of which is largely overlooked and not understood by the specialist.

But we must go further. We must ascertain what causes these minute spheres to increase in dimensions, for them to become lighter and to rise from the mass.

Before I go into this detail I wish to give you the views of modern thinkers and observers on the facts I am going to prove. Thus, E. E. Fournier d'Albe, in his book *The Electron Theory*, states: "We now know that electricity is a kind of subtle fluid consisting of *electrons* or very small corpuscles, some thirty thousand times smaller than the atoms of ordinary matter. The

electron theory is that theory which reduces all electric and magnetic phenomena to the distribution and motion of these electrons. . . . The research student cannot choose a more promising field for his labours, or one more likely to give him a rich reward, than the connection between electricity and heat." (This new statement, well supported by eminent thinkers, was made in 1906.) With this I quite agree, except as to the dimensions given, for it is impossible to get data upon which to obtain such dimensions. Now in 1894 I showed in my book, *What is Heat?* how experiment proved that Nature's fundamental factor was a fluid called Ether, a "*smaller or finer atomic matter than the atomic or molecular matter recognized by the chemist and the physicist.*" The difference between me and the most advanced thinkers is, therefore, only a question of terms; they call the fundamental factor *electrons* or *corpuscles*; I call them *Ether atoms*. This is the only difference.

I am now going to explain what I believe is a most instructive, inductive, and deductive series of experiments.

This box (fig. 26) you will notice has a glass front and glass ends. The rest of the box is of wood, stained internally a dull black. I call this box the Analyzer, because it analyzes the invisible, and makes the invisible visible. By means of the lantern, a beam of light can pass through the ends of the box, but nothing is seen through the front glass—this latter is constructed so that we can observe what is taking place in the box. If, however, I charge the box with smoke-motes (tobacco smoke is most convenient) through the tube *h*, and keep the intense light passing through the box, then the

motes are seen as a fog, but the *air molecules are not seen*. If the air molecules were visible to us we could not see objects in stellar space. Now these smoke-motes are very remarkable objects. They can be placed under the microscope, and each individual smoke-mote can be seen (fig. 27). They appear to be spheres. The experiment is very important, as it is the first time the gaseous molecule has been seen. These motes condense,

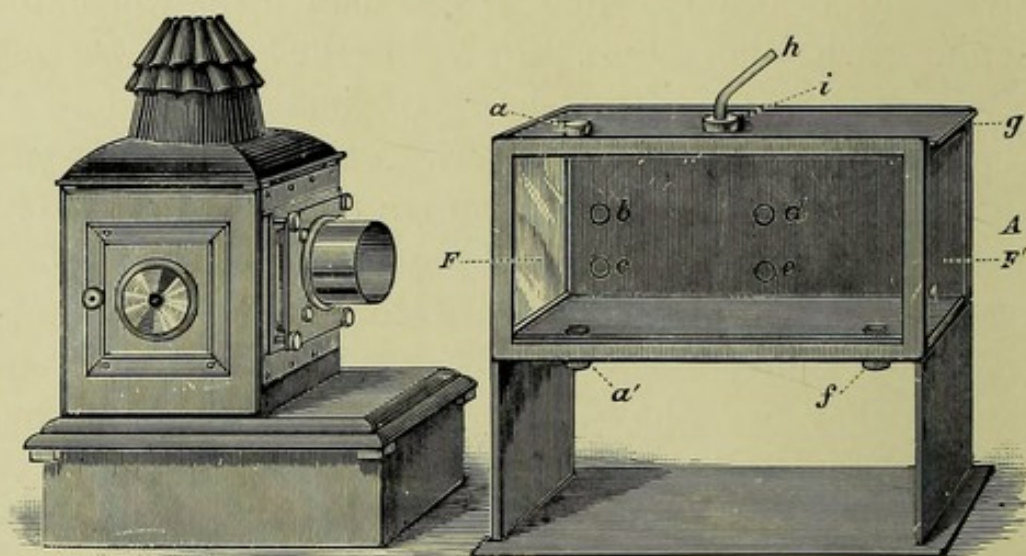


FIG. 26.—A lantern which throws a beam of light through the Analyzer. The light is quite invisible inside the box until it is charged with smoke-motes.

that is, become so small that the individual mote becomes invisible under the microscope, and they collect themselves into a viscid mass. We have in this viscid mass the nicotine which we find in our pipes.

Well, now, these objects are undoubtedly buoyed up between the invisible air molecules, just in the same way as the ink molecules were buoyed up between the water molecules (fig. 25). Let these three glass spheres (fig. 28) represent three *invisible* air molecules enormously enlarged, and this little ball represent one smoke-

mote. Only recollect, these give exaggerated views of the fact, as both air molecules and smoke-motes are very minute. I only want to convey an idea—a concept. Then these motes are buoyed up between the air



FIG. 27.—Smoke-motes seen under the microscope. Each molecule is in intense but small vibratory motion, but they never approach each other. This is the case if there are many or few under observation. The wing-like processes are no parts of the motes.



FIG. 28.—Model showing how a small visible sphere—the molecule of nicotine in the gaseous form—is buoyed up between three spheres, gaseous molecules, of which air consists but which are quite invisible.

molecules, just in the same way as this small ball is held or buoyed up between the glass spheres. But as neither the motes nor the air molecules are rigid, as in our illustration, the motes ultimately become decreased in volume and slip between the elastic air molecules—a most important conception.

The box is perforated at various places, and corks inserted. And if I take out the corks a and a' , air comes from without and below the box and streams into the air charged with motes, or fog, which is in the box. But because the air from the outside is not charged with smoke-motes, it is seen by contrast in the fog or the air charged with motes. And thus we are able to see the motion of air in air. Now notice, the air not charged with motes is a *dense black*. We have here the key to the most important experiments. It is important to note that by this simple apparatus the invisible becomes *visible*.

Our fingers are studded with minute orifices which are openings from the sweat glands. The sweat glands give forth an invisible vapour which comes out of the orifices. Everyone knows that if a finger is put on a cold steel knife this vapour condenses into the liquid form and can be readily seen on the steel knife. In this description everything depends on the word "condenses." Now I am sure you will believe that the vapour from the finger coming out of the interior of my body is devoid of smoke-motes; and if I put a finger into this illuminated box (fig. 29) then this vapour devoid of motes *is seen* streaming off the finger and displacing the air charged with illuminated motes; but mark, it *rises* from the finger—this is most important. Fig. 29 shows what is seen. It, like the air molecules coming from without the analyzer, appears *quite black*, being not charged with smoke-motes.

Now we have taken a second step in our inductive reasoning, by seeing the vapour rising from the finger, as we saw the motion of air in air.

We will alter the experiment. Slip on the finger an

indiarubber finger-stall, and touch the cold steel knife with the finger covered with the indiarubber stall. There is now no condensation to be seen, for the indiarubber stall has kept back the vapour; but something is done to the knife—it is warmed. What is done in warming the knife? *That is the issue.* Place the finger in the box as we did before, only now the finger is covered with the indiarubber stall, and there is seen

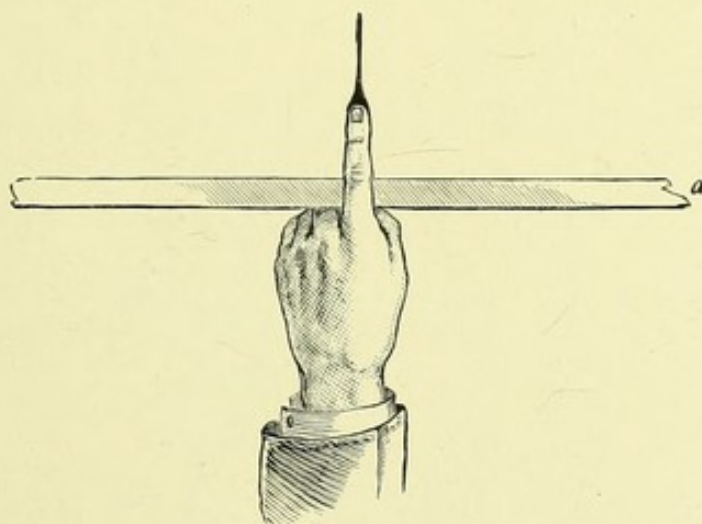


FIG. 29.—Finger passing through a hole at the bottom of the Analyzer, showing the now *visible* sweat vapour coming off the finger.

a second fluid coming through the indiarubber, devoid of smoke-motes, and therefore *quite black*, and rising just as the vapour did. Here we have the same displacement of the air charged with illuminated motes. What is this second fluid? This is what we have to explain experimentally, together with its reaction on molecules.

Here is a glass rod. We put the rod in flame, or otherwise heat it. We insert it vertically in the box, as we did the finger, charged with the illuminated motes; and then we see the same fluid rising from the rod as was seen rising from the finger, and if we touch

the cold steel knife with the heated rod, we warm the knife, just as the finger did when it was covered with the indiarubber finger-stall. In both cases there is no condensation. In these experiments the *black* rising fluid is slightly obscured by the layer of air charged with motes through which the black fluid is viewed. It is easy to get rid of this defect by putting the rod horizontally from the back of the box to the glass front,

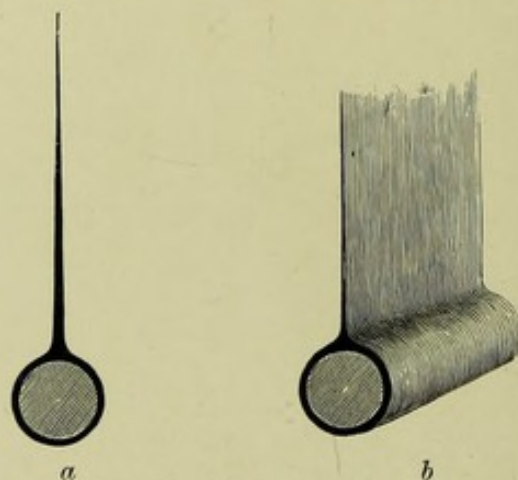


FIG. 30.—*a*. Showing free Ether oozing out of the sides of a solid glass rod and rising upwards. *b*. The same viewed obliquely.

so as to nearly touch it; and now a most surprising thing is seen (fig. 30).

The black-looking fluid, which is *perfectly transparent*, is seen oozing out of the sides of the glass rod and rising from the rod, or antigravitating.

It is clearly defined, and it is as black as it is possible to imagine blackness to be, but quite transparent. Now as this fluid comes out of the rod the rod decreases in volume, and the decrease of volume is proportional to the loss of this fluid.

That this black fluid is moving and rising, and causing the air molecules to move and rise, is easily shown by making *black* vortex rings in the box, and causing them

to float up to this fluid, when they become destroyed by the rising black fluid (fig. 31). When the vortex ring strikes this fluid it is destroyed, as if it had struck a solid wall. This is an experiment to be seen closely to be appreciated. The reactions which take place when a vortex ring comes out of the glass tube *b* (fig. 31) are very wonderful¹ (see fig. 32), and vortex rings clearly show

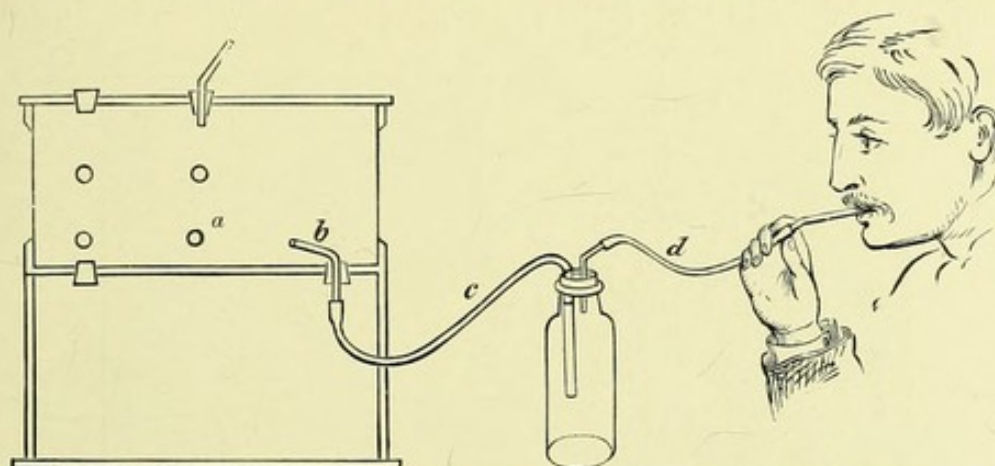


FIG. 31.—Section of the Analyzer, showing how black vortex rings are made. The Analyzer is filled with smoke-motes. Through the hole *a* is placed a heated glass rod, passing from the back of the Analyzer to nearly touching the glass front, when the free Ether, fig. 30, is seen surrounding and rising from the rod. If a small puff of air is made from the mouth into the bottle there comes out of the glass tube *b* a black vortex ring which floats to the glass rod. If the process is inverted—that is, the small bottle filled with smoke-motes and the Analyzer made free of smoke-motes—then the vortex rings are white, and as they float up to the moving Ether coming off the heated rod, the vortex rings are destroyed as if they struck against a solid wall. The reactions are extremely beautiful.

that the molecules of which the gaseous air consists are spheres, rolling by *contact*, just the same as these small shot roll over each other in this bottle when the bottle is tilted. Now notice the experiment destroys what is called the “kinetic theory”—a dogma derived from metaphysical reasoning only.

The issue does not, however, end here ; for if we pass a

¹ For a fuller description of these important objects, see the author's work, *What is Heat? and What is Electricity?* p. 155.

thin wire carrying an electric current, and giving what is called "resistance," then we see the same fluid coming out of the thin wire, oozing out of the sides and rising from it. The conception of this fact is most important, as it explains so much.

Now I shall call this fluid "Ether," or a mass of "Ether atoms"—I might call it a mass of electrons or corpuscles. These Ether atoms must be very much

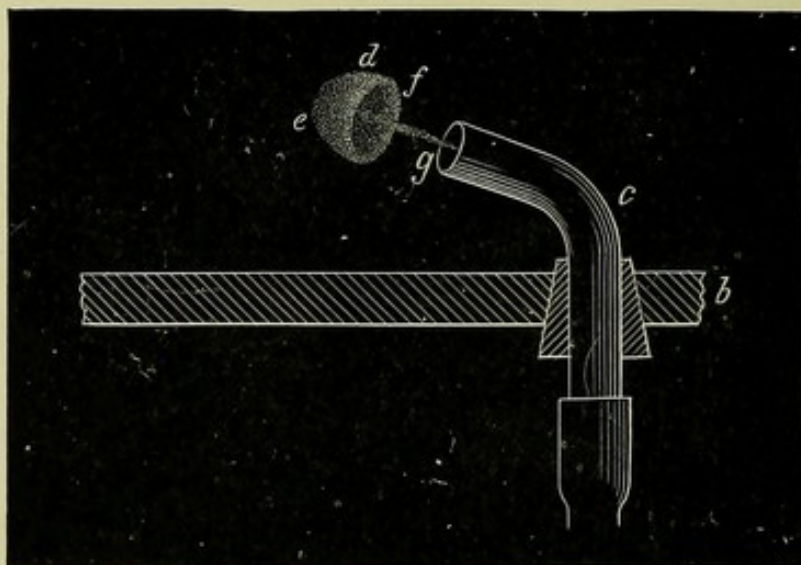


FIG. 32.—A piece of bent glass tubing passing through the bottom of the Analyzer, showing the birth of a white vortex ring. This jellyfish-like object, *d*, gradually alters into a perfect vortex ring by the outside of the object, *f*, rolling itself into a circular tube, and, as it were, sucking into the tube the apex of the object *e*.

smaller than the atoms—so-called—by the chemist and physicist.

The name is of no consequence ; what we have to impress on our minds is the *existence* of this fluid, which is perfectly invisible under ordinary conditions.

You will recollect in our first diagram (fig. 25) I pictured to your minds the *gaseous* water molecule as an object of very much larger dimensions than it is when in the liquid condition. It is clearly this fluid

—this Ether—which rises from the heated rod, from the wire carrying the electric current, and from the finger, which causes the swelling of the molecules. This I shall show experimentally. Experiment also proves, as we shall see, that it is the passage of this fluid *through* what is known as the molecule which produces what we call heat and molecular temperature. The *flow* of this fluid in matter is called electricity.

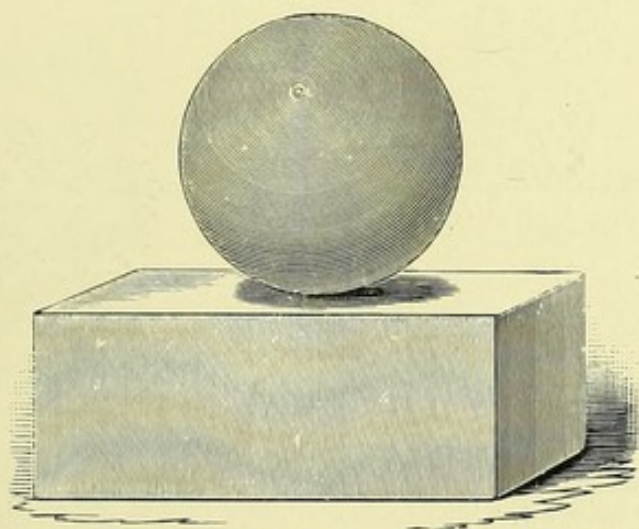


FIG. 33.—A model illustrating a molecule which increases in dimensions as air passes *through* it, and decreases in dimensions by the release of *internal* pressure.

I have here a most interesting model. It is simply a common indiarubber balloon mounted on a box (fig. 33).

There is a small pinhole in the top of the balloon, and if I press air *through* the balloon, just in proportion to the internal pressure of the air—which for the purpose of my lecture I will call “strain”—the dimensions of the balloon increase; while if I decrease the internal pressure or strain, the dimensions of the balloon decrease. The diagram fig. 34 shows the apparatus by which the model is worked. When the working parts are hidden the illusion is very complete, as the indiarubber balloon appears to expand and contract by

its own inherent power ; this is what the real molecule does. Let the balloon represent an enlarged or greatly exaggerated molecule. This concept is most important. Now instead of the balloon, which represents what physicists and chemists call an atom or a molecule, being increased or decreased by the current of air, as I illustrate, the true gaseous molecule, which is very minute, increases or decreases in volume, by the increase or decrease of the current or flow of the fluid

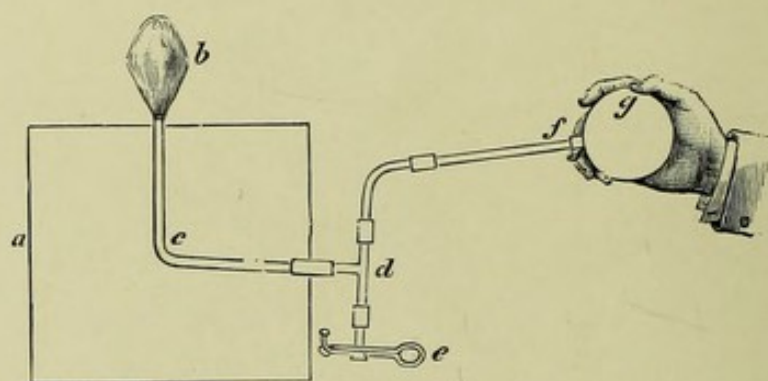


FIG. 34.—*Diagram of the Section of Model.*—*a* is a wooden box to support the indiarubber balloon *b*, which is shown unexpanded. The latter is connected with a piece of tubing *c*, which passes through the box *a*. This tubing is divided at *d*: one way is left open and can be closed by means of a clip *e*; the other way is connected by means of a small indiarubber force pump *f*, having a small hole *g*. The object of the clip is to deflate the indiarubber balloon quickly by opening it.

“Ether,” which we experimentally showed rises from the heated rod, the electric lead, and from the finger. This explains what takes place in a thermometer, where the mass expands or contracts. Thus I have here a thermometer, and I place the bulb between my finger and thumb — covered with indiarubber stalls — and notice the liquid molecules absorb the fluid we have seen oozing through the finger-stalls; they increase in dimensions as the model does, and the mass likewise increases in volume and rises in the tube. This alteration in volume is called alteration of temperature of the

mercury. And as the molecule increases in dimensions by the absorption of this *antigravitating* fluid, the molecule, both in the gaseous and liquid condition, becomes lighter and rises in the mass of gas or liquid, and produces what is called "a convection current."

