802ND ORDINARY GENERAL MEETING,

HELD IN COMMITTEE ROOM B, THE CENTRAL HALL, WESTMINSTER, S.W.1, ON MONDAY, MAY 18TH, 1936, AT 5 P.M.

SIR ROBERT ARMSTRONG-JONES, C.B.E., M.D., D.Sc., in the CHAIR.

The Minutes of the Meeting of May 4th, 1936, were read, confirmed and signed, and the HON. SECRETARY announced the following elections :— Life Member : Ian Neville William Mackie, Esq. ; Associate : Rev. C. Cooper, M.A.

On being called upon by the CHAIRMAN, the HON. SECRETARY announced Mr. William Henry Boulton as winner of the Langhorne Orchard Prize Essay, among nine competitors, subject, " Miracle a Necessary Adjunct of Revelation." Coming forward, Mr. Boulton was presented with the prize, a cheque for £20 and commemorative silver medal, and, receiving the congratulations of CHAIRMAN and Audience, made suitable reply.

After a few introductory remarks, the CHAIRMAN called upon Sir Ambrose Fleming, D.Sc., F.R.S., to deliver his Presidential Address entitled " Some Philosophical Conceptions of Modern Physical Science and their Relation to Religious Thought," and commenting thereon called upon Mr. Oke to propose and Lieut.-Col. F. A. Molony to second a cordial vote of thanks to the PRESIDENT for his Address.

The Vote was carried with acclamation.

ANNUAL ADDRESS.

SOME PHILOSOPHICAL CONCEPTIONS OF MODERN PHYSICAL SCIENCE AND THEIR RELATION TO RELIGIOUS THOUGHT.

By SIR AMBROSE FLEMING, M.A., D.Sc., F.R.S.
(*President*).

I—OBJECTS OF SCIENTIFIC RESEARCH AND ITS METHODS.

FOUR years ago in an Annual Address I attempted the presentation to you of a brief sketch of some then recent discoveries in physical science and conclusions from them.

At the present time there have been some more notable additions to our knowledge and conceptions concerning the physical Universe, and it may be acceptable to you if an attempt is made on the present occasion to summarise some of these new ideas in a non-technical form.

Very shortly we can include these novel conceptions under four or five headings as follows :—

(1) The nature of Light and Radiation generally.
(2) The relations of Space and Time, Matter and Energy.
(3) The principles of Causation and Indeterminancy.
(4) The expanding Universe.

And lastly in general,

(5) Our present conceptions of the physical Universe and of its apprehension by us.

Apart from the discovery of new facts or their technical application, the chief object of scientific research is to ascertain the relation of observed phenomena and their metrical statement, and also to be able to view these in any department of knowledge as consequences of some general or more fundamental principles or facts and to confirm the assumptions made by proving that they enable us to predict or predetermine events and that their logical consequences agree with the results of further observations.

Broadly speaking, there are two modes of approach in this effort to unravel the phenomena of Nature. We may endeavour to make some mental picture or working model of the thing or event studied which will necessarily be built up of conceptions which have previously come into our minds through our senses or experiences. We then endeavour to deduce the logical conclusions to be drawn and note whether they agree with the results of our experiments or observations. Thus, for instance, we are well acquainted with spherical balls of all sizes, footballs, cricket balls, golf balls, and small lead shot. Hence we have no difficulty in picturing to ourselves a ball as much smaller than a small grain of dust as this grain of dust is smaller than the globe of our earth. Accordingly, a former mental picture of an atom of matter was to conceive it as an extremely small ball. When it was found that atoms were built up of still smaller particles it was again possible to visualise it as a sort of exquisitely small solar system in which little spheres of negative electricity revolve around a small central sphere of positive electricity. This conception must have a certain fragment of truth in it, as it enables us to account to a small degree for some properties of atoms. This process of visualisation or mental picture or model-making has a particular attraction for minds

of a certain practical type. But we shall see that there is a large range of physical phenomena in which it does not appear to be possible. All that we can then do is to endeavour to ascertain certain numerical facts or relations and embody these in suitable mathematical formulæ and follow out the consequences in accordance with the rules of mathematical analysis.