In the model, the intensity of strain producing increase of molecular volume is counteracted by two factors: (a) the desire of the model molecule to contract of its own inherent power; and (b) by the pressure of the air surrounding it, or by any other external pressure on the molecule, such as my holding the ball by my hand to prevent it expanding, or any pressure causing it to contract. This can be done in mass by the condensing pump. We shall experimentally prove that these are the factors in Nature's molecules. Those factors tending to decrease volume or to keep the volume constant we will call "stress." Thus we have two species of stresses to one and only one species of "strain." Now let us see what the effect of arresting this increase of volume in our model is. The current of air, being kept constant, gets forced along with an increased strain. It is the same as in a water syringe; the greater the force producing the current the more intense is the current, although there is no increase of size in the hole of the nozzle. We can all understand this in the syringe. In other words, strain is increased, but *volume or temperature is not increased*. This is the reaction we obtain in our steam-boilers.

There is another point I want you to grasp. As there is a flow of air through the model, we have plus and minus signs illustrated in the model. As the air enters it, the model has plus (+) air; as it leaves the model, the model has minus air (-). Thus in speaking of a

real molecule one may use the two signs, plus (+) for the entry and minus (-) for the exit of Ether. This explains so much in electrical science which is not now understood.

A liquid thermometer is a fine glass tube expanded into a bulb at one end, and it is partly filled with a liquid. When I place a thermometer holding alcohol between my thumb and finger, covered with the india-rubber finger-stalls, as I have just explained, each liquid alcohol molecule increases in dimensions by absorbing the "Ether" which we have seen coming out of my hand; and as each individual molecule increases in dimensions, the mass of liquid increases also. We must always remember that a liquid or gaseous thermometer only shows increase or decrease of volume of the liquid or gas *in the instrument*, and this difference in dimensions *of volume* is what is called *difference of temperature*. Hence molecular volume is temperature.

I have selected an alcohol thermometer to illustrate the reaction, because in my subsequent lecture I shall make the spirit molecules so large as to be seen by the naked eye. They are hollow spheres. There is one thing I want to impress upon you: a thermometer shows its own temperature only, which does not always agree with the temperature of the medium surrounding the instrument, as is commonly thought. It is true there is a relation between the external medium and the instrument, especially in liquids and solids; but the reactions are often quite inverse in gases. Thus while the contents of the liquid thermometer increase in volume, the gaseous material in which the thermometer is immersed decreases in volume or temperature. I can easily prove this fact by comparing an air thermometer with a mercury thermometer (fig. 35). The latter is

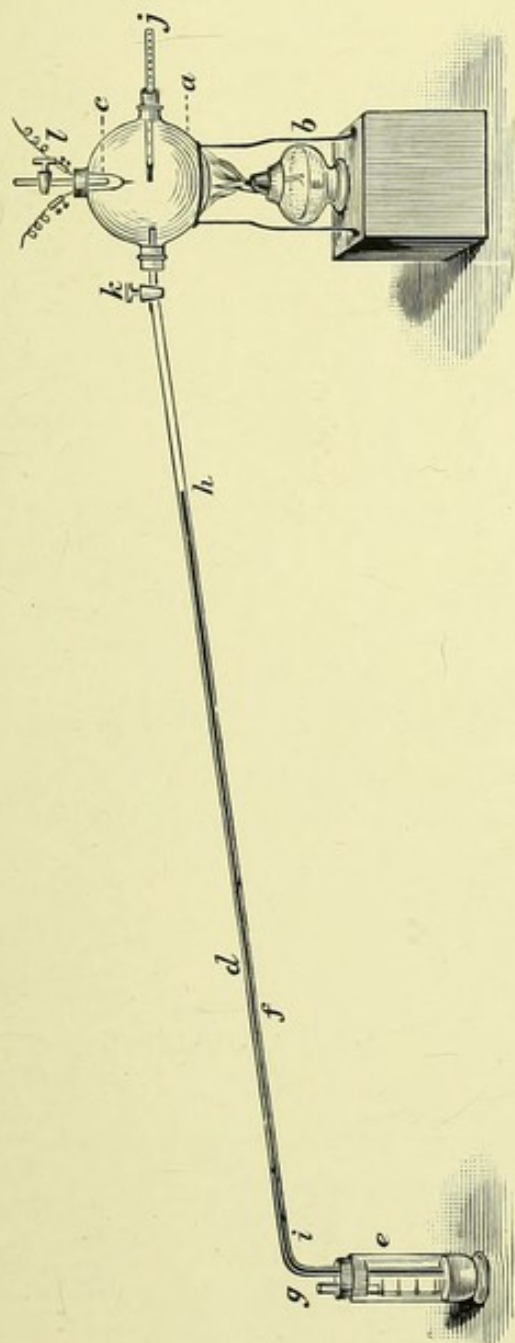
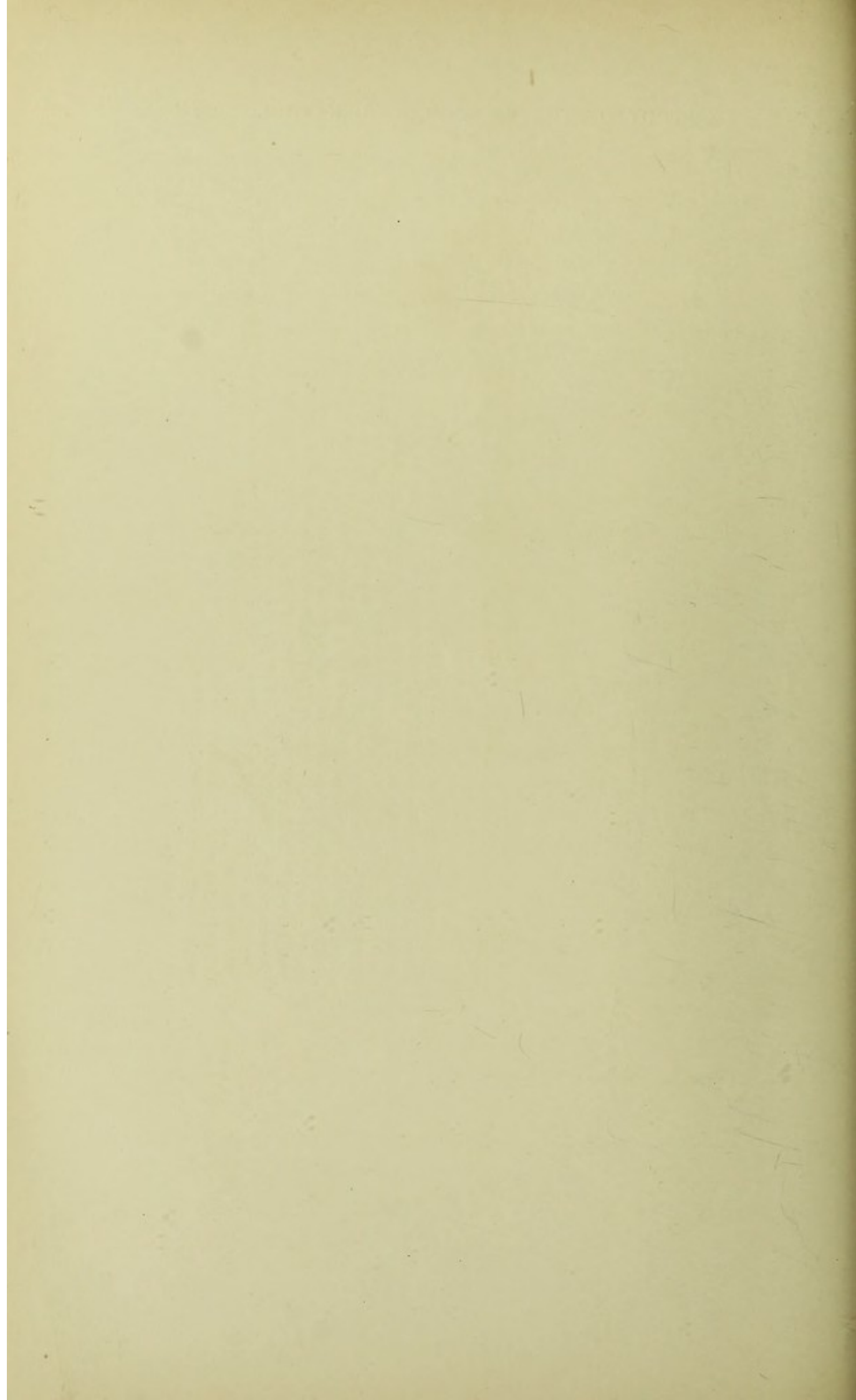


FIG. 35.—*a* is the bulb of an air thermometer, consisting of a three-way receiver about 3 inches in diameter, into the necks of which there are inserted three perforated india-rubber corks. Through one of these corks is inserted a long piece of glass tubing *d*, 47 inches long, passing through a cork in the neck of the bottle *e*, containing coloured spirit of wine; *g* is a piece of glass tubing to permit the pressure of the air to act on the surface of the spirit. The object of this tube is to prevent excessive evaporation of the fluid; *k* is a glass stop-cock in the tube, and *l* is another glass stop-cock passing through the india-rubber cork. The latter is found to be very convenient when the apparatus is permanently set up, for by turning it on we can allow all the spirit to run from the tube *d* into the bottle *e*, or by it we can regulate the height of the fluid in the tube. Through the upper india-rubber cork there passes a thermoelectric pair *c*, which is connected with the galvanometer. Through the third cork there passes a mercurial thermometer *j*.



inserted in the bulb of the air thermometer. The liquid stands at *h*. Now notice, when I warm the bulb of the latter—which I can easily do by placing my warm hands on the bulb or heating the bulb by a lighted spirit-lamp—the air increases in volume or temperature, and forces the liquid in the tube to *i*, and so does the mercury in the liquid thermometer increase in volume, *i.e.* temperature

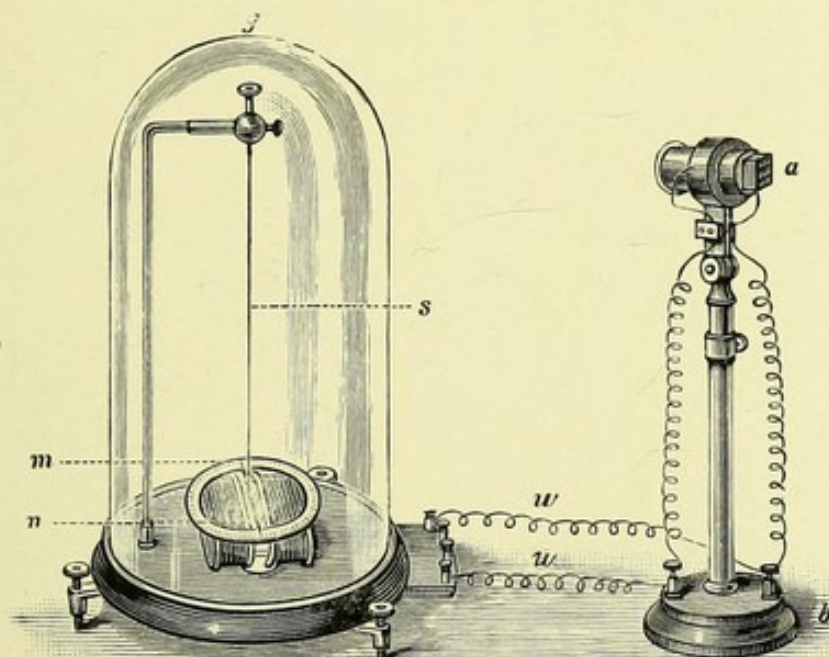


FIG. 36.—A galvanometer under a glass shade, to prevent air currents, connected with a thermopile. *n* is the upper needle or magnet, *m* is the dial marked into degrees, *s* is the filament of unspun silk to hold up the needle, *w w* are the wires connecting with the coil beneath the dial.

—but directly I remove the hand or spirit-lamp—the source of the so-called heat—the air in the air thermometer decreases in volume or temperature, and the liquid rises in the tube *d*, showing the decreased volume of the gas, while the mercury in the liquid thermometer *increases* in volume or temperature even to 30 degrees or more! The reactions are therefore inverse, hence actions and reactions are not equal. What has taken place is: as each air molecule gives out or soaks out the Ether the

mercury molecules absorb or soak in the Ether. This is an universal law—what one gains of Ether the other loses.

The instrument which measures *current or flow of "Ether,"* i.e. the electric current, is called a "galvanometer" (fig. 36). I will now endeavour to show you what the action of this instrument is. You see that it consists of a mass of insulated wire wound into two coils, and in the centre of the coils lies a magnet, and above the coil lies another magnet. There is only one length of wire with two free ends. The upper magnet only is seen; the two magnets are rigidly connected together

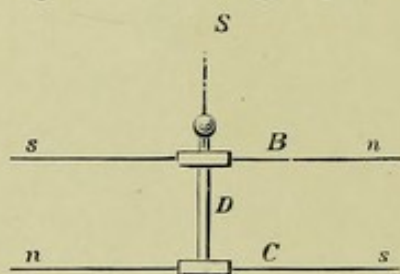


FIG. 37.—The compound needle used in the galvanometer. *S* is the silk fibre holding the needle, *B* is the upper magnet and *C* the lower magnet, which swings in the centre of the coil, *n* north pointing, *s* south pointing.

so that they can only move together. I shall therefore call the two magnets one needle. The top magnet has its north-pointing pole one way, and the bottom one the reverse way, as in the illustration, fig. 37.

The compound magnet or needle is suspended by means of a fine filament of unspun silk, and the whole is placed under a glass shade to prevent air currents affecting the apparatus.

Now, experiment proves that this fluid "Ether" flows through the coil, and, as we have explained, oozes out of the sides of the wire passing through and between the air molecules, which, as we have shown, can be *seen* in mass in the Analyzer.

The operation is just the same as would take place with a liquid (water) passing along a *porous* pipe. Some of the water would ooze out of the sides of the pipe and fall by gravitation; the residue would pass out of the ends of the pipe; only the Ether rises. I have no doubt that this is the reaction in the movement of the electric fluid—the movement of Ether atoms. The lateral flow is that which makes the iron magnetic, while the direct flow is the factor in the arc lamp. According to this view electricity moves slowly, but the results of the flow are almost instantaneous. It acts like a bell-wire—the motion of the wire is small, but the reaction in ringing the bell is immediate. We must recollect that Ether is always present: the wire is always full of Ether.

We shall better understand these reactions when in my last lecture I show you that the Ether passing out of a solid wire and forcing its way through a liquid can also be seen. But experiment also proves that the steel magnets have eddy currents of “Ether” moving round them; these eddy currents making the so-called “lines of force,”¹ and that the “Ether” which comes out of the sides of the wire (which we have seen) attacks the “Ether” surrounding the magnet and causes the magnet to move with the “Ether.” The “Ether” in this case, moving from and to

¹ It is very remarkable that these “lines of force” can be seen in the very minute objects—cells—of which every organism (including man) is built. But if our views are correct, the centre from which the lines of force flow is undergoing chemical reaction. This produces a flow of free Ether radiating from that centre. This, if true, solves one of the most difficult of problems in biology. (See *The Cell in Development and Inheritance*, by Professor Edmund B. Wilson, Ph.D. Macmillan & Co.)

the magnet as eddy currents, and the "Ether" exuding from the wire, are quite invisible, as is the "Ether" coming from the heated rod, the finger, and the electric lead when seen under ordinary conditions. All that is visible is the moving of the magnet.

I have here a very striking form of galvanometer (fig. 49). In the many lectures I have attended I have never seen this instrument, yet I think that it conveys to a gathering such as I am addressing the reactions of the instrument in a very clear way.¹

Let the two free ends of the wire connecting with the galvanometer be connected up with a junction of two dissimilar metals such as I now show you. The junction is merely two pieces of wire of different metals soldered together (in this instance pure silver and an alloy known as eureka), and is called a thermo-couple; now if I let the fluid exuding out of my thumb and finger covered with the indiarubber stalls, or that exuding from the heated rod, or that exuding from the electric lead, attack the junction and "warm it," as it is called, a deflection of the needle takes place in one direction—this I will call deflecting to "heat"; whereas if I, as it is called, "cool" the junction, by putting near it a piece of ice, the needle is deflected in an opposite direction, which I call deflecting to "cold." And I must here draw your attention to one important fact, namely, that a liquid thermometer shows molecular volume only, and a thermo-couple connected with a galvanometer shows flow or current only of Ether. The two instruments

¹ This was a galvanometer made by Duboscq of Paris, which showed the dial on the screen with the moving needle, when it was properly illuminated by the electric-light lantern.

always act in unison. I have never seen a deviation of this rule. For example, when the galvanometer needle goes to "heat," the liquid, or gas, in the thermometer increases in volume, and whenever the galvanometer needle goes to "cold," there is a decrease of volume of the liquid or gas in the thermometer. I repeat, the two instruments give entirely different reactions. The thermometer shows volume only in terms of "temperature," while the galvanometer shows current, which is in its turn produced by a difference of what is called

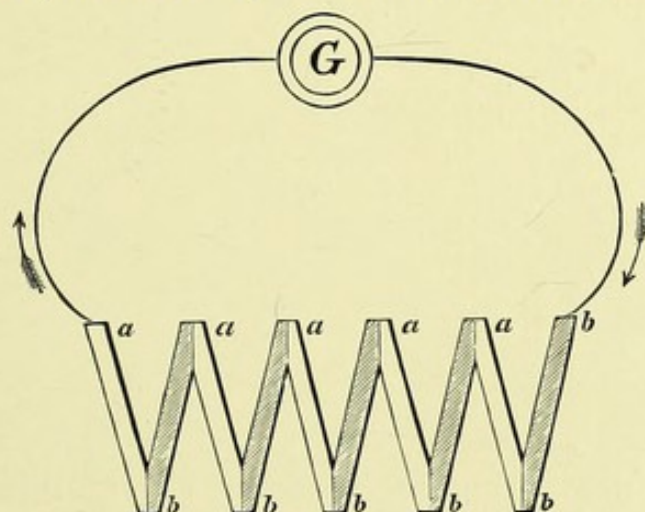


FIG. 38.

electric pressure—strain—which produces temperature in the molecules. This strain is called by electricians "potential"—the difference of strains, potential difference. The model, fig. 33, explains both reactions, the size of the model indiarubber balloon being temperature, while the air passing through the model explains the electric current.

When these junctions in a thermo-couple are repeated and are joined together as the illustration shows (fig. 38), making the instrument more sensitive, we have an instrument called a thermopile.

In the illustration, fig. 38, *G* represents the galvanometer and *a* and *b* the junctions of the dissimilar metals, *a* antimony, *b* bismuth. In practice the apparatus is made compact by placing the metals side by side, and the whole is placed in a case while the junctions are exposed (fig. 39).

Now notice, if I place my finger, covered by the indiarubber finger-stall, below the thermopile, the Ether,

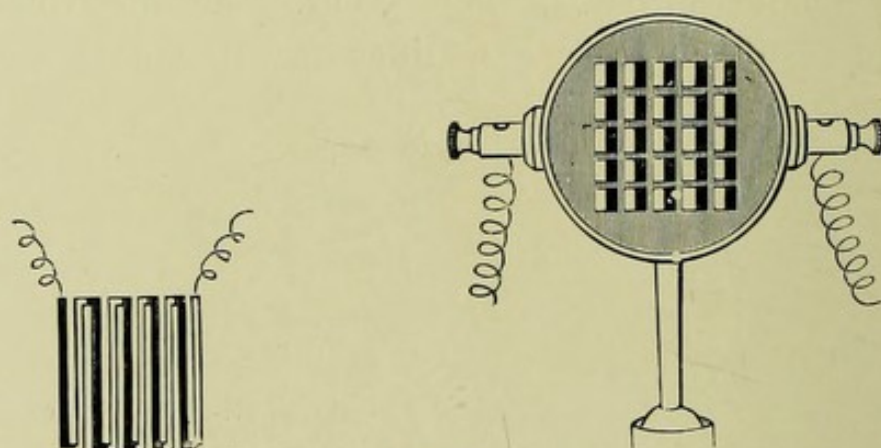


FIG. 39.

which *we have seen*, attacks the thermopile, and the needle of the galvanometer indicates heat.