More and more our studies of natural phenomena are revealing to us a certain apparent duality in phenomena which creates a serious obstacle to any process of visualisation by mental images possible to us at present. It has become clear that we cannot make a picture of the structure of very small things, such as atoms, by considering them as made upon the pattern of visible large things. Hence another school of physical investigation abandons altogether the attempt to make mental pictures or models of the invisible things of the Universe. It ceases to try to make any "graven image" of these unseen and invisible things. Its efforts are merely to find a mathematical formula or expressions which when handled with the rules of mathematical analysis shall enable us to predict the nature and degree of various consequences and find them in agreement with actual observations.

II—The Nature of Radiation.

We can illustrate these two methods of elucidation in connection with the phenomena of Light.

When Newton directed his attention to optical facts he was led to try to explain them by the assumption that Light consisted of small particles he called corpuscles which were shot out from luminous sources in all directions. These he considered rebounded from material surfaces of various kinds, and he was able in this way to offer an explanation of the facts of the reflection of light by mirrors. He was also able to give an explanation of the refraction or bending of a ray of light in passing from one transparent medium to another such as air and water by the assumption that the denser medium exerted a pull or attraction on the corpuscles and quickened their speed. In the course of time new effects were observed which were quite inexplicable by Newton's assumptions.

If light from a single point source falls on a screen having two very small slits in it very near together and if there is another screen on the farther side, then if the light is monochromatic,

which means of one colour, we find on the second screen a series of bright and dark bands called an interference pattern. If we stop up one small slit the dark bands disappear. It is found then that under certain conditions of distance two rays of light can destroy each other so that light added to light can produce darkness. We cannot conceive of any way in which two sets of particles or corpuscles could annihilate each other. On the other hand, we know that two sets of waves on a liquid surface can destroy each other if one set is half a wave-length behind the other so that the humps or crests of one set fill up the hollows of the other.

Christian Huygens (1629–95) was one of the first to suggest a wave theory of light and that it consists of vibrations in a universal medium called the æther. It was first assumed that these vibrations took place longitudinally; that is in the direction of propagation which is the case in the vibrations of the air creating sound. Then again fresh discoveries called for fresh modifications of theory. It was found that a ray of light can assume a state in which it has different properties on its sides; that is, it is not symmetrical with respect to the direction of propagation. In other words, the vibrations of light must be transverse to or at right angles to the direction of propagation of the ray. But transverse vibrations of this kind can only be created in solid bodies which resist distortion as well as compression. Hence it was necessary to make the very artificial assumption that the hypothetical æther was an elastic solid.

Nevertheless, in the hands of great mathematicians such as Fresnel, Airy, Green, and Hamilton, this elastic solid theory of light was found to explain a vast number of optical phenomena, and it reigned supreme in the early part of the nineteenth century. Before 1865, however, James Clerk Maxwell set himself to translate into mathematical language some of the great discoveries of Faraday and Ampère. He proved that if a sudden change is made in the electric charge of a conductor this effect is not felt everywhere at once, but it propagated through space with a definite velocity, in the form of an electric wave. We know nothing, as a matter of fact, of any æther having density and elasticity, but we do know that through space, even empty space, we can propagate electric and magnetic forces, as they are called, in virtue of two properties of space called magnetic permeability and dielectric power.

Maxwell gave us two mathematical equations which express in symbolic language these facts and from them we can deduce a vast number of optical results verified by experience. Maxwell proved from certain available measurements that when a sudden change is made anywhere, even in empty space, in electric or magnetic force, this change is propagated outwards in all directions with the velocity or speed of light, that is about 186,000 miles per second or more nearly 299,000 kilometres per second. Nevertheless, we cannot make any conception in terms of anything simpler of the nature of magnetic or electric force. They have to be accepted as an ultimate or final conception like space and time. Maxwell therefore abandoned the attempt to form any mental picture of the structure of his æther or visualisation of the nature of an electric wave by means of mechanical ideas. This theory was held to be sufficient to account for optical and electrical phenomena until towards the close of the last century when the so-called X-rays were discovered by Röntgen. Later on it was proved these X-rays also were electromagnetic vibrations but of vastly greater frequency, even 10,000 times greater vibration rate, than visible light.