I want to convey to you two important reactions which will take a very prominent part in our experiments, namely, a "push" and a "pull." I have here an ordinary glass syringe, and if I insert the end of the syringe in water and "pull" the piston out, I "pull" up the water into the syringe. Now many of you will object that it is not a "pull" but a "push," through the pressure of the air pressing the surface of the water and causing the water to ascend in the syringe. This is true; but nevertheless my action is a true pull, for if the pull did not exist, the water would not rise in the

syringe. The converse takes place when I “push” the piston down, and the water returns out of the syringe.¹ These two processes, the “push” and the

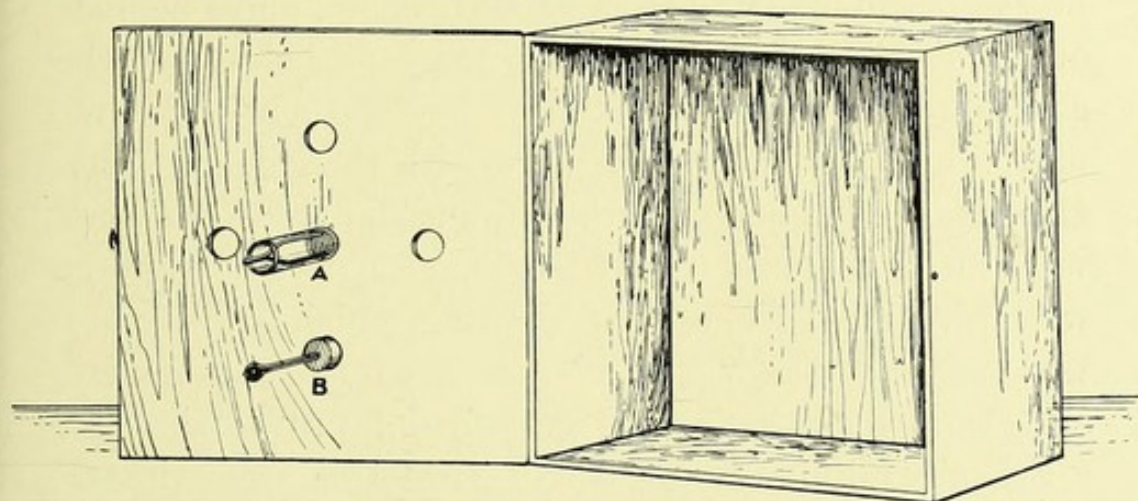


FIG. 40.—A wooden box in the lid of which there are five holes—four of which are equal distance from the centre hole A. In the centre hole is a thermo-couple (connected with the galvanometer) protected from the junction by a piece of glass-tubing, so that the junction is only exposed to the radiation of Ether. B is an ordinary thermometer whose bulb is exactly below the junction of the thermo-couple. Now if the bulb of the thermometer be heated and placed in the upper hole a deflection of the galvanometer needle will take place, and a similar deflection takes place when the thermometer is placed in the side holes. But there is a very much larger deflection of the needle when the bulb of the thermometer is *afterwards* placed in the lower hole. During the time the experiment is being made, the molecules of mercury are contracting in volume; thus the last experiment is made when the thermometer is lower in temperature. This shows that the Ether coming off the bulb is divided and does not follow the law of inverse squares. The experiment is made *when the box is closed*.

¹ In this experiment I think that there is a greater amount of energy to produce a “push” than a “pull.” All I do in the pull is to move the piston up; the water rising, simply follows the rising piston, while with the “push” I seem to press down the water in the syringe. If there is a difference in this energy, it solves a very remarkable problem. Many electrical phenomena are explained by this simple experiment, for it seems to explain the alternating current. It is the difference of push and pull which produces the current. Hence action and reaction are not equal and opposite. The experiment illustrated in fig. 50 becomes then quite clear, for the difference of the pull and push of the fluid Ether is that which leaks out of the side of the wire, and which is visible.

"pull," take a most prominent part in heat and electrical reactions.

In this box (fig. 40) the lid is perforated with four holes at equal distance from each other, and one hole at the centre equidistant from the four holes. In the centre hole is a thermo-electric couple, such as I have on the table, connected by wires with the galvanometer. Here is a thermometer with a round bulb. Now when we heated the *rod* or carried an electric current in a wire, giving what is called resistance (which is a leakage), we saw that the "Ether" rose from the rod or wire, and was visible. Careful experiment proves that the "Ether" is divided; most of it rises free from the rod or lead, but a part radiates a *short distance* downwards and laterally through the air molecules. The latter reaction is quite invisible. Thus if I heat the bulb of the thermometer B and put it above or on each side of the thermo-couple there is a very small deflection; while if I put it below the thermo-couple a most marked deflection takes place. I have here also some thin wire wound round a glass rod, and if I pass a current through the thin wire and put the thin wire above the thermo-couple, we have a very small deflection; while if I put it below the junction the deflection becomes considerable. But the evidence points to the fact that the downward and lateral flow of Ether is very small, and that it ultimately rises. Thus the motion of the fluid "Ether" in both cases is that of the rising of "Ether," while in the case of the electric wire we have converted what is called electricity into electricity again—a most important experiment which proves, to my mind, that electricity is the *flow* of "Ether." You will now understand how

complex the lateral leakage of "Ether" from the coils of the galvanometer must be.

In our next lecture we shall experimentally, by means of these two instruments (the thermopile and thermometer), prove the simple fundamental idea I have just conveyed to you.

LECTURE III

I THINK that I cannot do better in opening this lecture than by again drawing your attention to this simple and instructive model (fig. 33). The spherical object mounted on this box is made to represent an enormously magnified molecule. It is very important that you should understand the model. Now it is agreed by both chemists and physicists that all matter which we can see in mass, also that which we cannot normally see, such as gases, is built up of minute objects called molecules, which, when in the liquid, gaseous, and vaporous forms, have their free individuality; that is, each individual molecule can freely move in any direction, and I want this model to represent such an object. We have arrived at the conception that there is a fluid which operates on the molecule by an internal pressure which we call "strain," and an inherent "stress," which is the tendency of the molecule of its own inherent power to contract, also a second stress arising from the pressure of the atmosphere, or some other external pressure to aid the inherent tendency of the molecule to contract. Thus we call the reaction which causes contraction "stress," and we also call the volume of the object the "temperature" of the object, and we found that temperature depended upon the passage of what we call the fluid "Ether" passing *through* the molecule, just as the air is now doing in the

balloon—the volume or temperature being the result of the two opposing factors “strain” and “stress.”

Now I want to convey a further conception. The evidence tends to the fact that there are two classes of molecules: molecules built up of one elementary substance, which we may call “elementary molecules”—such as molecules of oxygen, hydrogen, etc.—and “compound molecules,” built up of two or more elementary substances, such as a molecule of carbonic-acid gas, built up of oxygen and carbon, or a molecule of water, built up of two “elementary molecules” of hydrogen and one “elementary molecule” of oxygen. Both of these “elementary molecules” are built up of an unknown number of elementary atoms. The molecules in the liquid, gaseous, and vaporous forms are “hollow” spheres filled with “Ether.” As a soap-bubble is always full of air and yet becomes fuller by expanding, so these molecules are always full of Ether, but hold more atoms of Ether by expanding.

The former of these objects, which we now call the “elementary molecule,” used to be regarded by the chemist as the atom. A molecule, then, is a hollow group of atoms—a sphere, or a spheroid. The evidence tends to the fact that the fundamental atoms of which a molecule is constructed are spheres of constant volume for each species. Thus the “molecule” of oxygen is built up of a number of “atoms” of oxygen, all the atoms of oxygen being of the same dimensions—solid spheres of constant volume. These views bring our ideas in harmony with modern ideas, for the chemist and physicist now know that what they regarded as the atom can be split up into something smaller than the old unit called “the atom.” Thus we may call a group

of atoms like the model an "elementary molecule" of oxygen built up of elementary matter—oxygen atoms; or a "compound molecule" such as a water molecule built up of two "elementary molecules" of hydrogen and one "elementary molecule" of oxygen.

Well, then, we may regard this model as built up of one elementary species or of two or more elementary species. Chemical formulæ will follow this concept. For instance, the chemist has hitherto conceived a molecule of water to be built up by one atom of oxygen and two atoms of hydrogen. There is no justification for this concept; all that the chemist knows is that in mass at ordinary temperature and pressure two volumes of hydrogen unite with one volume of oxygen to form a mass of compound molecules—molecules of water; neither chemists nor physicists have ever seen an atom or molecule. The view I am giving you states that this is not the case, but that "two groups" of hydrogen atoms—each group being a molecule, or "two elementary molecules" of hydrogen—unite with one group of oxygen atoms or an "elementary molecule" of oxygen to produce a compound group—a "compound molecule," *i.e.* a water molecule. This statement corrects what I believe is the only important error in my two books, *What is Heat and What is Electricity?* and *What is Life?* The error was inevitable, because I was compelled to follow authority, at least to some extent. But while I described the old concept of the "atom" being the finite entity, I gave the idea that it was a compound entity, by giving the fundamental fact that it increased and decreased in dimensions *per se*. Now our minds are so framed that we cannot conceive an object having these properties as being the finite particle. Yet

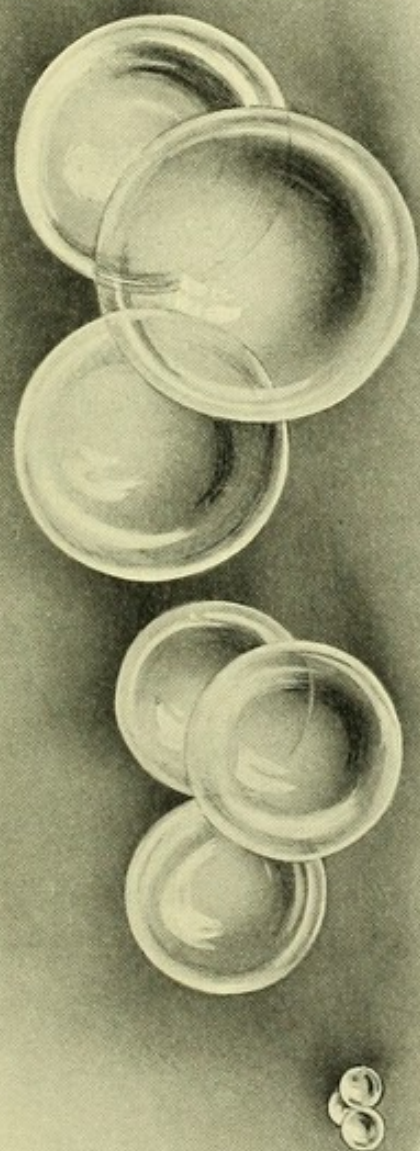
experiments thoroughly proved the concepts I have given in my books.

I have on the table a series of glass spheres in groups of threes (fig. 41); these will represent, say, water molecules, but enormously magnified, and these groups show the relative molecular condition of the liquid, the gaseous and the vaporous. The smallest (A) are hollow glass spheres—these represent the liquid¹ condition of water molecules, objects holding in their interior a very small quantity of Ether. These objects are so minute that they cannot be seen, even by the highest power of the microscope, but we can see a mass of them, and we call the mass water. The next larger groups (B) have thinner walls and a larger interior, thus holding more Ether; they represent water molecules in the gaseous condition. I think these could be seen by the highest power of the microscope as far as dimensions go, but they are objects our eyes are not able to see. The third group are objects much larger and with much thinner walls (C), holding an excess of Ether; these represent the vaporous molecules, that is, water molecules in the state of steam. These objects, under suitable conditions, are visible to the unaided eye, and it will be one of the most interesting of my experiments to show you these objects.

My reason for stating that the “elementary molecule” is a group of elementary atoms is that in the vaporous condition the coloured elements, bromine, chlorine, and iodine, can be seen as independent mole-

¹ I must refer the reader to my two books, *What is Heat and What is Electricity?* and *What is Life?* for conceptions relating to the solid. I thought it not wise to complicate matters in these lectures by importing too much detail.

FIG. 41.—Hollow glass spheres made to represent “compound molecules” of water. The molecules are in contact as shot are in a receiver. They are supposed to be vastly magnified. The smallest spheres, A, represent water molecules in the liquid condition. These molecules are invisible even under the highest powers of the microscope. B represents water molecules in the gaseous condition ; these might possibly be seen by the highest powers of the microscope, but our sense of sight is incapable of seeing them. C represents molecules in the vaporous condition—steam. These are easily seen by the naked eye so long as they are mixed with cold air molecules. The lower series of circles show sections of the upper row. Notice the smaller they are the thicker are the spheres. They must not, however, be supposed to be composed of a homogeneous substance as drawn, but they are built up of vastly minute *solid* spheres—these are atoms. The diagram fig. 5 in the author's work *What is Life?* third edition, more completely gives the concept. An engraving cannot convey the whole of the facts. Molecules are not rigid, as their atoms are.



A



B



C

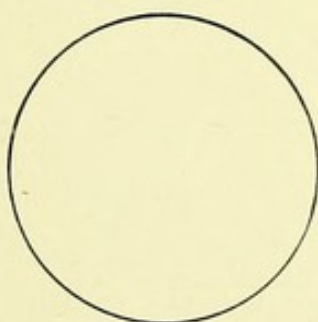
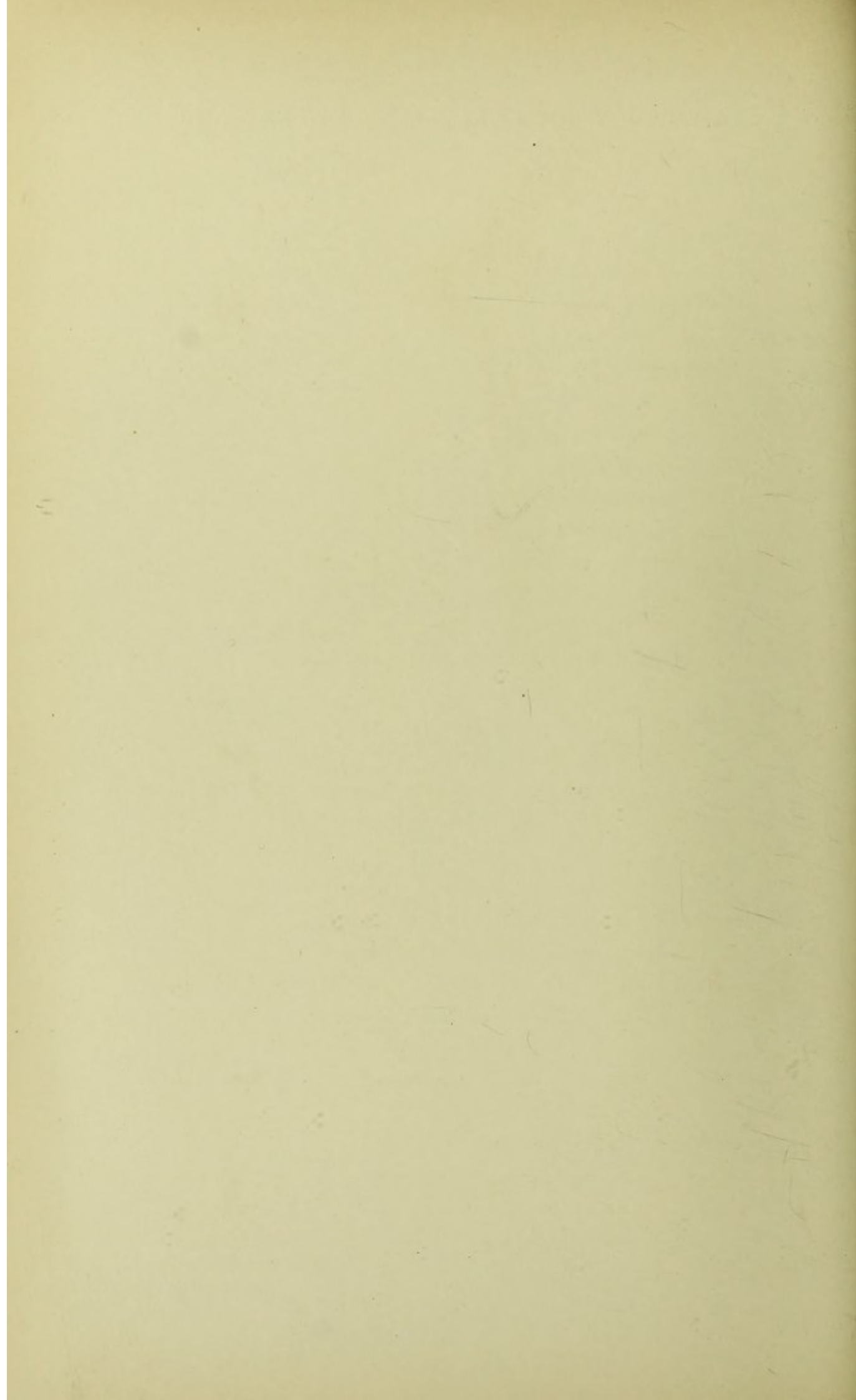


FIG. 41.



cules in the same way as we shall see the water molecules in the vaporous condition — the steam molecules.

There is another very important factor I want you to understand—the volume or temperature of the molecules depends upon external pressure, and that when this pressure is removed the Ether soaks into the molecule and causes it to expand; or perhaps better expressed—the expansion of the molecule causes a “soaking-in” (to use an electrical expression) of the Ether. The motion of the Ether atoms is, I believe, the electric current, and modern views are tending to this deduction. The first two experiments I am going to show you, in a most beautiful and complete way demonstrate these reactions.

I have here a bell-glass on the plate of an air-pump. The bell-glass is called a receiver. Fig. 42 (A) shows a section of the apparatus. Inside the receiver there is an elastic indiarubber balloon slightly inflated with air (*c*). Air exists also inside the glass receiver *e*. Inside the indiarubber balloon is inserted a thermocouple (*b*) connected with the galvanometer, and the bulb of a thermometer (*a*). There is also attached to the pump a mercury gauge (*g*) to show what is called the rarefaction of the air inside the receiver.

I am going now to make a false assumption. My reason for doing this is that it will make the experiment clearer to you. I will assume that inside the indiarubber balloon there are a hundred gaseous air molecules; these are confined in the balloon; they cannot get out of the balloon. Now the contents of the glass receiver holds, we will say, 10,000 air molecules, *i.e.* between the balloon and the bell-glass. Understand these numbers

are nonsense, for no human being can tell the number in the balloon and in the glass receiver. Now we begin to, as it is called, *exhaust* the receiver; that is, by pumping we draw out nearly the whole of the 10,000 air molecules.

Notice, as we draw them out of the receiver, the hundred air molecules in the indiarubber balloon expand, and force the indiarubber balloon to expand also, until we have drawn out nearly the whole of the 10,000 air molecules and the indiarubber balloon occupies nearly the whole of the glass receiver (C). Watch what the galvanometer needle and the thermometer are doing all the time we have been pumping. The mercury in the thermometer falls or becomes less in volume, while the galvanometer goes many degrees to cold.¹

Now observe that the volume of air in the indiarubber balloon having increased, shows an increase of temperature as explained by the air thermometer, but a decrease of temperature as shown by the mercury thermometer. This contradicts the kinetic theory. I hope now you will readily see the explanation of this reaction. The invisible fluid Ether is absorbed or is "soaked in" by the air molecules in the indiarubber balloon and they increase in volume, and this Ether passes through the glass, through the brass plate, through the thermometer, and through the thermo-couple, through the wires of the galvanometer causing the needle and the thermometer to indicate cold. The reactions are only visible in the thermometer and the galvanometer, and also in the increased dimensions of the balloon. If we leave the air thus increased in volume a short time the thermometer rises to the temperature of a thermometer

¹ The fall in temperature depends upon external pressure of the air, but mostly depends upon the rapidity of the pumping.