Then it was found that these X-rays when passed through air broke up or tore in pieces certain atoms of the gas, liberating from them electrons and leaving a remainder of the atom charged with positive electricity. The strange thing, however, is that it is not every atom which is so destroyed or ionised, and, moreover, the work or energy required to pull the atom in pieces may be very much greater than the energy falling on the surface of the atom if we make the assumption that the energy of the wave is uniformly distributed over its front.

These and other facts have led physicists to the conclusion that the energy in a beam of light must be concentrated in little drops or packets which are now called *photons*, so that a beam of light resembles a shower of rain comprising distinct and separate drops. It appears clear that when light gives up its energy to atoms, or when atoms radiate light, that energy can only be given up or sent out in certain definite amounts called quanta, but cannot be taken in or sent out continuously. Certain optical effects such as the interference just explained, and others such as diffraction are easily and completely explained by a wave-theory of light in which the energy is assumed to be uniformly spread or distributed over the wave-front. On the

other hand, there are other effects which seem to demand for their explanation that the light energy is concentrated in little packets called light-quanta or photons, in which the energy stored is proportional to the frequency or number of vibrations per second of that radiation multiplied by a certain constant. Thus when light falls on certain metallic atoms such as zinc, potassium or cæsium it breaks them up and liberates from these atoms certain small charges of electricity called electrons. For each kind of atom a certain energy is required, and hence for each electron which comes out a photon of a certain energy size and therefore frequency must fall on the atom, and no photons of less energy size will cause the emission. It may be illustrated as follows: To pierce the armour of a battleship we need to fire at it a shell of a certain mass and velocity, and no number of smaller shells with less energy will do the same damage as the single large one. Hence to effect this liberation of electrons, which is called the photo-electric effect, we must in each case employ light of a frequency greater than a minimum limit, and for a less frequency no photo-electric effect takes place by the impact of any number of photons of lesser individual energy. This proves that the light energy must be concentrated in photons and that the energy of a photon is proportional to the frequency of the light.

There is also something as yet quite unexplained about the propagation of light. In all cases of wave-motion in material media such as air or water the apparent speed of the wave is affected by the motion of the observer or the source. Thus if a very long airship had a man at the centre, who fired a pistol, and two men, one at the bow end and one at the stern at equal distances from the centre, if the airship was then stationary the two men would hear the bang of the pistol simultaneously. If the airship was in rapid motion the man at the stern would hear the sound before the man at the bow, because the former is moving towards the source of the sound and the latter is moving away from it. But strange to say nothing like this happens in the case of a ray of light. The earth is flying along its orbit with a speed of 18 to 20 miles per second. But if we measure the velocity of light by accurate methods we find the same value for it whether the ray is moving in the same direction as the earth or across it. In short, the apparent velocity of light is an absolute constant and not altered by the motion of the source of

light or of the observer. The full reason for this has not yet been discovered.

Another anomaly which is left unexplained by the simple wave-theory is the distribution of energy amongst the different wave-lengths in the radiation of a black substance when hot. If we form a spectrum or rainbow band by passing white light through a prism we find that the energy as represented by the heating power of the rays is small at each end of the spectrum, that is for very long or for very short wave-lengths, but rises to a maximum at some intermediate wave-length. This has only been rendered explicable by the investigations of Max Planck, who at the beginning of this century enunciated his ideas leading to what is now called the Quantum Theory of Radiation.

Modern investigations have shown that an atom of matter is an electrical structure comprising a very small body called the nucleus, having a charge of positive electricity and surrounded by groups of electrons which are point-charges of negative electricity. The peculiar fact is that these electrons can only exist at certain distances from the nucleus in so-called prescribed orbits. They can jump or be knocked from one orbit to another, but have no resting-place in any intermediate positions. Whenever an electron jumps from an outer to an inner orbit it loses some energy, and the difference is thrown out as radiation that is as heat, light, or X-rays. To lift the electron back or expel it from the atom we have to impart energy to it by radiation. But the atom can only give out or take in radiant energy in certain mouthfuls called quanta, and the energy of these quanta is measured by multiplying the vibration rate or frequency of the radiation by a certain small number called Planck's Constant. Hence large energy quanta have very rapid vibrations and small quanta have small rates. This explains why we can develop our photographic plates by *red* light, but they would be at once fogged if we admit any violet or white light into our dark room. The light photons are not therefore all alike. Some contain more energy than others.

In a mass of atoms which are radiating it is more probable an atom will give out a small energy quantum or photon than a large energy quantum, and it is this fact which explains the form of the energy curve of the spectrum of a radiating black body, because the total energy radiated at any wave-length is the product of the number of that class of photon by the energy

value of each photon. We may illustrate the result of this as follows: Suppose a collection was being made from a congregation in a very large church, say on Hospital Sunday. Everyone who gave anything would have to put in the plate a coin of a certain value, 1*d.*, 3*d.*, 6*d.*, 1*s.*, 2*s.*, etc., or even a £1 treasury note. Now it is far more probable it would be a small value coin than a large one. Yet even if 500 people put in 1*d.* each the total would only amount to about £2. At the other end of the scale there might be a few rich people who would put in £1 treasury notes, but as they would be few the total value would then only be small even though each donation is large. If however, we consider coins of intermediate value, say 2*s.* or 2*s.* 6*d.*, then if only 50 or 100 people put these in the offertory the total value would be much larger than that of the donations of 1*d.* or £1. Hence there is a maximum contribution in money corresponding to certain donations in one particular coin. The same things take place with the energy contributions made by atoms in the form of radiation. Corresponding to each frequency there is a certain energy value of the photon or energy packet, but there is a greater probability of its being a small than a large one. The high-frequency photons have a large energy and the low frequency a small energy. The energy of a photon of violet light has about twice the energy of a photon of red light, and that is the reason that violet and ultra-violet light can do many things in liberating electrons from atoms that red light cannot do. We have not, however, yet solved even a fraction of the secrets enclosed in a ray of light, but its duplex character of waves when transmitted through space and particles when entering or leaving an atom is paralleled by a similar structure of the ultimate elements of matter.

III—The Structure of Matter.

We must next consider our present views as to the nature of material substance. Up to the present there appear to be *four* elemental particles which are the bricks out of which the physical Universe is made. These are:

(i) The *electron* which is a centre from which radiates electric force. The electron charge is negative.

(ii) Then next there is a similar particle of the same mass or weight but having a positive electric charge. This

is called a *positron*. It does not appear to last long. It comes into existence, endures for a short time and vanishes.

(iii) Then there is a positively charged particle called a *proton* which has 1,840 times the mass of the positron or electron.

(iv) There is finally a particle called a *neutron*, discovered by Dr. James Chadwick of Cambridge, which has a mass equal to the proton but no electric charge.

An atom of hydrogen consists of one proton with one electron revolving round it. It is like a very heavy fat man waltzing with a little girl. The nucleus of other atoms is built up of protons and electrons packed closely together and a family of electrons revolving round it.

Now it is found that the same kind of duality attaches to an electron as to a ray of light. The latter behaves sometimes as a set of waves and sometimes as a set of particles. The electron also appears in the same double character; it is a sort of Dr. Jekyll and Mr. Hyde.*

Professor G. P. Thomson has shown by a remarkable experiment that when a stream of electrons is shot against an extremely thin metal plate a photographic film placed on the opposite side records a set of concentric circular dark and bright bands forming an interference pattern, which could only happen if an electron is indeed a train of waves of some kind. The only suggestion I have been able to make to myself to account for this double character is that the motion of an electron is not a smooth, uniform motion like a billiard ball rolling along a table, but is a series of rapid jumps like a sparrow hopping along the ground. At each jump an electric pulse would be created in the electron field. At this point it may be well just to say one or two words about the process by which radiation in the form of dark heat, light or X-rays is produced. When a mass of material substance is heated, the atoms are set in rapid motion. They jostle each other and electrons are liberated from the atomic orbits. These electrons are dashing about with various speeds between the