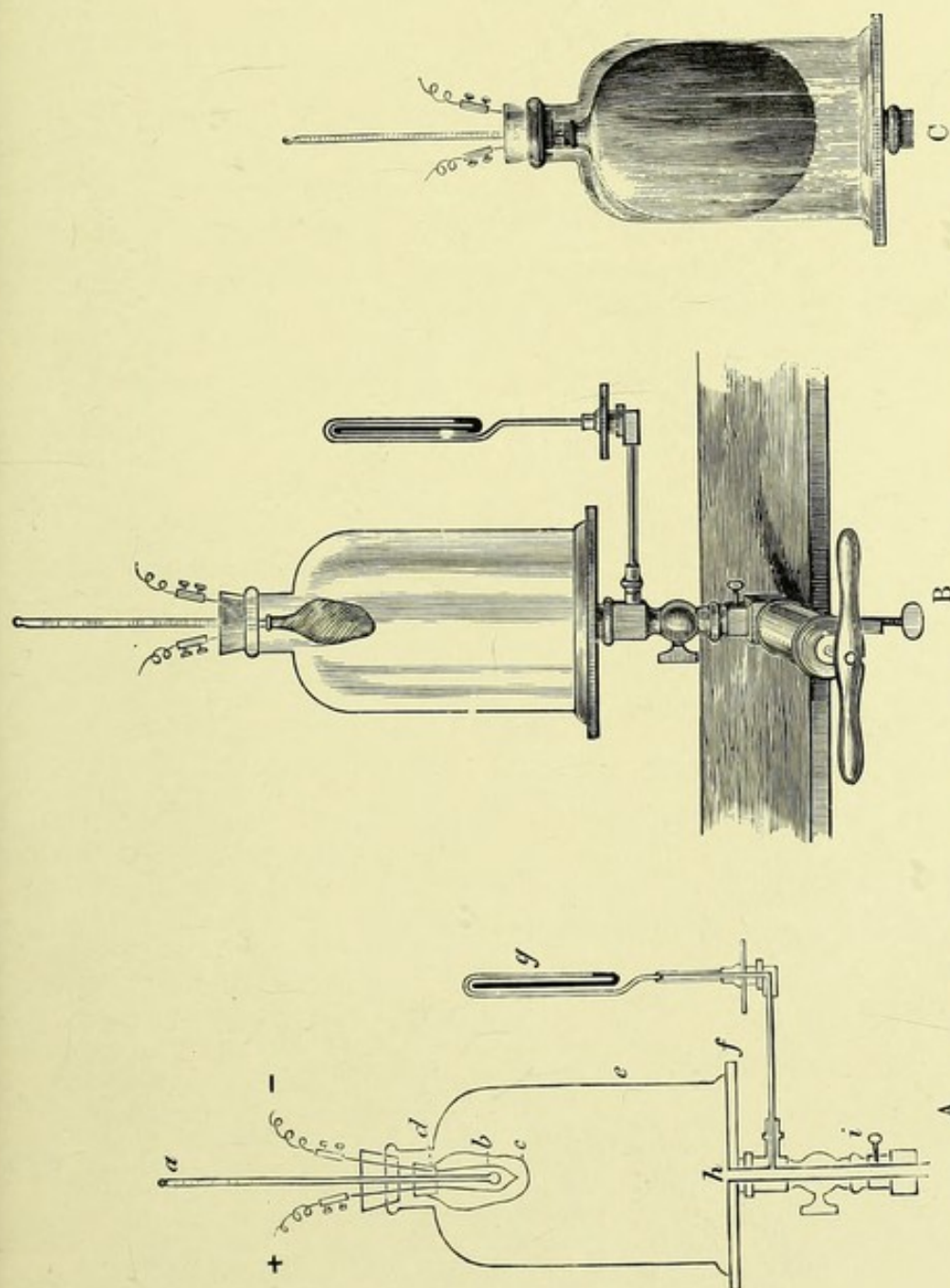
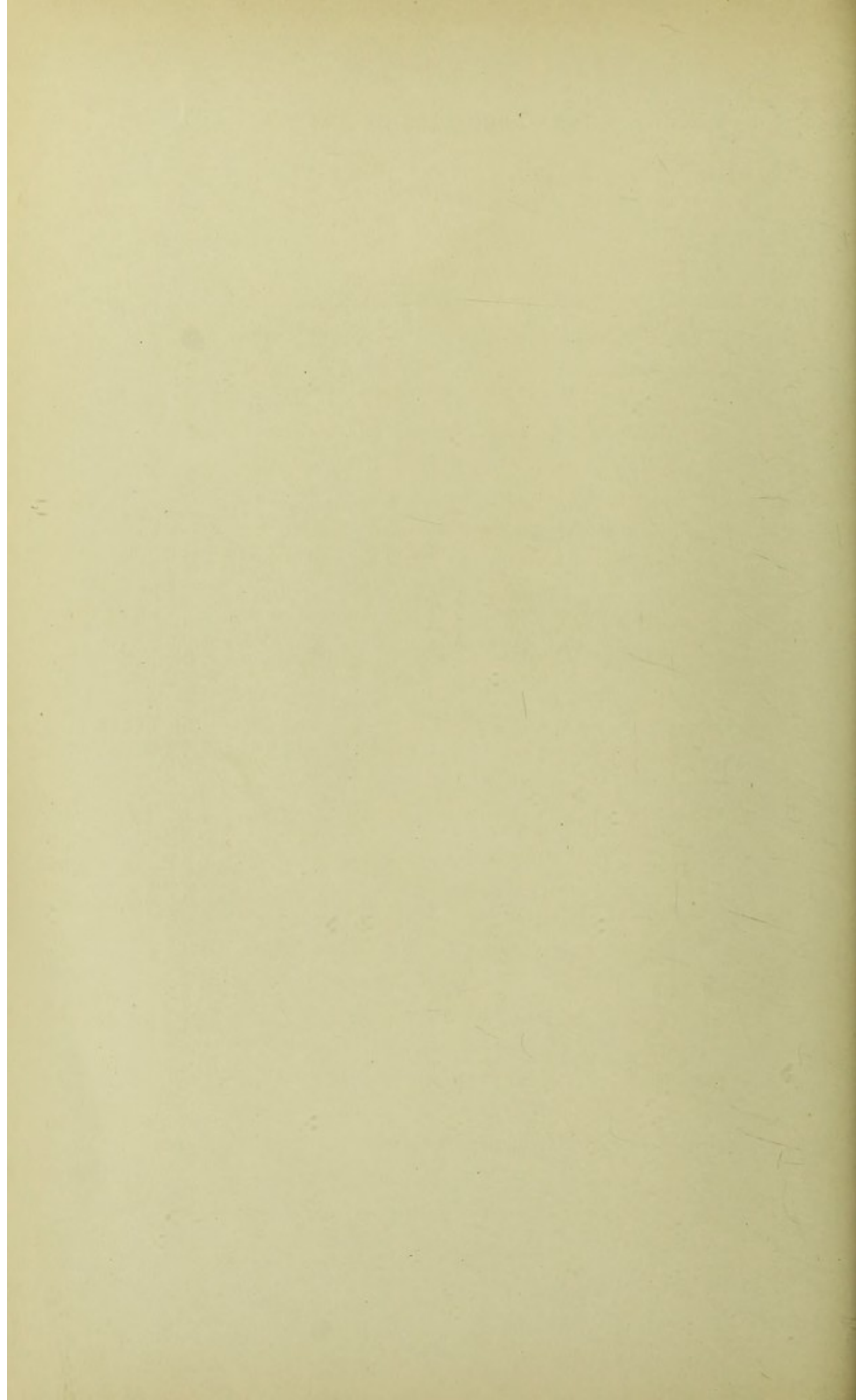


FIG. 42. *Explanation of diagram, fig. A.*—*a* thermometer, *b* thermo-couple, *c* indiarrubber balloon, *d* small indiarrubber cork, *e* bell-glass receiver on plate, *f* of air pump, *g* mercury gauge to show the release of pressure on the air molecules, *h* outflow, with stop cock, through which the air molecules pass, *i* valve to allow the air molecules to re-enter the receiver. B, C, the external appearance of the apparatus.



outside the apparatus, or to the condition in which it was before we made the experiment, but there is no alteration in the dimensions of the balloon. Obviously the thermometer does not register the temperature of the air in the balloon. Why does the thermometer, then, fall during the time the volume of the air in the balloon is increasing? Because the mercury molecules are giving out the Ether faster than they can obtain Ether from the outside air surrounding the apparatus. Or we may thus express the reaction: as the molecules inside the receiver and the balloon expand, there is a true pull of Ether by them to cause them to expand.

If now we allow the air to re-enter the receiver, 10,000 *fresh* air molecules rush into the receiver, compress the air molecules in the indiarubber balloon, and a current of Ether passes through the mercury molecules in the mercury thermometer in an opposite direction, and also through the thermo-couple and through the wires, and the needle of the galvanometer is deflected the reverse way. That is, the needle deflects to heat, and the thermometer registers an increase of volume or temperature. This again contradicts the kinetic theory. Now this reaction is a true *push* of Ether. By allowing the air to re-enter the receiver, we press the Ether out of the air molecules in the indiarubber balloon, just as we can press water out of a sponge. But here notice, because the second reaction is quicker than the first reaction, the volume of mercury is increased and the needle of the galvanometer goes further to heat than it did in the previous experiment to cold. Obviously, time is a factor in the reactions.

We will alter the experiment by using a double

receiver (fig. 43A). This is illustrated by the diagram, fig. 43.

There is the same receiver as before, but we have added a second receiver (*a*) connected with the lower one by a stop-cock (*c*), and below the orifice of the tube in which the stop-cock is placed is a thermo-pile connected with the galvanometer. There is a second stop-cock (*d*), and thermometers to show the reactions in the two receivers, and one to show the temperature in relation to the external air (*f*). This latter will of course show no alteration, as we shall not interfere with the air which surrounds it.

We turn off the stop-cock *c* and exhaust the lower receiver—that is, we pull out nearly the whole of the hypothetical 10,100 air molecules, and we get the same reaction as in the previous experiment—that is, while the air molecules increase in volume or temperature, the mercury molecules in the thermometer are reduced in volume or lose temperature, and the galvanometer needle goes to cold. This is a true pull of Ether by the molecules inside the bell-glass. It is the same experiment as the former, only we have now no india-rubber balloon to prove to the sense of sight that the air molecules actually expand. Next, we allow the thermometer to go to the temperature it was before we made the experiment. We now turn on the stop-cock *c*, keeping the stop-cock *d* closed, and the air molecules in the smaller receiver being smaller, or lower in temperature, rush out and impinge on the face of the thermo-pile, and compress the air in the lower receiver which is holding larger air molecules or molecules of higher temperature. Notice the remarkable reactions; the mercury molecules in the thermometer *j* increase

in volume or temperature, while the galvanometer swings quickly to cold and shows a decrease of the tem-

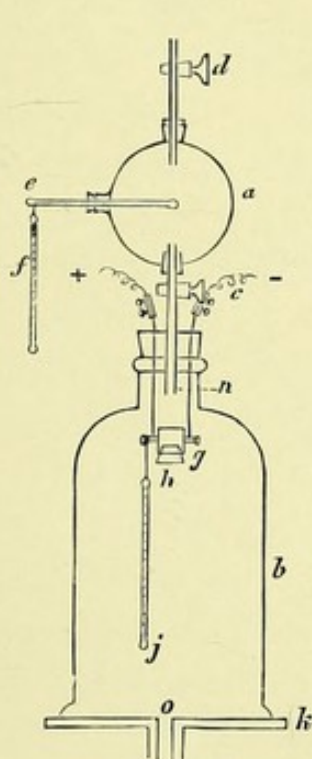


FIG. 43.



FIG. 43A.

Explanation of Diagram.—*a* is an upper receiver, connected with a lower receiver *b* by a glass stop-cock *c*. The stop-cock *d* connects the apparatus with the external air; these stop-cocks are inserted by means of indiarubber corks. *e* is a thermometer to show the temperature of the interior of the receiver *a*, passing through an indiarubber cork; *f* is a thermometer to show the temperature of the external air; *g* is a thermopile, plugged at the back with an indiarubber cork *h*; in order to prevent any direct reaction on the back of the thermopile, it is supported by and connected with insulated wires to the galvanometer; they pass through the indiarubber bung in the neck of the receiver *b*; *j* is a thermometer hung on the thermopile to show the temperature of the lower part of the bell-glass *b*; *k* is the plate of the air pump. There are thus two ways of allowing air to re-enter the receivers—one by the valve *i* (see fig. 42, A), the other at the top of the upper receiver *d*.

FIG. 43A.—The external appearance of the apparatus.

perature of the molecules which are impinging on the thermo-pile.

Now see how the simple concept I have shown in the model explains these apparently contrary reactions. As the smaller air molecules rush out of the top receiver each

molecule is expanding as it touches the thermo-pile, each takes a small proportion of the Ether away from



FIG. 44.—Section of a fire-syringe. *a* is a piece of German tinder which ignites by the passage of Ether through it, when the air in the syringe is compressed.

the thermo-pile to permit it to expand ; and because there are a great many air molecules rushing out of the upper receiver and each taking a small proportion of Ether, the sum of these reactions produces a great deflection of the needle ; in fact, it goes as far as it can to cold (90°). Again, this is a *true* pull of Ether by the air molecules. Now when the smaller air molecules rush into the lower receiver, where the air molecules are much larger, the latter become compressed in volume by the molecules received from the upper receiver, they become reduced in volume or temperature, and the Ether is pressed out of the air molecules in the lower receiver—that is, at the lower part of the receiver—and the glass of the receiver becomes warm, as also the brass plate and the mercury in the thermometer receive a proportion of the Ether. The mercury

molecules increase in volume ; their temperature is said to rise ; in other words, what the air molecules lose of Ether by being reduced in dimensions the liquid mercury, in part, gains of Ether. Notice that the bulb of the thermometer *j* is so

placed as to receive the maximum pressure. The squeezing out of Ether from the air molecules is well shown in the instrument called the fire-syringe (fig. 44). It is merely a piston inserted into a tube

closed at the end. See how elastic the air molecules are! I can press the air in the tube into a small volume and it immediately shows resilience. If I press down the piston I reduce the volume of the air-molecules. That is what the air thermometer records as loss of temperature, or less of volume. *While the air loses volume or temperature the metal tubing receives the Ether pressed out of the air molecules and becomes increased in temperature, or, as it is called, warm.* That is, what the air loses of Ether, the metal gains of Ether. Simple as this reaction is, curiously enough, because of the erroneous education the physicists and chemists receive, they cannot see this plain reading of Nature! If I insert in the end of the piston a piece of German tinder, and reduce the temperature of the air quickly by pressing down the piston, the Ether radiates very quickly through the tinder. I compress the air; see the result: the tinder has such an affinity for the Ether that it becomes incandescent; it burns.

Having obtained the great fundamental idea we will make a further experiment with this simple apparatus (fig. 43A). We will turn off both stop-cocks and again pull out nearly all the air molecules in the lower receiver. Having done this we will repeat the last experiment, but with a lighted spirit lamp we will, as it is called, heat the air molecules in the upper receiver before we make the experiment. Now notice what we are doing. *We are increasing strain but not increasing the temperature or volume of the air molecules, or only to very slight extent, because the glass, being rigid, does not materially increase in volume by the so-called heating of the glass.* The glass does, however, expand to a small degree. The mercury molecules in the thermo-

meter increase in volume, because there is a space in the tube free from liquid to allow them to expand. There is no such tube attached to the upper receiver, but the strain is increased, and this is what takes place when we, in our steam boilers, as the saying is, "get up steam."

But see what takes place when we turn on the stop-cock *c* and let the so-called hot-air molecules impinge on the thermo-pile. The reaction is the same as before; now the thermo-pile with the galvanometer *gives the reaction of cold*; and if I place the bulb of a thermometer just above the face of the thermo-pile, or replace the latter with a thermometer, there is a fall of the mercury, or the reaction is that of cold. Obviously what the thermometer tells when we have heated the upper receiver is an illusion. It does not register the volume of the air molecules; it only registers the intensity of the current of the Ether passing *through* the mercury molecules. *I venture to say that there is no other possible explanation than that which I have here given which will explain this remarkable and apparently contradictory experiment.*

Now I have already given you a conception of the water molecules being very minute hollow spheres when in the liquid condition, like these glass marbles, only they are not rigid, and this concept applies to all liquids. Nature abhors the rigid, hence cannot be interpreted by rigid ideas. My reason for believing this to be the case is that the volume of water is constantly varying, the same as the spirit or mercury in a glass thermometer. If we make a glass thermometer partly filled with water, the variation of the

volume of water is seen in the same way as in the mercury or spirit thermometers. This variation of mass involves a like variation of volume of the individual molecules of which the liquid consists.

I want now to show you the evidence that the fluid Ether is ever present, at least terrestrially. The fact that a liquid thermometer is always varying, and that the mercury never gets to the absolute zero or a minimum volume, is of itself conclusive evidence; but another proof is the fact that whatever the condition of the air, so long as it is gaseous—as far as I have been able to ascertain—the air molecules, or gaseous molecules, are always saturated with Ether just as a soap-bubble is always *full* of air. Perhaps the best proof is to compress the air in this copper sphere. The diagram, fig. 45, shows what is to be seen where the air surrounding the sphere is charged with motes, as in the Analyzer, during the time that the air is being compressed. The free Ether (D) rises from the outside of the copper sphere, just as it did from the finger, the heated rod, and the electric lead. I cannot show this to an audience such as I am addressing, but I can show the reaction by means of the thermo-pile and the galvanometer. I place a thermo-pile over the copper ball. The Ether rising from the ball, due to the air being compressed, attacks the thermo-pile, and the galvanometer gives the reaction of increased motion of Ether, or, as it is ordinarily termed, an increase of heat. This experiment, as you see, is performed under a glass shade, as otherwise air currents mar the reaction. This is the same experiment as that with the fire-syringe, but the reaction is shown in a different way. It is a true *push* of Ether; the Ether is squeezed out of the

air molecules and goes through the copper, rises from it, and becomes visible in the Analyzer.

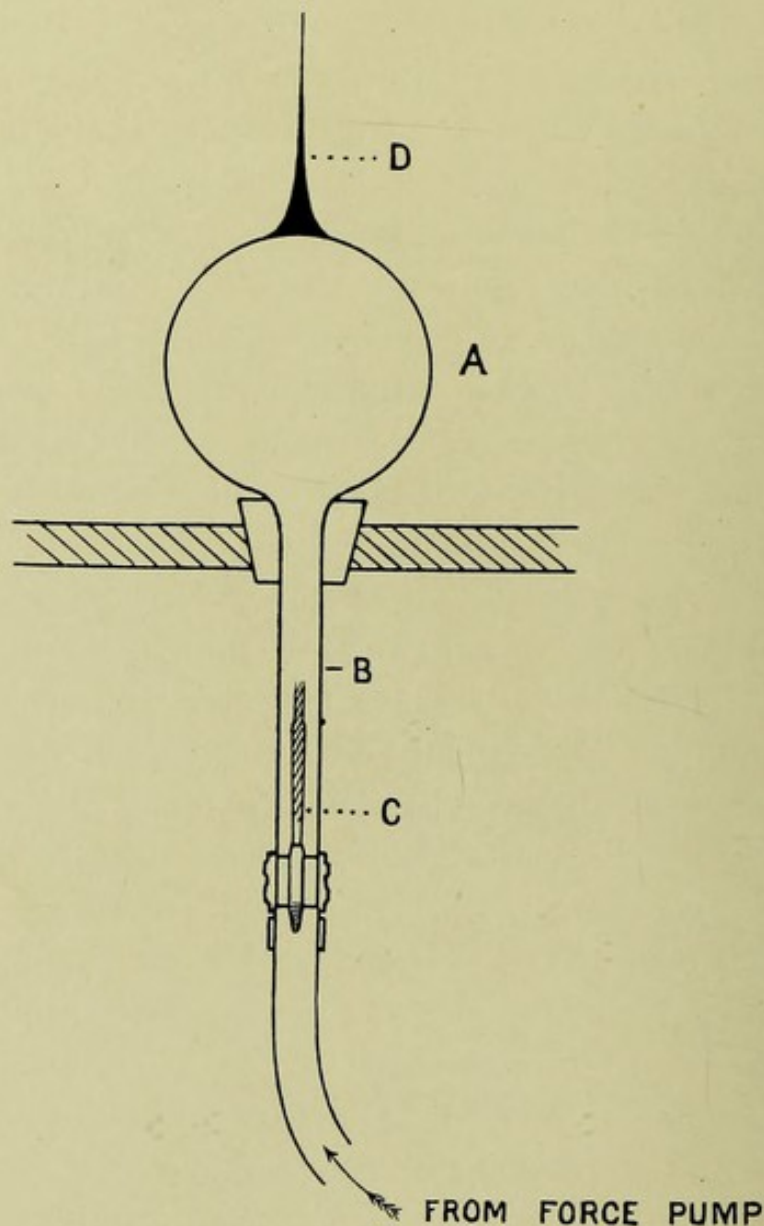


FIG. 45.—Diagram showing section of a hollow copper ball into which air is compressed, the free Ether, D, oozing out of the ball and rising in the air, and is seen in the Analyzer charged with smoke-motes. The valve C is an ordinary bicycle valve, and prevents the air returning.