* This duality seems capable of explanation in terms of what is now called "Wave Mechanics." It is, however, impossible to give the briefest sketch of it without the use of mathematical symbols, which is not suitable in the case of the present Address.

atoms, and are then drawn in to any ionised atom. If the electron happens to have small speed it may only penetrate a little way into an atom's family circle. If it has high speed it may push its way far in, or may even hit a nucleus. In any case it loses velocity and energy. The amount lost is transformed into a single photon of varying energy which, as already explained, determines the frequency of it. Electrons thus penetrating into atoms give rise to photons. Again if a photon with sufficient energy falls upon an atom it may liberate from it an electron. There are, however, great differences between photons and electrons. Photons can only move with the speed of light and have no existence when at rest. Electrons can move with any speed less than that light. Electrons have a charge of negative electricity, but photons have no electric charge. There are mysteries not yet solved concerning the nature of light and matter and their transformations. Electrons coming into an atom can eject photons and photons coming into an atom can eject electrons.

IV—The Relativity of Knowledge.

This, then, leads us to consider some modern ideas of space, time, matter and energy.

Einstein first showed us that many of the conceptions in the science of 25 or 30 years ago were incorrect. Thus, for instance, he pointed out that two events which may appear simultaneous to one observer, such as two flashes of lightning, are not necessarily simultaneous to other observers in motion with respect to the first observer. Then time measurement is in the same way affected by motion of the observer. If an observer was flying away very rapidly from a clock with seconds pendulum he would notice that the time of each swing was lengthened out compared with that of a similar clock moving with him. In other words, a clock moving away from an observer appears to go slower than a quite similar clock close to the observer. It is also possible to show that if a rod moving away rapidly from an observer in the direction of its length would appear to be shortened to that observer at rest, compared with its length to an observer moving with it. The result is to show that measurements of time, length and mass are different to different observers

in motion with respect to, and those at rest with respect to, the events measured.

Einstein then went on to lay down a general principle which must govern all our outlook on the phenomena of Nature. It is that when we put into mathematical form any so-called law of Nature it must be an invariant; that means have the same mathematical form for all frames of reference and all observers, because no one observer can be considered as specially privileged. Thus, for instance, Newton stated his law of gravitation in the form that the force of attraction varies inversely as the square of the distance between the bodies. But then the question arises, Distance measured by whom? For it is different to different observers, moving in different directions in the respect to the length or distance in question. Newton's expression is not, however, an invariant. After much labour Einstein found a new mathematical expression for the law of gravitation which is an invariant. It enabled him to explain a motion of the orbit of the planet Mercury which had not been fully explained by Newton's law.

Moreover, he showed that we must abandon the idea of a "pull" or force of gravitation between material bodies. The earth revolves round the sun in a slightly oval orbit, not because it is subject to a pull or force of attraction but because the path of the earth is always along a geodesic or shortest path. The mathematical expression for the distance between two points in space of three dimensions is not an invariant. If, however, we consider a space of four dimensions in which time multiplied by the velocity of light is the fourth dimension then the interval, as it is then called, between two event points is an invariant. Einstein and Minkowski have therefore shown us that each observer in our present system of three-dimensional space and independent time sees a different Universe. It is the same as with the rainbow. When sun, rain, and cloud conditions are fulfilled we all see a rainbow; but the rainbow you see when at a distance from me is not the same rainbow that I see. We each have our own rainbow and if we run or motor along our own rainbow accompanies us. The only way in which we can eliminate the personal element in our several views of the physical Universe is to amalgamate our separate conceptions of space and time into a single space—time—unity—of four dimensions. But we cannot then form any mental picture of four-dimensional

space. We are born and bred in space which gives us through our senses a three-dimensional conception of it. We recognise up and down, right and left, forwards and backwards, and also separately what is meant by present, past and future in events as regards time. If, however, the Universe has an absolute existence apart from personal aspects for different human observers then this separation of space and time is only the outcome of our present limitations of thought and movement. We cannot identify positions in space as being the same at two different times, and we cannot assert that two events occur at the same time in different places. If, however, we ignore or are ignorant of the proofs of the truth of the above statement then we are able to deceive ourselves and think that the time interval between two events must be the same when observed at different places, and space intervals as shown by the dimensions of matter must appear the same at all times. The truth is that time and space are inseparably connected, owing to the absolute identity of the velocity of light to all observers. In addition to the inter-connection of Space and Time we have to notice that of Matter and Energy. When material substance is in motion it possesses the power of making physical changes and causing motion in other matter. This is called its kinetic energy and is proportional to the square of its velocity or speed. It if imparts this energy to other matter it loses an equal amount itself. Hence energy is said to be conserved. If an electron plunges into an atom and loses thereby some kinetic energy, this loss is converted into a single photon whose frequency is equal to the lost energy of the electron divided by Planck's Constant. If the electron impinges on a positron the matter vanishes and a photon is created whose energy is equal to the mass destroyed, multiplied by the square of the velocity of light. In this manner our sun loses 240 million tons of its mass per minute to supply the light and heat sent out in the form of photons. The same in various degrees for other stars. The material Universe is thus melting away into radiation or photons. Also all the kinetic energy in the Universe is passing into the form of low temperature heat universally diffused. It cannot be gathered up so as to again produce kinetic energy of large masses of matter.

Matter can therefore be transformed into radiant energy and energy dissipated into uniformly distributed heat, but the reverse process does not take place so far as we know.

V—Radio-Active Matter.

We know that the nuclei of certain atoms such as radium, thorium, etc., break up as it were spontaneously. But we cannot tell why one atom should break up rather than another of the same kind. On the average half of the atoms of any mass of radium breaks up in 1,580 years and half of the remainder again in 1,580 years: we cannot predict the life of any single atom, but we can predict the average life for a large number of atoms. It is the same with human lives. We do not know how long each of us will live, but the life insurance societies who have statistics of large numbers of lives can fix very closely the expectation of life at any age and thus arrange the premiums on life policies. When the nucleus of a radio-active atom breaks up and sends out some part of itself a new kind of atom is formed which again in turn breaks up. The final result of a long series of such changes is to produce an atom of lead, which is stable and does not change. Thus an atom of uranium after two or three changes gives rise to radium, and this after many more is changed to lead. These transformable atoms are called radio-active elements. We are beginning to find out how to produce radio-active atoms from non radio-active elements by bombarding them with electrons or alpha particles moving with terrific speeds.

There are also high-speed particles moving through space in all directions and these give rise to what are called the *cosmic rays*, capable of penetrating through a wall of lead many feet in thickness or through water hundreds of feet deep. Their exact nature is not yet known.

VI—The Principle of Indeterminacy.

The German physicist Heisenberg has shown that we cannot fix both the position and the motion of a single electron. If we could know its motion we could not fix its position because it is continually moving, or if we could see it the very fact of light falling on it would change its position. The same may in all probability be true of a proton. But although we cannot determine both the position and the motion of single electrons or protons we can do so for vast numbers of them forming a visible mass of matter. Thus we can say exactly where the moon will be in the sky 10 years hence and in what direction it

will be moving in space. It appears, then, that events in the physical world may be divided into two great classes.

There are those connected with the position and motion of large masses of matter which can in most cases be predicted at least approximately. These are called macroscopic-phenomena.

But then, on the other hand, there are events connected with single atoms and electrons and protons which cannot be predicted. There is an element of *Indeterminacy* connected with them. They are called the microscopic phenomena. We cannot say, for instance, why one atom of radium should break up spontaneously rather than another. It seems wilful and irregular and appears to violate the idea of Causality.

It is possible, however, that the determining cause does not lie in the physical world at all but in the direct operation of Mind. It leaves room, therefore, for operations outside of the realm of physical causality and limits the action of that rigid determinism which was formerly held to have complete sway in the physical Universe and to prevent absolutely any deviation from a fixed and inviolable order of events.