Now I make a very pretty experiment showing the reaction of the evolution of free Ether rising from a wire giving what is called a *resistance*. I shall show in the next lecture that this is an erroneous term. Recollect I

demonstrated to you that when what is called a "resistance" takes place, the Ether could be seen oozing out of the wire, and rising from it. In this glass cup is a coil of fine platinum wire, and over it a very light windmill made of aluminium, placed horizontally, suspended on the point of a needle. Notice that directly we turn on the current the free Ether attacks the air molecules; they expand by the absorption of Ether; or, otherwise expressed, they increase in temperature; they rise and strike against the vanes, and the windmill moves. The experiment, as you see, has to be made under a glass shade. If the windmill is held suspended on the point of a needle between the finger and thumb, the same reaction takes place, and from the same cause. These rising molecules are what the physicist called "convection currents," *a term he has never understood, as he has never understood the underlying cause of these currents.* It is by means of the push of Ether, out of the molecule when it is contracting, and pull of Ether by another molecule when it is expanding, or, as it is technically called, "rarifying," that Dewar and others have liquefied gases.¹ But, curiously enough, they do not understand the reactions that are taking place.

And now I want to show you how to see the molecule. Here is a flask containing (fig. 46) a small quantity of water. We will afterwards repeat the experiment with a flask containing a small quantity of alcohol. The results are the same as with water. I may mention here that almost any liquid will give the reaction. The flask is strongly illuminated with the light from the electric-

¹ For full explanation, see Appendix to the two books already mentioned, *What is Heat and What is Electricity?* and *What is Life?*

light lantern. If the flask is heated from below, the water molecules absorb the free Ether arising from chemical reaction producing flame, and the upper layer of water molecules, relieved from the attraction of the

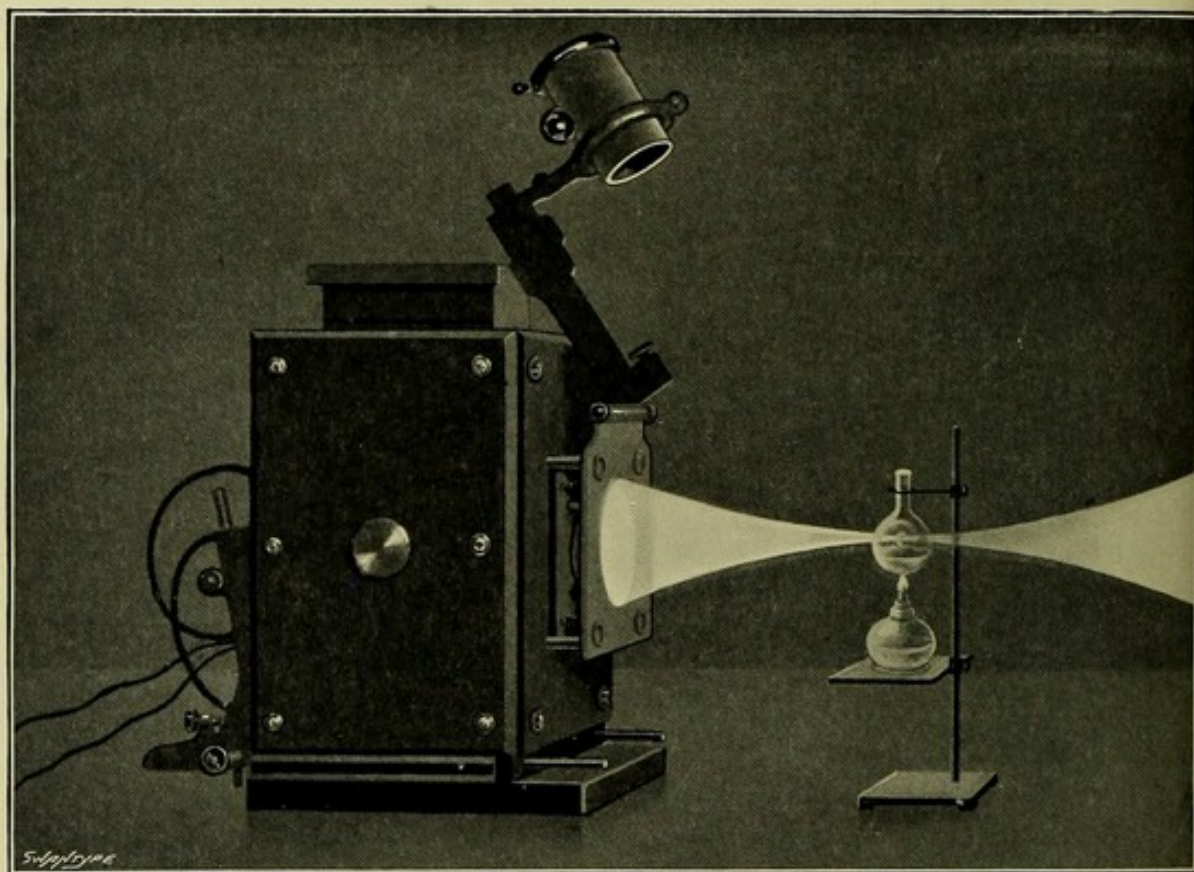


FIG. 46.—Flask containing a small quantity of liquid—water or spirit of wine. When, as it is called, it is heated—that is, when the molecules become surcharged with Ether—each molecule increases in dimensions, and under the intense light from the electric light each molecule can be seen rising from the liquid. The molecules swirl round and partly deliver their charges to the colder part of the receiver—that is, that part which is farthest from the light. Thus there is a constant circulation going on, while the experiment is continued until all the air is excluded from the flask, and then the visible reaction ceases, but the molecules are seen as they come out of the flask and mix with the cold air.

mass, expand in volume and dart away from the remainder of the water.¹ The larger molecules, now in the vaporous condition, are easily seen by the naked eye; they are hollow spheres filled with Ether, and

¹ For reactions causing the evolution of free Ether from chemical combination see my work, *What is Heat and What is Electricity?*

as they get near to the light they receive from it a further charge of Ether coming from the electric light, swirl round to the other side of the flask, and deliver up their excess of charge to a cooler part of the flask. Now these molecules are only visible so long as the air is in the flask. Directly we expel the air by increasing the number of the rising molecules, as we can by heating them continually, then these very interesting objects become invisible inside the flask. Everyone must have noticed that when a jet of steam passes into cold air, the steam near the nozzle is invisible. It is only seen when mixed with cold air, and then each steam molecule can be seen if suitably illuminated; similarly we see the vapour coming out of our mouths in cold weather, but we cannot see it in hot weather. It is the difference in dimensions of the water-vapour molecules and the air molecules which produces this result. But although they are invisible the steam molecules are there, for they come out of the mouth of the flask into the colder air, and rise, and we call the mass *steam*. We will illuminate the steam as it comes out of the flask and see the whole appear exactly like flame, and it is easily seen by all. Each individual molecule is a hollow elastic sphere which contracts and disappears when it becomes colder or denser or smaller, and as it contracts it gives out Ether, which Ether warms the air. This is the mode adopted for heating buildings by apparatus containing steam or hot water. Each molecule is what is termed an "ion" by the specialist, and the Ether atoms may be termed electrons, corpuscles, or atoms of Ether—the term does not matter. I have used the last term. We repeat the experiment with alcohol and obtain the same results. Perhaps an equally pretty way is to fill

spirit lamps with various liquids (fig. 47) and submit their wet wick to the intense heat and light from the lantern; that is to say, the free Ether issuing from the carbons under the influence of the electric

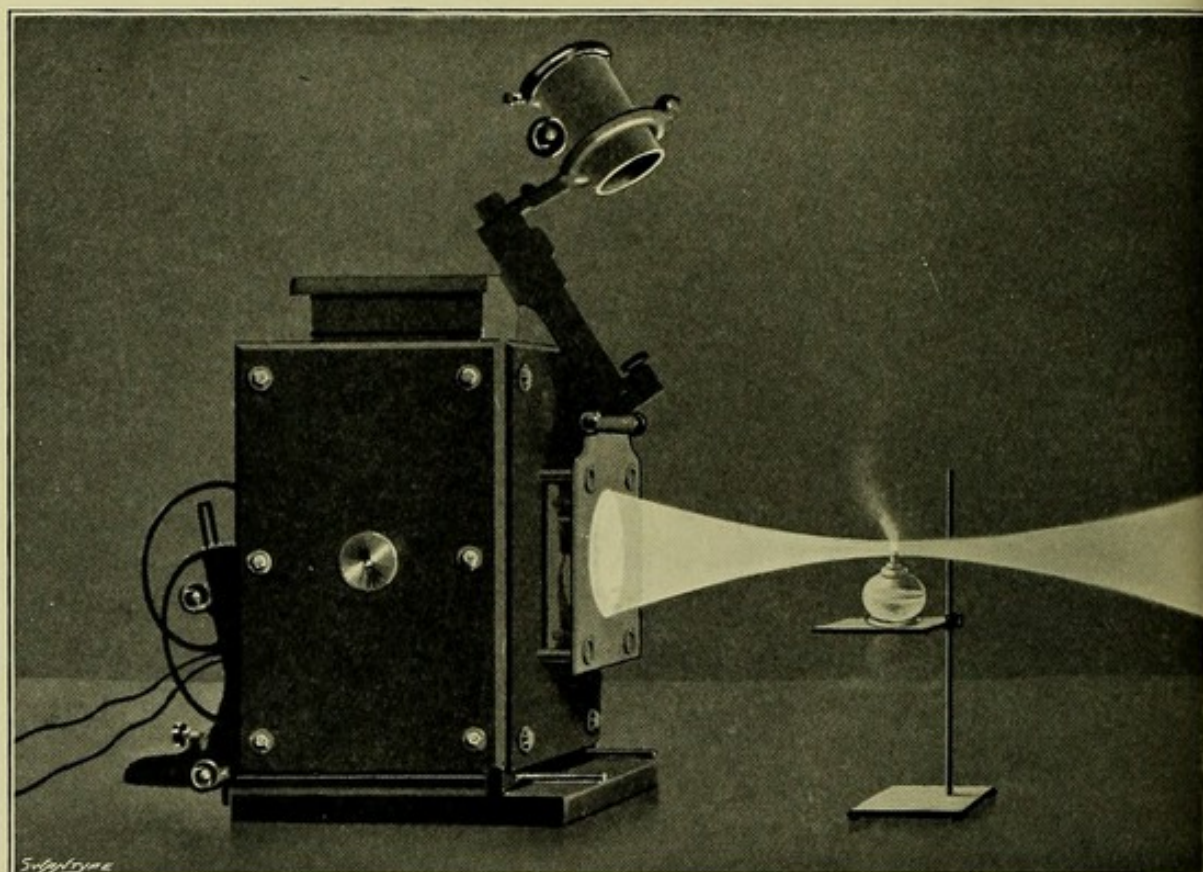


FIG. 47.—Spirit lamp holding almost any liquid—the experiments at the lectures were made with water and alcohol—which under the intense heat and light coming from the lantern cause each molecule to become visible. The reaction is exactly the same as flame—in fact, it is flame without chemical reaction. It is a very beautiful object.

current attack the liquid molecules, and they expand to the vaporous condition and are visible. See the *liquid* spheres dart off the wick of the lamp (that is, the liquid), expand because of their elasticity and become vaporous, and they become visible and lighter as they carry their charge of antigravitating Ether or electrons—don't let us bother about these

terms ; we want to get the conception. Directly they get away from the Ether given out from the lantern they deliver their charge to the air ; they contract, or, as it is called, become denser, and the Ether increases the volume of the air molecules, or, as it is termed, raises the temperature of the air-molecules. I shall still further simplify these experiments in my next lecture.

Now, I want you to recollect I have only been able to show you a few of the experiments I have made.¹ They all convey the same concept, namely, we are dealing with a fluid which permeates everything. It depends on the quantity of this fluid held by the molecules forming any material, if it is in the solid, the liquid, the gaseous, or the vaporous condition ; and more important still, chemical reaction depends upon the quantity and stress of this wonderful fluid. I have much more to say, but time in this lecture will not permit me to say all. I have confined myself solely to the proof of the existence of the fluid and two reactions on the molecule, namely, increase or decrease of molecular volume, otherwise called molecular temperature. It is a view the whole of the scientific world is coming to. I thought you would like to see the proof in the London Institution before it is shown elsewhere.

At the next lecture I shall show you how to see the fluid Ether passing through a liquid, and in an Appendix I shall explain why physicists and chemists are blinded from seeing these most evident reactions in Nature, which are all visible to our sense of sight if we take the proper means to look for them.

¹ Many more are illustrated in my book, *What is Heat and What is Electricity?* The book is quite devoid of technicality. The subject does not want technical phraseology.

LECTURE IV

I SHALL now complete my experimental work by showing you in three fundamental experiments many of the reactions I have explained in the previous lectures.

In the first we have a receiver holding alcohol or water (fig. 48). In the alcohol or water dips a thermometer and a thermo-couple connected with the galvanometer, also there is a thistle-headed funnel which does not dip in the liquid. The whole passes through a cork. The source of the flow of Ether is from a lighted spirit-lamp, the free Ether thus rising from chemical reaction. Beneath the receiver and above the lighted spirit-lamp is a sheet of platinum. I have chosen platinum, as we shall use that metal in the next experiment. Thus the free Ether passes through the platinum plate and through the glass receiver. The wick of the spirit-lamp not being touched during the experiment, the free Ether which passes through the platinum plate and attacks the liquid molecules is a constant; in other words, the heat given off from the spirit-lamp is the same minute by minute. Now the first reaction to observe with water is, any air molecules *in the liquid condition* mixed in the water absorb the free Ether before the water molecules, and ascend in the mass of water in the gaseous condition as air-bubbles. Thus we see there is a preference in the liquid air

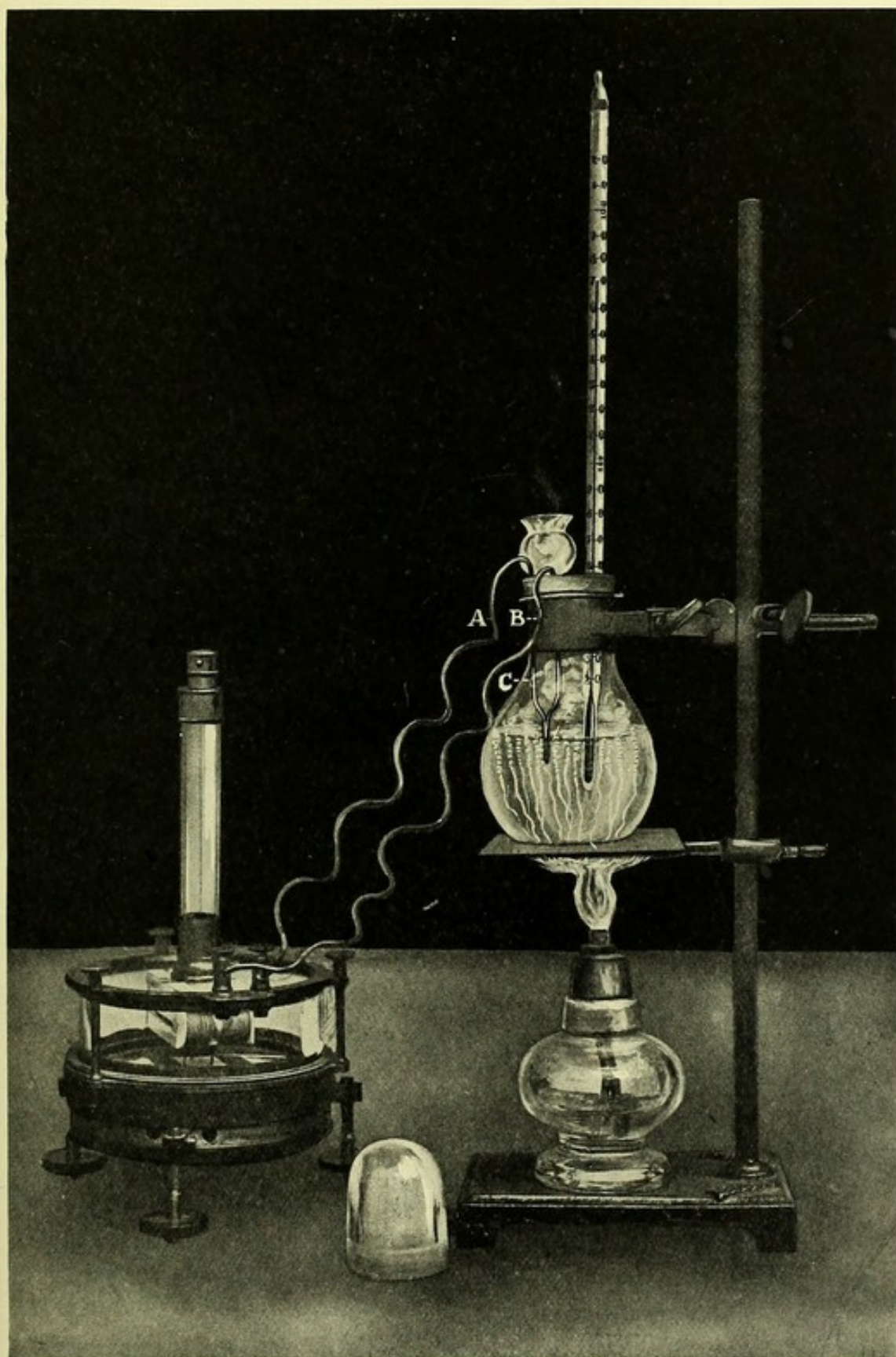
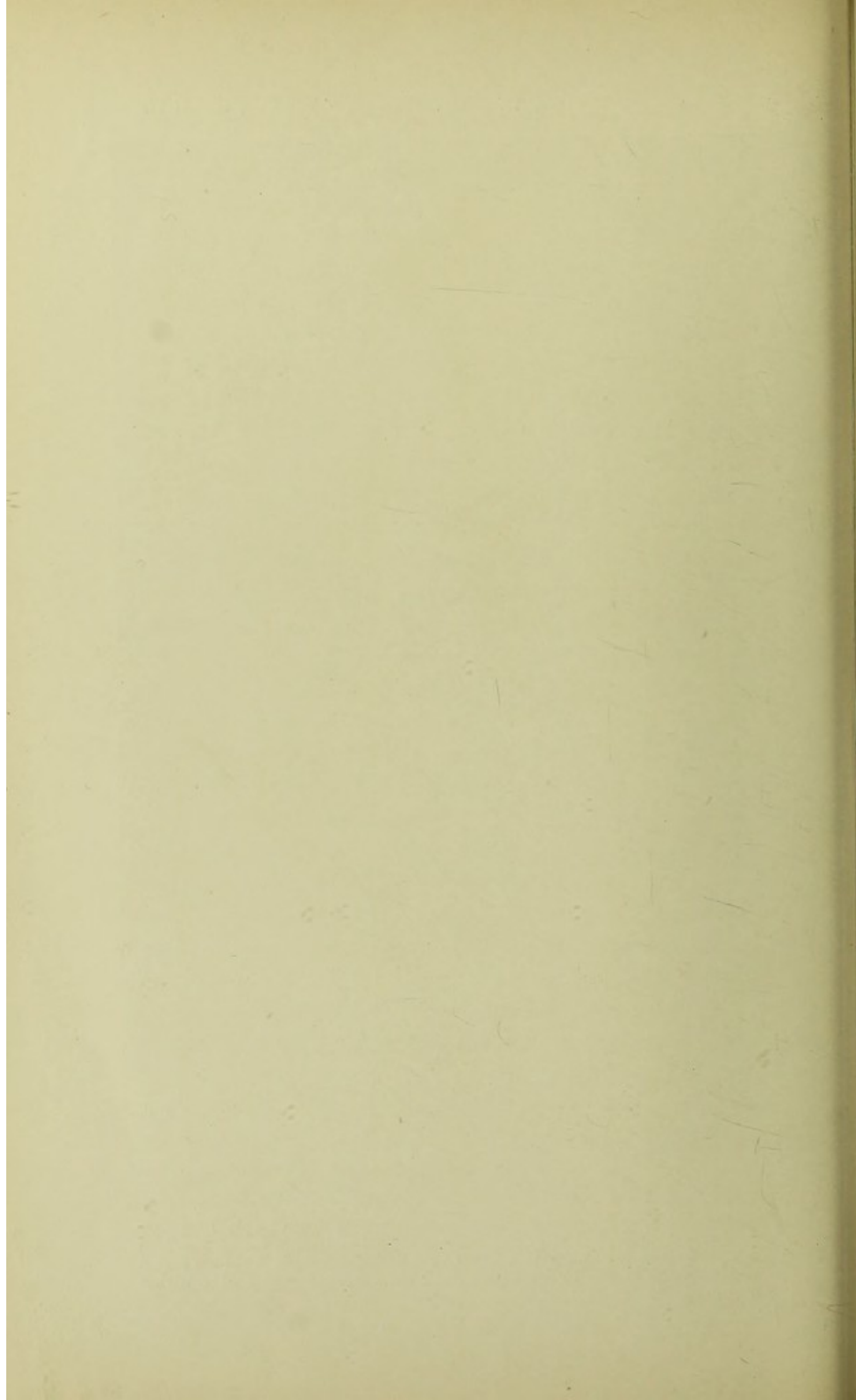


FIG. 48.—Free Ether, arising from chemical reaction, passing through a platinum plate and the glass receiver and attacking water or alcohol molecules, converting them into vaporous molecules which rise through the liquid and come out of the funnel as hollow spheres filled with Ether (ions). C. Thermo-couple connected with wires A B to the galvanometer.



molecules over the water molecules in seizing Ether. This preferential power in seizing Ether is a grand universal law, and applies to all mixed molecular matter. This explains distillation and also evaporation.

Now the instant the lighted spirit-lamp is placed below the receiver convection currents commence. Gradually the water or spirit molecules get excited by the flow of free Ether amongst them; they swell by absorbing Ether, become lighter, and rise in the mass of liquid; this explains the "convection current," a term which has been glibly used but never explained before. After a time the molecules of liquid expand to the vaporous condition and rise through the liquid in masses of vapour, and we say the liquid "boils," an expression used by chemists and physicists which does not explain the physical reactions. Moreover, as they rise from the mass into the thistle head of the funnel, each molecule, mixing with the cold air, *is distinctly seen inside the thistle head as a hollow sphere*. In making the experiment with alcohol, if we exclude the cold air by lighting the alcohol molecules in the mouth of the funnel chemical reaction takes place, the mouth of the funnel becomes filled with flame which does not go into the funnel, and the spirit molecules *cease* to be *seen* inside the funnel. The question arises: How does the free Ether pass *through* the platinum and through the alcohol? That is best explained by this most interesting model. It is a glass vessel holding glass spheres—ordinary glass marbles—three-quarters of an inch in diameter. Here also is a flask holding the smallest of lead shot. Now notice: if I pour the fine shot into the mass of marbles the shot pass *between* the glass marbles and settle at the bottom of the glass vessel. Everything in Nature is relative.

We have only got to conceive that the platinum molecules and the liquid molecules consist of relatively larger spheres (although these are so minute that they are invisible to our sense of sight, even with the highest magnifying power) and that the Ether atoms are relatively smaller, and all is explained. Notice during the experiment the glass marbles were not displaced; they gave all the reactions of a rigid body. However, the Ether atoms rise in the mass of alcohol instead of falling, as in the case of the shot, showing that the finer Ether atoms antigravitate. Moreover, if we reverse the experiment by pouring the glass marbles into the smaller shot, the former cannot pass between the latter; this explains the ever-present Ether and its motions, which are invisible. This explains also why large gaseous molecules cannot pass through glass. It is impossible to get away from the concept that during ebullition something passes through the platinum and through the bottom of the receiver. The question is: What is this something? Now we can understand the relation of this experiment to Nature. Put some hot water into a glass bottle and carefully cork it down, or hermetically seal the bottle; all the free Ether will pass *through* the glass and rise outside the bottle, causing convection currents in the air, and the water will gradually become cold, so that a thermometer placed in the hot water will eventually register the same as one in the room—say 60° Fahrenheit. The finer Ether atoms have passed *between* the larger glass molecules. Hence Ether, being atomic and vastly smaller than any other *atom* or *molecule*, is incessantly circulating amongst *all matter in mass*.

In the experiment fig. 48 it is the Ether which passes

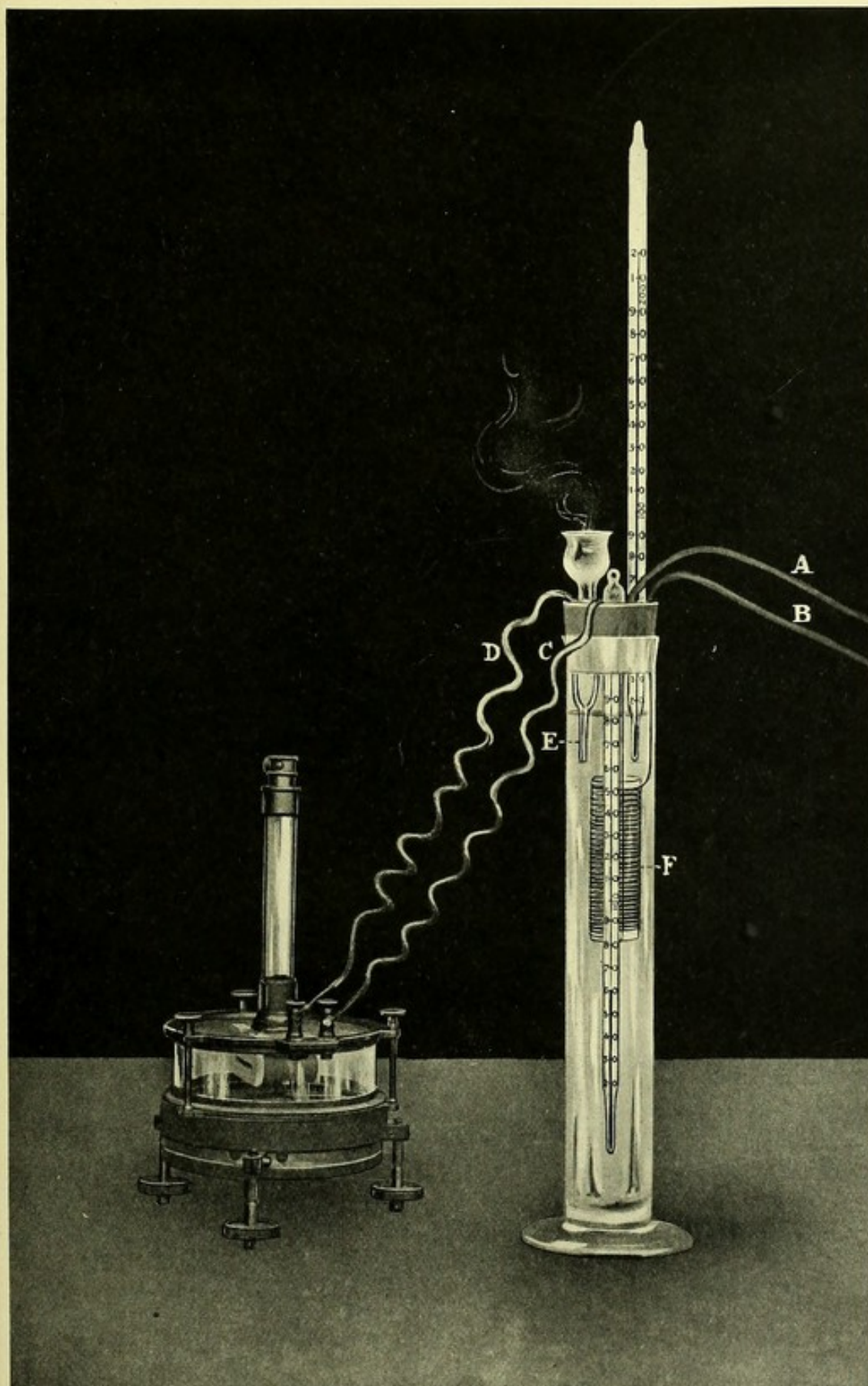
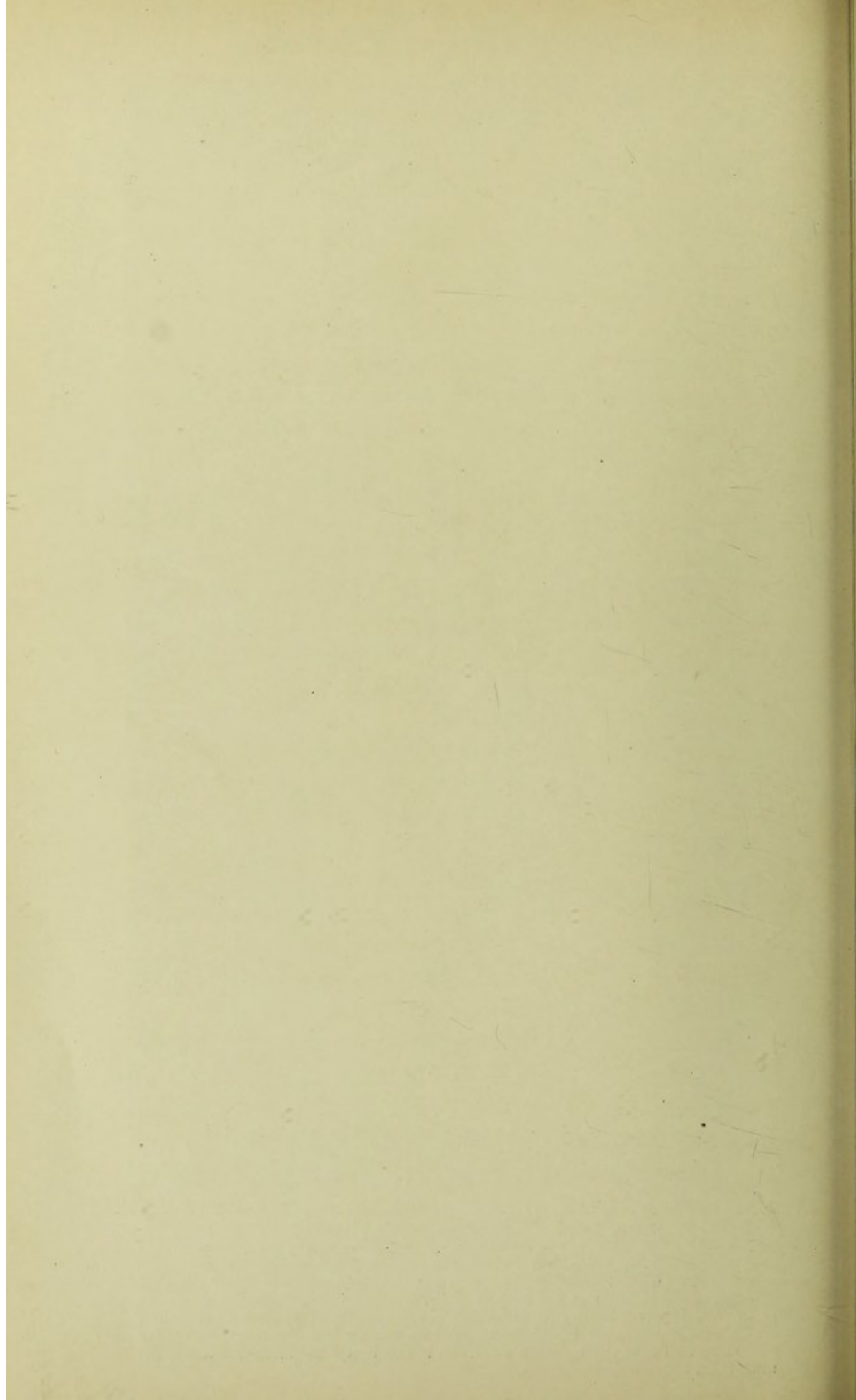


FIG. 49.—Glass receiver holding alcohol (or water). A B are wires from the electric company's mains (a constant or alternating current gives the same reaction) connected with a fine coil of platinum wire F. E, a thermo-couple connected with the galvanometer by the wires D C. Two thermometers are used. One registers the temperature of the mercury at the top of the liquid, the other registers the temperature of the mercury at the bottom of the liquid. When the Ether comes out of the coil it seizes the liquid molecules, converts them into vaporous molecules which pass through the liquid, and rises into the air and becomes individually seen as molecules in the vaporous condition in the colder air molecules inside the funnel and rising from the orifice.



through the bulb of the thermometer, attacks the mercury molecules, causes them to swell and in mass to rise in the tube, and we say the mass is higher in temperature. Similarly it is the Ether which attacks the thermocouple C, travels along the wires to the galvanometer, leaks out of the coils, rises, and attacks the local eddy currents of Ether surrounding the magnets and causes the magnets to revolve.

The second and complementary experiment is thus explained:—Here is a glass vessel nearly filled with alcohol (fig. 49). Other liquids will answer the purpose; for instance, water, but water does not show all the reactions I want to illustrate.

There are in the alcohol two thermometers; the bulb of the upper one dips into the upper part of the alcohol, and will show the temperature derived from the top of the liquid. The other has its bulb at the bottom of the liquid, showing the temperature derived from the liquid in the bottom of the vessel. Also there is a thistle-headed funnel, the bottom of which does not touch the liquid; this gives vent for the vapour. The whole passes through a cork. I have twisted round a piece of glass tubing a spiral or coil of platinum wire which is very fine—*i.e.* of small diameter, F. The coil of wire is inserted in the upper part of the alcohol and the ends of the wire connected with the electric mains. There is also inserted in the upper part of the alcohol a thermocouple E, connected with the galvanometer. Now notice, when I turn on the current the Ether passes *along* the platinum wire, and as it passes a certain quantity oozes out or leaks out of the sides of the wire and passes into the liquid. (This reaction, lateral leakage, is called by the specialist by the erroneous

name of *resistance*.) The latter operation makes the liquid (as it is called) *warm*, then *hot*, and produces convection currents in the liquid. Notice in the upper thermometer the mercury is rising—increase of temperature; the liquid at the top is increasing in volume—increase of temperature; the galvanometer needle is moving to *heat*, showing an increase of current. The so-called *heating* effect (*i.e.* rise in temperature or volume), which is a species of excitation of the alcohol molecules, accelerates until a time comes when the Ether passes through *the alcohol molecules* with such intensity of excitation that the molecules are converted into the vaporous condition and can be seen in mass in the liquid; thus the Ether is seen pouring out of the solid platinum wire (fig. 50). When properly illuminated by the electric light this is a most beautiful, fascinating experiment. It is impossible to doubt that something is passing out of the solid platinum wire.

We, in a secondary way, thus see the free Ether coming out of the fine wire, rising to the top of the liquid and passing through the funnel into the cold air as *minute hollow spheres* filled with Ether like so many tiny soap-bubbles, in which condition they can be seen as illustrated in the last experiment. Now, I want you to notice one fact: the liquid at the bottom of the vessel remains quite cold, the thermometer registers the same as it did at the beginning of the experiment. What is the explanation of this most important experiment? The Ether consists of finer or smaller particles than the chemist's *atoms* or *molecules*; call these finer particles if you like "atoms of ether," "electrons," or "corpuscles"—the name does not matter; they pass through the coarser or larger molecules of platinum, just

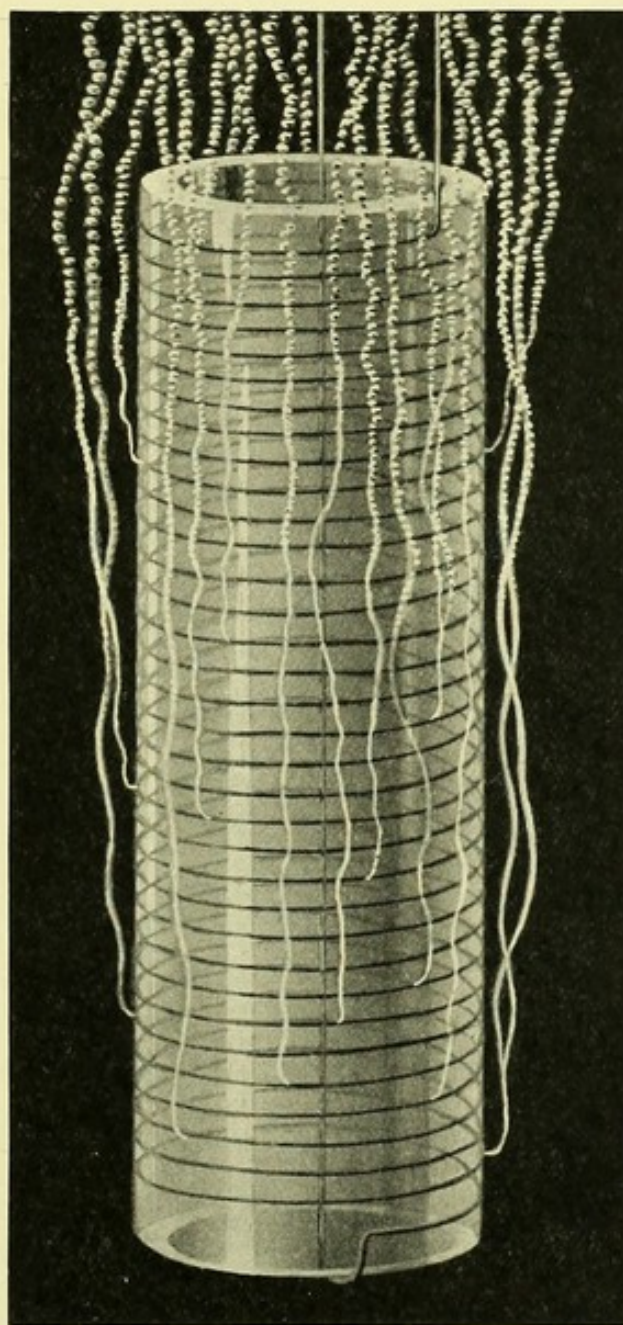
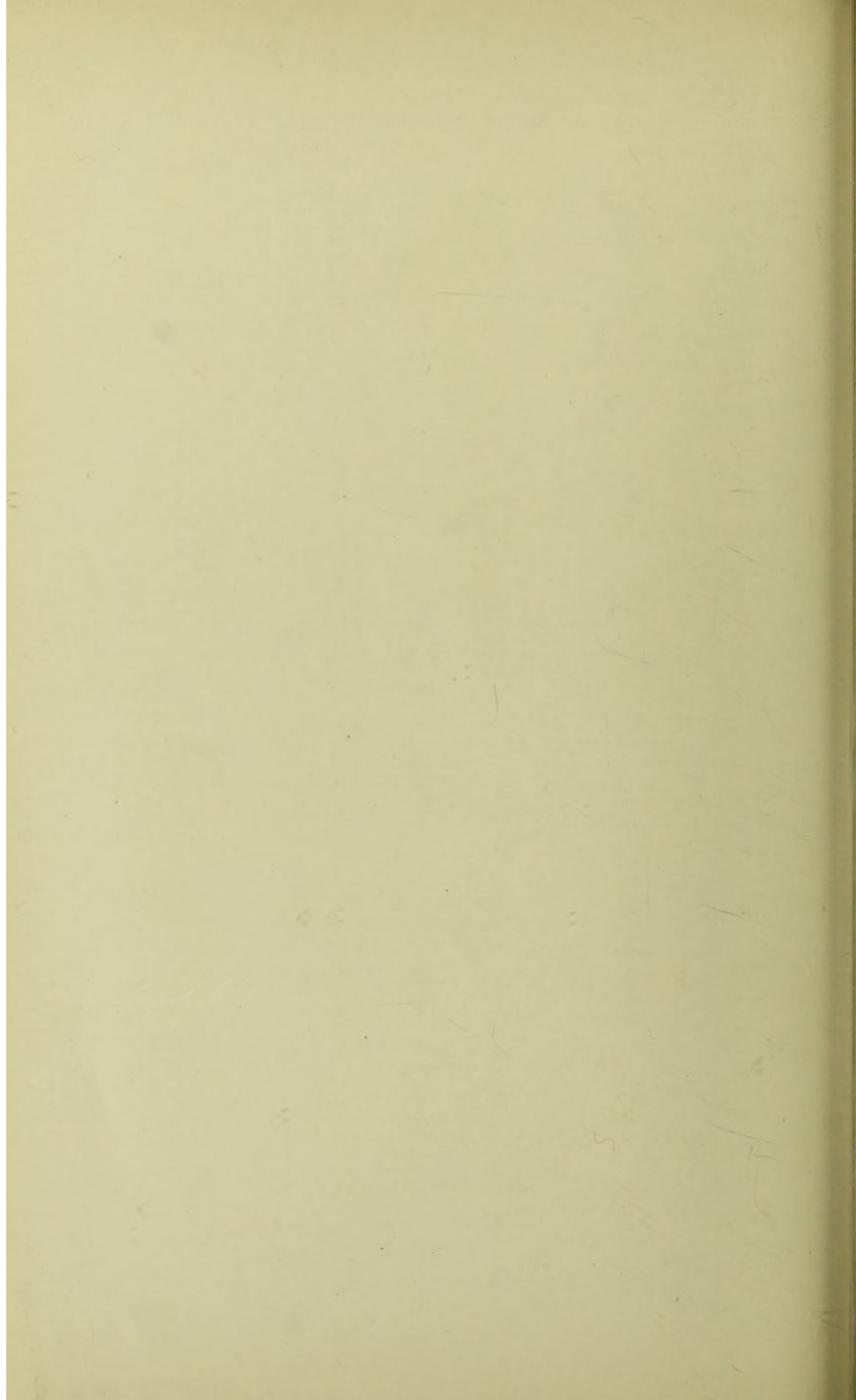