VII—The Expanding Universe.

Astronomical research shows that our sun, and attendant planets, is a member of a vast group of stars called "our galaxy." Its dimensions are so great that it cannot be measured in miles but only in light-years; that is the distance, equal to about 6 billion miles, which a ray of light travels in a year. Our galaxy contains probably 100,000 million stars distributed over a bun-shaped space about 250,000 light-years diameter and 40 to 50 thousand light-years thick. This stupendous mass of stars is probably in rotation as a whole. Outside of, and far distant from, our galaxy are other immense groups of stars called the extra-galactic nebulæ at distances varying from 2 to 140 million light-years.

The extraordinary fact is that all these far-distant galaxies appear to be flying apart from us and each other with speeds, increasing with their distance from us, up to 10,000 to 15,000 miles per second. This is ascertained by noting the shift or displacement of the lines in their spectra towards the red end of the spectrum. This shift is called the Doppler effect, from the astronomer who first drew attention to it. Former ideas of

space permitted us to think of it as infinitely extended in all directions so that it would be possible to move forward for ever in a straight line without encountering any limit. On the other hand, we cannot admit that an unlimited space is filled with an unlimited number of stars or else the result would be that the sky would appear closely packed with stars. If, on the other hand, the number of stars is not infinite general gravitation would be drawing them together. Observation, however, shows that the far-distant spiral nebulæ quite outside the region of our galaxy are flying apart from us and from each other with speeds which seem to increase proportionately to their distance from us.

This, then, has created the idea of a closed yet expanding space. We can derive some help in this connection by considering the surface of a sphere. This is space of two dimensions curved in a third dimension or direction. There is no boundary or limit to motion over the surface, yet the area of the surface is finite and can be measured up in square feet or miles. We cannot form any mental image of, or visualise the nature of space of three dimensions which is curved in a fourth dimension, but the above reasons almost necessitate the conception that our three-dimensional space is not unlimited, though it is unbounded and an important quality is therefore that called the Cosmical Constant, which determines the curvature of our space.

It has been suggested that this "running away" of the nebulæ may be more apparent than real and that the shift of the spectral lines towards the red end in their case may be due to a loss of energy of the photons in travelling these immense distances which would reduce their frequency. The notion of a possible general curvature of space is, however, supported by the proof that Einstein has given that what Newton called gravitational attraction between masses of matter is, in fact, due to a local curvature in space produced by these masses, and the curved path of a planet moving round the sun is not due to any "pull" between them but to a tendency on the part of the planet to move along a geodesic or shortest path.

VIII—Our Present Conceptions of the Physical Universe.

The result of progress in our knowledge of the physical universe both in macroscopic and microscopic phenomena has

been to reveal a vast number of quantitative or numerical relations which cannot be the result merely of our own human thought but must depend upon metrical qualities imposed on the physical Universe by some Power other than our own. Scientific thought generally is realistic, that is it regards the physical universe as existing apart from our appreciation of it. Hence if any aspects of it appeal to our intelligence it can only be because they have been ordained by a Supreme Intelligence other than our own. Accordingly, the great modern accumulation of facts regarding the presence of number, weight and measure in the physical world have in the opinion of many persons destroyed the old materialism and presented the Universe to us rather as a thought than a thing, and thought implies a thinker. Furthermore, such effects as the dissipation of energy, the increase of entropy, the transformation of matter into radiation, and the spontaneous change of radio-active matter into non-radio-active matter, all support the truth of the conception that the physical universe had a beginning in Acts of Creation and was not self-produced nor infinite in past duration. Also that left to itself it will have an end. Moreover, this "running down" which is thus disclosed is the very opposite of any Evolution in the sense of a spontaneous advance. It gives denial to any assertion that the Universe is the result of a set of "happy accidents" or freaks or casual combinations or any mode of operations which dispenses with the necessity for belief in a creation and therefore in a Creator. It is somewhat strange, however, that whilst these ideas appeal mostly to those who study the inorganic part of the Universe, the biologists still seem in large degree to think in terms of self-acting mechanism and extensively hold a theory of species production which is based on mere accidental variation combined with a struggle on the part of living organisms to continue to exist. They accept for the infinite varieties in living organisms a process of production which they would themselves reject for the productions of mankind. There is a very remarkable illustration of this at present on view in the National Science Museum at South Kensington. On the ground floor there is on exhibition a series of splendid small and large models illustrating the growth and development of three great human inventions, the stationary steam engine, the steam locomotive engine, and the aeroplane. Along one side of the room are a series of glass cases with models