FIG. 50.—The glass cylinder, fig. 49, F, magnified. Ether passing out of the sides of the fine platinum wire wound round glass tubing. This Ether passing through the alcohol molecules, causes them to expand and become lighter until the excitation becomes so great that they assume the vaporous condition (see fig. 41, C) and rise in mass to the top of the liquid. They then flow through the funnel, and are seen by means of the electric light (fig. 46) to be hollow spheres filled with Ether. As they rise in the air they contract and disappear. They contract by exuding Ether into the air molecules, which are then—as it is called—made warmer.



as the fine shot passed between the glass marbles, only the free Ether atoms or electrons which leak out of the sides of the wire rise instead of fall, thus showing that the Ether antigravitates; and as these fine particles come out of the wire they attack the alcohol molecules, enter them, and cause them to expand. As the Ether antigravitates, the alcohol molecules charged with these finer particles partake of the *antigravitating* qualities of the Ether particles, rise to the top of the water, and become free into the air. They are now free carriers of Ether, or they may be called "ions" in the vaporous condition; they are visible only so long as they are mixed with smaller and colder air molecules.¹ (This reaction explains why the water in the bottom of the vessel does not increase in temperature.) Now, the scientific world generally has the vaguest idea of the existence of this fluid—Ether—but it is beginning to recognize it, and I feel that these two experiments are so conclusive, because they make the vaporous molecules in mass visible in the liquid and the individual molecules visible in cold gases—the air—that I may venture to challenge the most eminent authorities on them. So I shall challenge Lord Rayleigh, Sir Oliver Lodge, Sir J. J. Thomson, and all the learned metaphysical host to explain this experiment in other terms than I have done. In making this challenge you must recollect the responsibility I take. It is, to my mind, as you will presently see, a sacred duty. You, ladies and gentlemen, and especially

¹ If the vapour molecules are illuminated by the electric light (as in figs. 46 and 47) they are distinctly seen by the naked eye, and if looked at at a distance they look like flame, and I have no doubt that flame is the same phenomenon, only the spheres are too small to be individually seen.

members of the press, have a similar sacred duty to perform, and it is this, to insist upon the challenge being taken up by these men. There is most certainly a fluid coming through the platinum in the first experiment, and a fluid coming out of the platinum wire in the second experiment. This is undoubted ; and the persons challenged, if they deny my explanation, must state *what that fluid is*.

In the first experiment the Ether rising from the spirit-lamp is a constant, and in the last experiment the fluid Ether — called electricity — is passing through the platinum wire nearly as a constant, for there is very little alteration in the indication of the ammeter or the voltmeter during the experiment. Hence the reaction of the Ether on the molecules must be a process of excitation or irritation of the molecules produced by the Ether in time. *The molecules live*. In both experiments the galvanometer and the thermometer act in unison.

Let me repeat the explanation of the reactions which take place in the last most important fundamental experiment.

1. The liquid is of low temperature, say 60° Fahrenheit, when the experiment is commenced.

2. The Ether travels along the fine platinum wire (see experiment, page 74). Those Ether atoms which leak out of the side of the wire attack the liquid molecules, which immediately begin to swell by the absorption of the much lighter Ether atoms, and thus rise in the mass of the liquid ; and having delivered their charges near the surface, contract, become denser, and fall in the liquid. This operation, being continuous, is called a convection current. During the process the

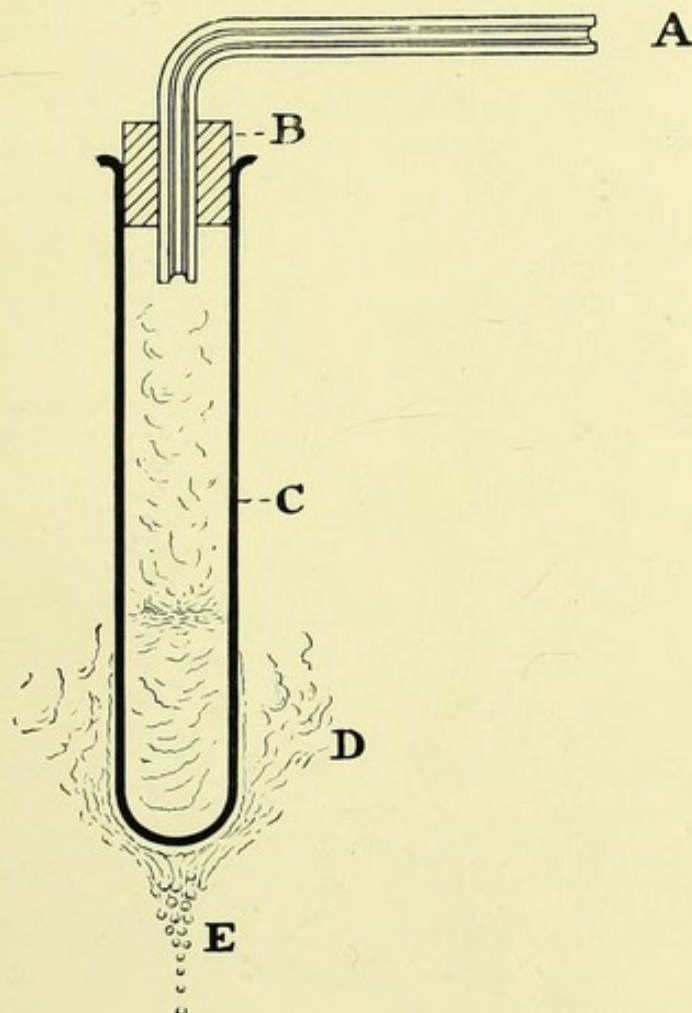
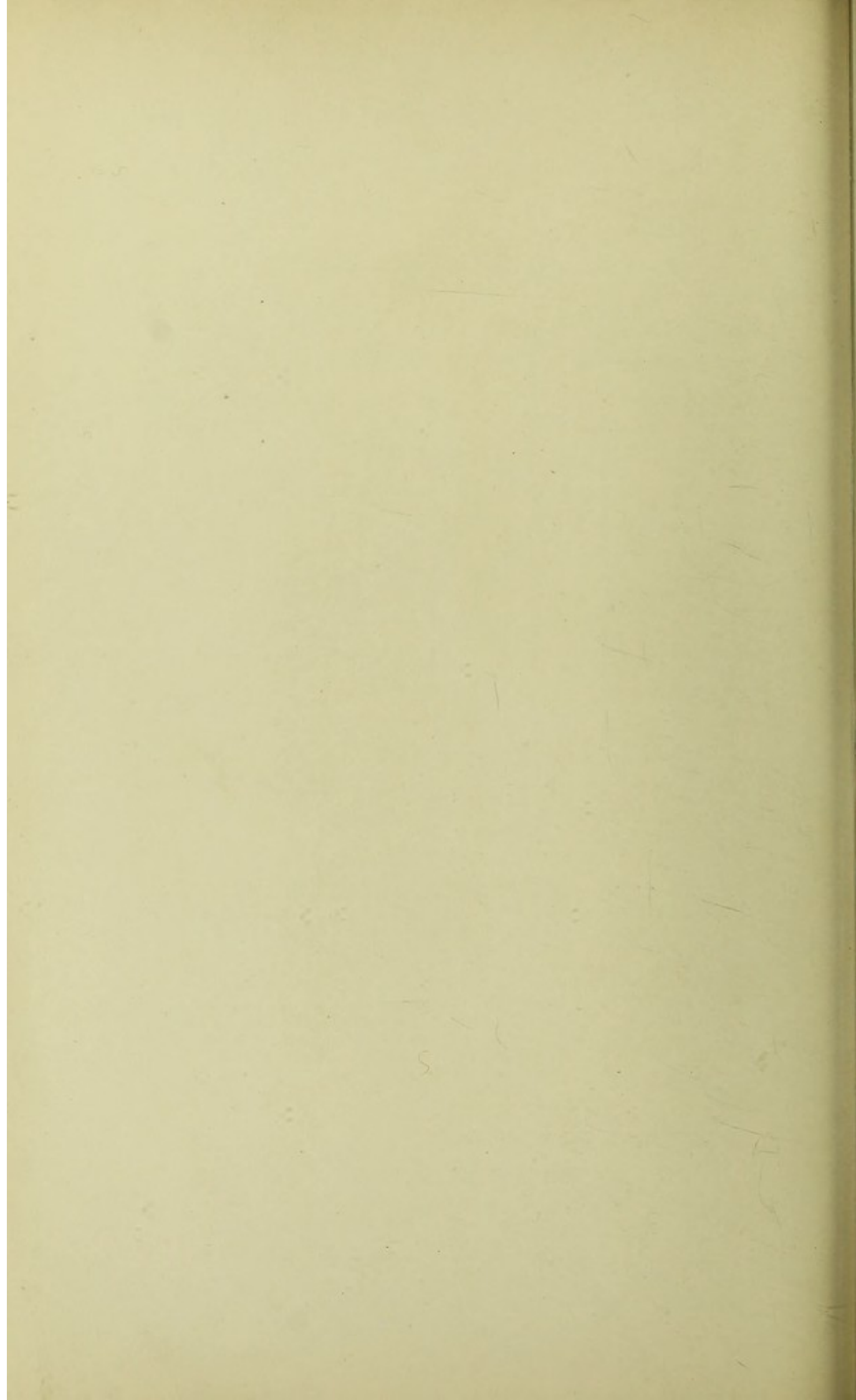


FIG. 51.—A little liquid air is put into a test-tube. The liquid air molecules become alive during the time they are seizing Ether C. This molecular motion or life is restrained by the pressure of the air. To remove this pressure an indiarubber cork B is inserted, through which passes a tube A connecting with an exhaust pump. The life or motion is thus much increased by the rapid absorption of Ether by the molecules, and the external air condenses outside the test-tube D and falls as drops of liquid air molecules beneath the test-tube E. Thus the Ether which the liquid air in the test-tube C gains, the air molecules external to the test-tube lose.



liquid molecules become more excited and absorb the Ether faster and faster, and presently the liquid molecules are converted into the vaporous condition and rise in the mass to the surface of the liquid; this is ebullition. When they get into the colder air outside the receiver they are separated by the cold air molecules, and each charged molecule becomes visible.

3. During the whole of the process the liquid at the bottom of the receiver never rises in temperature, remaining at 60° Fahrenheit; thus proving that the Ether which comes out of the wire is an anti-gravitating fluid.

My final experiment is one made by Sir James Dewar, fig. 51. We can now easily understand the experiment. But Dewar does not understand it!

In conclusion, I believe I have experimentally shown that there is a fluid which is, under ordinary conditions, invisible to the human eye, and which permeates everything terrestrial and—most likely—celestial; that this fluid is always in differential motion; and that this motion, acting upon those very minute objects called molecules, causes them to assume the solid, liquid, gaseous, and incandescent forms. The experiments I have made before you all prove this fundamental concept.

We have seen this most wonderful fluid we call "Ether" coming off a heated rod, off a warm finger, and off an electric wire, also from air while it is being compressed, showing that gases are always filled with the fluid Ether, even in the coldest regions. We must not run away with the idea that this fluid comes off the finger only. It comes off all parts of the body. In fact, we are saturated with and bathed in this fluid.

We have seen that this fluid is ever present, but in different proportions, producing the phenomena known as heat and cold. When the principle is understood a thermometer proves it. And now we go one step further. Sir James Dewar has shown that this fluid is *necessary* for chemical reaction. Thus he states: "Modern research has, however, revealed the fact that the most powerful chemical affinities are completely suspended by allowing substances to come into contact at very low temperatures." But then he does not know what "low temperature" means! I have experimentally shown that "low temperature" means molecules almost entirely devoid of Ether. They are consequently very small. Thus air reduced in temperature from a normal condition to a liquid condition is air reduced in volume to about the $\frac{1}{800}$ th part of the normal bulk, and *this is all*. This decrease of volume in mass is the result of each molecule being reduced in volume. But this reduction of volume is erroneously called by chemists and physicists *increase* of heat or temperature! Here is the fundamental error. The specialists (chemists and physicists) cannot see this very simple and important issue.

But mark how profound is the issue! Here is a fluid which permeates everything,—that is, it is "omnipresent"; it regulates the very smallest chemical alteration, consequently it is the factor in the largest and most complex of chemical alterations—hence it regulates all life. It is therefore "omnipotent." The relative intensity of its operations produces composition and decomposition. Hence a small flow of this fluid will convert a mass of quicksilver into an oxide of quicksilver; a more intense flow, or a higher temperature, will decompose this red oxide and produce free oxygen and

pure quicksilver again. Consider how different is life, animal and vegetable, on different parts of the globe; simply caused by the different local flow or pressure of this Ether, or, as it is called, local temperature. Now, however complex the building up may be under a suitable temperature, subject the organism to a greater flow of Ether—that is, a higher temperature—or put it into the fire, and all the great complexity is undone. Another way of explaining the fundamental issue: consider a bird's egg. Subject it to a steady but small flow of Ether, such as an ordinary thermometer shows, and marvellous chemical alterations take place, and by-and-by a miracle appears—a chicken walks out of the egg-shell. But increase the flow of Ether—*i.e.* raise the temperature by boiling—we cook the egg, and get no chicken. Again, put the boiled egg to still a greater flow of Ether, that is, put it into the bright fire, and all the complex formation is undone—the egg ceases to exist. This natural miracle is only understood by man when he knows the orderly and definitely molecular alteration going on in the egg, developing under its normal temperature. This information we are now collecting. The same argument applies to the brain cells—the thinking cells. But here is the important point to understand:—Every organic being, including man, is governed by the same factor—the flow of the Ether, or, as it is called, the temperature. Yes—you and I were formed by the same means as the chicken was formed; and I venture to say that when man understands this important issue a new order of thought will arise which will materially add to the happiness of mankind. I come now to another important fundamental issue, namely, that because chemists have, or think they have,

discovered some eighty elementary substances, therefore only eighty shall exist in Nature! But this view is going away with the late discoveries. We want a system which explains the millions and millions of forms we find in Nature; and I venture to think that this is only to be understood by allowing that in Nature there is a vast unknown number of elements so sparingly distributed in the mass of matter that they cannot be obtained in sufficient quantity to be recognised. Granting this, we may assume that these millions of elementary substances are all—every one of them—regulated by this subtle force or power called Ether. This is a sublime idea. It explains all. I will now read you an extract from a book called *The Creed of Science*, by a most earnest and thoughtful writer, Mr William Graham, who fully sees the fundamental issue as I see it; for if we call this Ether “God” or “Divine Spirit” then we can understand the following:—“But is God denied entirely in the system of Haeckel? Apparently not. Apparently it is only the Personal Creator,¹ if we are to judge from the following passage: The more developed man of the present day is capable of, and justified in, conceiving that infinitely nobler and sublimer idea of God which alone is compatible with the monistic conception of the universe, and which recognizes God’s spirit and power in all phenomena without exception. This monistic idea of God, which belongs to the future, has already been expressed by Giordano Bruno in the following words: ‘A spirit exists in all things, and no body is so small but contains a part of the divine substance

¹ That is, the *man-like* God, or, as Haeckel has properly described the conception, a gaseous vertebrate.

within itself, by which it is animated.' If, in short, we say to Professor Haeckel, 'Spirit is at the bottom and the most fundamental thing, the final word in your system should be spiritualism and not materialism; if only a second principle is admitted, not superior to matter, but also not resolvable into it, then your system is dualism and not monism!' But however the conception of a Nature filled with the spirit of God consists with Haeckel's materialism, the conception is admitted by him and is a truly great one."

Yes, it is a truly great one. But to have experimentally proved the existence of this fluid or power, I venture to say, is a great feat.

To my mind, the most remarkable fact is that man can use this fluid. Thus by our freezing machines we keep away the Ether from the organic matter, and chemical reaction is arrested. This wonder is qualified, however, when one reflects that he or she is part of the eternal mechanism—for we have seen that this fluid comes out of our bodies and that *it is the factor in our life*, as it is also the factor in every chemical alteration, and thus the things in us and around us are part of the great eternal whole, regulated by the Eternal Power, which indeed from its potency we may call God. It is by this power of powers we are born, we grow, we live, we think, and we die.

Experiment having proved this grand fundamental conception, I may now revert to my first lecture, and show the far-reaching influence of this wonderful power—Ether. I showed in the first lecture how the world was always going through a condition

of very slow change. I showed how the sea was wearing away the cliffs, how the sedimentary deposits pushed up layers to any and every kind of distortion. I showed how the hills and valleys were worn away by atmospheric influences. I showed, in a word, that the whole was a cosmic process of eternal change. Now consider. This power, which we may call Ether, or Spirit, or God—the name is of little consequence—controls everything. What we want to have impressed on our minds is this—the *fact* that this power exists and that it is omnipotent and omnipresent, for here is the grand issue. If this power did not exist, we could not have the liquid condition of the water, and life cannot exist without liquid water. Man, animal life and vegetable life, would cease to have an existence. There could be no wearing away of the cliffs, because there would be no liquid water to wear the cliffs away. All would be frozen to a degree of cold we have no conception of. There would be no rain, because rain is condensed vapour, and without this power the vapour is impossible. Consequently there could be no wearing away of the solid layers of the land by atmospheric influences. There could be neither air nor gases, no liquids, no chemical reactions, no fire, no volcanoes, for experiment proves that all chemical reactions are the result of this power acting on what we call matter, even to the smallest atoms or molecules—so small as to be beyond human experiment.

Therefore we are compelled to receive this grand truism, that this power is the factor in all change, and we obtain the grandest of conceptions, namely, that we are part of this power.

And here religion and science meet, and here only.
We can now express our ideas in religious terms, and
say—

“Like viewless music in viewless air,
The spirit, God, is everywhere”;

and

“God is not the God of the dead, but of the living.”

Hence—

All is in a state of change :
Change is life—life is regeneration.

APPENDIX

TO

A STUDY OF THE PRINCIPLES OF NATURE

THERE is a section of the community whose business it is to study the questions I have considered in these lectures. In the division of labour the men who serve in this section are called "physicists." Now, as a class, they absolutely refuse to look at the experiments I have shown to you, and their minds are perfectly unable to appreciate or digest such experiments and their teachings. The question arises: "Why is this so?" The answer is extremely simple and, when understood, far-reaching. The whole of my reasoning and the whole of the experiments are the result of approaching Nature direct and in the proper spirit. If we do this Nature tells her tale clearly and distinctly. The physicist does not do so, but attempts to overreach or dictate to Nature. His object is to create a profession; in a word, to deal with mysticism. In order to do this he must wrap up what he knows of Nature, as also what he does not know of Nature, with mysticism, and this mysticism is known as the *higher mathematics*. The effort is to interpret Nature in terms of numbers and numbers only. There are no fundamental concepts lying behind the numbers. I say this after very careful examination, and the evidence I can produce is overwhelming. The exposure of this fundamental error is of the highest importance *to all of us*. What I have stated I will briefly prove. Let us consider what a number is. It is always an adjective, and of no sense without the noun it qualifies. Thus when we use

figures, say, 1, 2, 3, and so forth, and there are no nouns qualifying the figures, then they convey no conception or ideas. If, however, we say one man, or two oranges, or three pounds, yards, or minutes, a conception is obtained. When we say "good" or "bad" no conception is received, but if we say "good man" or "bad woman" we have a conception. This fact the physicists do not understand—hence the most extraordinary ideas are expressed by them. I will give you an example. It is from the late Professor W. E. Ayrton's *Practical Electricity*. The Professor explains that if we allow a current of something (which he does not understand, for the existence of anything flowing he denies) at a certain strength to go through a certain volume of a liquid in a certain time, then the electric current will convert a certain volume of the liquid into a certain volume of the gas. This is all quite intelligible if we have an idea of what the current is. It is "common sense," and, as Huxley truly stated:

"Science is, I believe, nothing but *trained and organized common sense*, differing from the latter only as a veteran may differ from a raw recruit; and its methods differ from those of common sense only so far as the guardsman's cut and thrust differ from the manner in which a savage wields his club. The primary power is the same in each case, and perhaps the untutored savage has the more brawny arm of the two. The *real* advantage lies in the point and polish of the swordsman's weapon; in the trained eye quick to spy out the weakness of the adversary; in the ready hand prompt to follow it on the instant."

Now Professor Ayrton formulates this common-sense idea in this formula:

$$\frac{V}{S} \text{ cubic centimetres.}$$

This mathematical concept is: That a volume of one or more cubic centimetres is divided by one or more seconds of time; or we put it this way: How many seconds of time are contained in any cubic volume? The idea is a delusion, a species of madness. It is absolutely impossible to divide volume by time, and physicists in common with Professor

Ayrton—for he is no exception—crowd their works with these impossible ideas which they call “*formulae*.” For illustration I have this watch which shows seconds of time: a second is an artificial equation showing that during that unit period the earth at the Equator has moved in its rotation about 507 yards. Also, I have a piece of wood—a cube—of one cubic centimetre; a measure of a volume of space. Now consider what relation has the second to the cubic centimetre, and try to multiply or combine in any form a centimetre with a second. Physicists think they can interpret Nature with this order of thought! That is a great fundamental error.

The multiplying a concrete number¹ into or by a concrete number and inversely to divide the same is a physical impossibility. I shall show that the order of thought adopted by physicists is a fatal and terrible mistake, and, moreover, it is only the physicist who does so. A biologist would never think of dividing one male by one female, or multiplying one man by one woman. A chemist never thinks of multiplying oxygen molecules into hydrogen molecules to produce water molecules. A surgeon would never think of multiplying or dividing a muscle with a bone; but he divides a bone with a saw, and makes two halves of the bone. Now it is very curious that this common-sense operation cannot be performed in mathematics. I have elsewhere shown this fundamental error in the Table on the following page. It is in terms of concrete numbers.

Now, all above the horizontal line is “common-sense” mathematics. All below the horizontal line is metaphysical, existing only in the mathematician’s brain, and represents no operation in Nature. IT IS, HOWEVER, ALGEBRA.

The proof of all mathematical ideas is shown by making numbers concrete, that is, adding the noun to the adjective, and then ascertaining if the process can be performed. This is the only proof. Now to multiply “one” or unit object by or into another “one” or unit object to “produce” one unit is, as I have stated, a physical impossibility. In the Table given it will be noticed that the true part (above the horizontal

¹ A concrete number is when the adjective (the number) is added to the noun. Instance: *one* apple is a concrete number.

line) can be infinitely extended; and below the line, or the erroneous, equally extended. Another very important fact to notice is that in multiplication and division the "multiplicand" and "product," also the "dividend" and "quotient," must come out in the same terms; that is to say, if the first be the number of apples, pounds, yards, etc., the last must be the number of apples, pounds, yards, etc.

MULTIPLICATION.					DIVISION.				
Multiplicand, or Number of Objects Operated upon.		Process, or Operation of Multiplication, Mathematically Symbolized.	The Multiplier, or Number of Times the Objects are Added.	The Result of the Operation—the Equation, i.e., the Number of the Objects resulting from the Operation—the Product.	The Dividend, or Number of Objects Operated upon.		Process, or Operation of Division, Mathematically Symbolized.	The Divisor, or Number of Times the Objects are Subtracted.	The Result of the Operation—the Equation, i.e., the Number of Objects Subtracted each Time—the Quotient.
+	4	×	4	= 16	+	16	÷	4	= 4
+	4	×	3	= 12	+	12	÷	3	= 4
+	4	×	2	= 8	+	8	÷	2	= 4
+	4	×	1	= 4	+	4	÷	1	= 4
+	4	×	0	= 0	+	0	÷	0	= 4*
+	4	×	$\frac{1}{2}$	= 2	+	2	÷	$\frac{1}{2}$	= 4
+	4	×	$\frac{1}{4}$	= 1	+	1	÷	$\frac{1}{4}$	= 4
+	4	×	$\frac{1}{8}$	= $\frac{1}{2}$	+	$\frac{1}{2}$	÷	$\frac{1}{8}$	= 4

Now we are in a position to understand the truism expressed by one of the greatest philosophers the world has ever seen, the late Professor Huxley. He said:—

"Mathematics may be compared to a mill of exquisite workmanship, which grinds your stuff to any degree of fineness, but, nevertheless, what you get out depends upon what you put in; and as the greatest mill in the world will not extract wheat flour from peascods, so pages of formulæ will not get a definite result out of loose data."

This statement was endorsed by the late Lord Kelvin. When two concrete numbers—as such numbers are termed, when the nouns are added to the adjective—are multiplied together *on paper* as the physicist expresses it, we find that

* Or any other magnitude!

the process is physically impossible. Let us consider what is the product of the operation of multiplying "one" apple into "one" orange, or "one" foot into "one" pound. This is the physicist's concept. Take an apple and an orange and try by any conceivable means, multiplication or otherwise, to "produce" by any mathematical operation on these two units a unit which is neither an apple nor an orange, and the fallacy is immediately seen. This concept of the physicist is the idea of getting wheat-flour from peascods. Huxley has truly pointed out that this is impossible with the true mathematical machine.

Again, we will put the issue in this way: Physicists think that when multiplying concrete numbers together the product gives definite ideas, and tells us how to increase or decrease either of the factors, *for this is the practical issue*. It does nothing of the sort. The following shows the fallacy:—A man had assets £1000, and liabilities £10. Call these concrete figures "factors," as the algebraist or physicist does, then the numerical value of that man is 10,000. He is a man of means—solvent. Another man has assets £10 and liabilities £1000, and his numerical value is also 10,000, but he is a bankrupt. Now, if these two men appealed to a judge on their numerical value alone, how could the judge distinguish the bankrupt from the man of means? This multiplying of unlike factors is the principle adopted by the physicist.

As children, we are taught the multiplication table.

Thus:—

2 times 2 are 4;

3 times 3 are 9,

and so forth. But we are not told what the word "times" means. This is fundamentally important. By our system of education, without thinking, we carry the indefinite ideas through our lives. I can illustrate this fundamental omission by quoting from a well-known text-book on Algebra by Hall and Knight. They say:—

"The definition of multiplication, in the strict sense of the word, supposes that a quantity is to be added to itself a certain number of times. But when the multiplier is a fraction, this definition ceases to be intelligible. The operation can therefore be only understood in some extended sense."

Now the extended sense in algebra consists in substituting another set of symbols—letters—instead of numbers. These letters are only intelligible when they stand for numbers, and have always to be interpreted into numbers to be worked by arithmetic. So that algebra is only fogged arithmetic. All the trouble arises from algebra. *The science must be abolished.* Algebra never gives the concept of form. This latter is most important, and of the highest value.

That the definition of multiplication as given by Hall and Knight in arithmetic is not true is easily shown in concrete mathematics, for if I add two apples to two apples, I only add a number *to itself* "one" time and I produce on paper, as you see, four apples. This means that one times two is four; thus the multiplication table as explained by Hall and Knight cannot be true. Evidently mathematicians do not understand their fundamental terms. There is another way to look at these mathematical fallacies. We are taught that in making an invoice we can multiply commodities by money. Here is an example:—

Two pairs of gloves at 2s. per pair produce 4s. The latter is inserted in the money column. The concept is a fallacy; it implies that I can multiply 2s. by two pairs of gloves; this is a physical impossibility. I have on the table 2s. and two pairs of gloves. Try to operate on these two groups of objects and "produce," by multiplication or otherwise, 4s., then the fallacy is discovered. Now if we alter all these absurdities and put the facts in forms of equations, everything falls into common-sense mathematics. If a pair of gloves equals (*i.e.* is bought for) 2s., then obviously by multiplying or dividing both sides of the equation we get true mathematical results. Thus we may write in terms of money:—

$$1 \text{ pair} = 2s.$$

$$2 \text{ pairs} = 4s.$$

$$4 \text{ pairs} = 8s.$$

In commerce we never think of multiplying the four pairs of gloves into or by 8s. to produce a numerical value of 32. But this is the physicist's idea.

Now take Ayrton's idea. He describes an operation in

Nature taking a certain time to perform. He explains that a certain quantity of liquid becomes converted into a certain quantity of gas in a certain time. Thus, in mathematical terms we may say, in one second there is produced one unit volume (say one cubic centimetre) of gas. If the process is continuous without any alteration, then we may write—

$$\begin{aligned} 1 \text{ volume of water} &= 1 \text{ volume of gas} = 1 \text{ second}; \\ 2 \text{ volumes of water} &= 2 \text{ volumes of gas} = 2 \text{ seconds}; \\ \frac{1}{2} \text{ volume of water} &= \frac{1}{2} \text{ volume of gas} = \frac{1}{2} \text{ second}; \end{aligned}$$

and this is Huxley's fundamental idea. This is a very different concept to that given by Ayrton, namely, how many times is a second contained in a given volume?

I am so convinced that this fundamental error bars progress and ruins intellect, that I have dwelt upon it largely. I will further illustrate the error from a book published recently by an eminent chemist, Professor Sir William Ramsay, a gentleman who commands my highest respect, and has several times lectured in this theatre. He says in his book, *The Gases of the Atmosphere*:—"Now it can be shown that the product of pressure and volume of a gas *p.v.* is equal to two-thirds of the energy of translation of all molecules of the gas, or—

$$p.v. = \frac{2}{3} X R,$$

where X stands for the number of molecules in unit volume, and R for their energy of translation." Now to multiply pressure into volume is the same concept as multiplying or dividing a cubic centimetre by a second of time; and how can he tell the number of molecules of a gas in a cubic inch, when he must confess he has never seen and has no idea of a molecule? He has no data. All such difficulties of conception and contradiction are brought about by the rigid order of thought in mathematical education—especially by the teaching of algebra. Now Nature in her operations in mass is never rigid. Consider the waves on the seashore—a very good illustration. Has anyone seen two waves alike? Then it is folly to attempt to interpret Nature by rigid ideas. All the experiments I have shown are devoid of rigidity—they are beyond mathematical teaching. They give the idea of form

as well as numbers. Experiments prove that the molecule is not constant in volume. But, says the physicist, I will not allow this because it upsets mathematical reasoning. This is the issue. In other words: if Nature has made the molecule inconstant in volume, then the physicist attempts to put his foot on Nature, or to control Nature. I hold that this is a wrong attitude. I am not alone in this view. Consider this statement by one of the greatest mathematical physicists that ever lived, the late Professor John Clerk Maxwell, who was essentially the product of University teaching. He said:—

“Mathematicians may flatter themselves that they possess new ideas which mere human language is as yet unable to express. Let them make the effort to express these ideas in appropriate words without the aid of symbols, and if they succeed, they will not only lay us laymen” (he wrote this under the name of “Layman”) “under a lasting obligation, but, we venture to say, they will find themselves very much enlightened during the process, and will even be doubtful whether the ideas as expressed in symbols, had ever quite found their way out of the equations into their minds.”

It is quite true that tossing about figures in any arbitrary manner may produce numbers which we find on a thermometer tube, or degrees given by the galvanometer or any other measuring instrument, but the numbers which are the results of so tossing figures about give absolutely no concept of Nature's operations any more than multiplying good into bad does. What we want to know is, not the numbers on the thermometer and galvanometer, but what takes place in the thermometer to make the liquid rise, and on the galvanometer to make the needle move—an issue the physicist does not understand and consequently cannot explain. Now Nature is so exact and perfect that whenever she gives results, if we repeat the process under the same conditions *the results are always the same*, however often we repeat the process. This is the important fact to understand and to remember. Thus in a dynamo, if we have a wire of a certain measured diameter, a certain measured length, and a certain measured pressure produced in it by the revolution of the armature in a definite measured time, we always get a definite result. Now all such

measurements I have just given are common-sense mathematics, and thus by *equating* results we want no further mathematics. I am so particular to convey this important fact to your minds, because the retaining in the memory these impossible formulæ narrows the mental power. The effort required is well described by Sir Oliver Lodge, who says:—

“I am also convinced that it is unwise to drift along among a host of complicated phenomena without guide other than that afforded by hard and rigid mathematical equations. The mathematical theory of potential and the like has insured safe and certain progress, and enables mathematicians to dispense for the time being with theories of electricity and with mental imagery. Few, however, are the minds strong enough thus to dispense with all but the most formal and severe of mental aids; and none, I believe, to whom some mental picture of the actual processes would not be a help if it were safely available.”

“The human mind,” says Clerk Maxwell, “is seldom satisfied, and is certainly never exercising its highest functions when it is doing the work of a calculating machine.”

The mathematical physicist will say: See what I have done in electricity and elsewhere by mathematics! My reply is: I cannot find any results from the pure mathematician. It is when he ignores the higher mathematics and resorts to experiments only, that he succeeds; indeed the great discoveries are by minds largely destitute of the higher mathematics—such was Faraday’s mind.

Dr Louis Büchner truly states:—

“It lies in the nature of philosophy that it should be common property. Expositions which are not intelligible to an educated man are scarcely worth the ink they are printed with. Whatever is clearly conceived can be clearly expressed. The philosophical mists which envelop the writings of scholars appear more to conceal than to exhibit their thoughts. The times of scholastic bombast, of philosophical charlatanism, or, as Cotta says, of intellectual jugglery, are passing away. May our philosophy . . . soon perceive that words are not facts, and that, to be understood, we must use intelligible language.”

The metaphysical concentration adopted by physicists pro-

duces most remarkable ideas. Thus Principal E. H. Griffiths, in the presidential address in the Mathematical Section at the British Association's Meeting at York in 1906, stated: "It must ever be remembered that to the scientific investigators the rule of three has ceased to hold any significance," and he talks of the truth "of the statement that a part may be greater than the whole."

The fact is, directly the fundamental error which algebra teaches is made clear—namely, that multiplication has an extended sense over that which arithmetic teaches, and that extended sense cannot be defined or understood—then the whole of mathematics from that point of departure becomes nonsense. "Our definitions," says Merz, "must be consistent, and follow logically from the fundamental principles of arithmetic, otherwise we run the risk of sooner or later committing mistakes and encountering paradoxes."

And finally, the terms used by the physicist are utterly devoid of conceptions. He talks of "current," without an idea of something flowing; of "resistance," without an idea of something resisted; of "capacity," without an idea of anything contained; of "difference of temperature," without any idea of what causes the difference of temperature—indeed he cannot logically define the word. His "convection current" is devoid of any idea of the structure of the molecule, or of how something acts upon the molecule to cause it to become a part of a convection current. All is wrapped up in metaphysical mysticism.

When I wrote my book, *What is Heat?* published in 1894, I very severely criticised the mathematical order of thought and showed its absurdity. The reaction arising from this has not suddenly appeared. It was like a seed put into the ground—a time must be allowed for the plant to appear. But the reaction is coming quickly. In 1904—only four years ago—at Cambridge, the very hotbed of mathematics, the president of the Mathematical Section of the British Association Meeting—Professor Horace Lamb—made this remarkable statement: "Now the physicist and the mathematician alike are in trouble about their souls." I was present at the meeting, and can testify the approval of the meeting of the remarkable

address, which was entirely antagonistic to the higher mathematics. The fact is, our ideas are going through a very wonderful revolution, and, I have no hesitation in saying, for the better. Perhaps the following will convey this fact in a very clear way. The president's annual address to the Physical Society for the year 1907 was given by Professor Perry, D.Sc., F.R.S. (a mathematical physicist), a gentleman whose courage I much admire. In this address he stated:—

"I wonder if it is possible to bring to the thousand wranglers who are teaching in Great Britain a consideration of the awful waste, not merely of time but of mental power, that is going on in our common methods of teaching mathematics. . . . I think that Cambridge is greatly responsible for the fact that elementary mathematics is full of tricks, conundrums and puzzles, and her responsibility is due to her method of examination."

But then in this address he stated: "It is on algebra that we must mainly rely." I was so pleased with the address that I wrote to Professor Perry approving of what he had done, but I added that I did not agree with the last statement, and I wrote to him that algebra must be destroyed, as it abrogated the fundamental principles of arithmetic—that "Common sense abhors a system which states that the same 'is' and 'is not.'" To which I received this remarkable reply:—

"Many thanks for your letter. When I say that 5 tables $\times$ 3 chairs = 15 'table-chairs,' I mean by $\times$ or 'multiply by' something quite different from what I mean by $\times$ in $5 \times 3 = 15$. One is Arithmetic. The other is Algebra, and a mighty useful science it is. We may or may not be creating a New Science when we define what we mean by a 'table-chair' which may or may not have any relation to a 'chair-table.'"

To this remarkable statement of mental illusion I replied:—

"Thanks for yours of the 5th instant. In reply, I hereby offer to give you five hundred pounds sterling (£500) if you will, *in public*, 'multiply' five tables into three chairs, or three chairs into five tables, and 'produce' fifteen table-chairs or fifteen chair-tables. It must be a physical operation and not a metaphysical one on paper. If you do not accept this

challenge, then what you have written is, as you call it, 'hugger-mugger,'¹ *but it is Algebra!* In view of the gravity of the issue I ask permission of you to publish this letter."

I registered the letter, but received *no reply!*

Thus there are five hundred sovereigns lying at Professor Perry's feet, but algebra has so deprived him of common sense that he has not the mental power to pick them up!

Now this correspondence clearly shows the illusion physicists are suffering from. No wonder—now the issue is raised—that "physicists and mathematicians alike are in trouble about their souls."

Perry clearly sees the gravity of the issue. "It is surely," he says, "an awful thing that many earnest men, because they have faith in us, should be induced to spend years in making ropes of sand. . . . The nation feels that its common sense has been outraged, and it is not merely elementary education that is going into the melting-pot."

The experiments I have shown all give definite ideas. They show that molecules are not constant in dimensions (and therefore beyond rigid mathematical ideas); that they alter in volume in proportion to the Ether absorbed—this is difference in temperature; that as they absorb this anti-gravitating fluid—Ether—they rise or become lighter, and this produces the convection current. Now when this conception is gained the higher mathematics cease to have a use.

¹ *I.e.* confusion.