in them showing the gradual developments of man's artificial wing from the earliest gliders and motor-driven planes of the Wright Brothers up to the most finished passenger aeroplanes of the present day. At the end of the room there is another glass case containing examples of the wing in Nature, *e.g.*, the flying fish (*Exocoetus*) with its gauzy wings, the flying lizard (*Draco spilopterus*), the bat's wing of membranous tissue between its fingers, arms and legs, and lastly, examples of the feathered wing in birds such as the albatross and gannet. Ask a biologist of the Evolutionist School how this animal wing came into existence and he may tell you, by accidental variations in ova and germ cells and by a continual struggle to obtain food or escape from enemies over vast spaces of time evolving the wing. Take him to the aeroplane cases and ask him how man's artificial wing came into being and he must reply: "by countless experiments guided at each stage by the thought of intelligent originative human minds." Is there not a little inconsistency between these two sets of ideas? If the thought of a living mind was essential in one case why not in the other? If "every house is builded of some man," how can we evade the conclusion that there is thought of a mind other than our own as the source of the phenomena of Nature? It is true that our apprehension of that thought is imperfect owing to the limitations of our minds. We are, to use Plato's analogy, as given in the eighth book of his *Republic*, like persons endeavouring to guess from the shadows of unseen objects thrown on a wall what are the shape and true nature of those objects.

There is now a well-marked feeling in the minds of leading physicists that we are not yet in contact with absolute reality. Moreover, recent progress in analysis of phenomena has served to limit belief in the perfect determinism in physical events which left no possibility for any variation in the course of them as normally observed. It is impossible to deny the existence in the physical world of numerical and geometrical facts such as those exhibited in chemical combinations, in crystal forms, and atomic phenomena which require intelligence to appreciate and therefore a kindred intelligence to produce them.

We have no knowledge of any kind of order which is the result of chance or of the spontaneous action of non-living agencies, but always find it when traced to its ultimate sources to depend on the originative or creative operation of mind. Finally, we

can derive an argument against the truth of the dominant idea of Evolution from the fact that modern physics finds everywhere discontinuity and not continuity in Nature. The fundamental underlying idea of Evolution is that of perfectly continuous change by infinitely small steps. To borrow a phrase from Socialism, it is the "inevitability of gradualness" or universal prevalence of slow gradual change. But now the discoveries of physics everywhere contradict this assumption of perfect continuity in Nature. Everywhere we find discontinuity and not continuity; matter is discontinuous and cut up or composed of discrete molecules. Molecules are divided into atoms, atoms into electrons and protons, radiation into photons, and quanta, and the universal presence of Planck's Quantum or unit of action suggests that even Time and Space may not be infinitely divisible but composed of units.

Natural changes take place by jumps, and there is evidence that the order in Nature is at times interrupted by sudden catastrophies, all of which are antagonistic to Evolution. The assumption that living matter was in past time spontaneously evolved from non-living matter, which view has been put forward and agreed by many biologists, is a pure assumption and contradicted by experimental evidence not easily refuted. But if it has not been so produced it shows an unbridged gap which is inconsistent with Evolution. Also if a similar uncrossed chasm exists between the animal mind and the rational human mind and spirit with its powers of free choice, origination, creation and worship, then the conception of Evolution has the ground cut from underneath it and we are compelled to admit as the only possible alternative that similar but infinitely greater powers than our own are the attributes of a Universal Spirit and Supreme Intelligence who has created all things and for whose pleasure they are and were created.

Discussion.

The Chairman, Sir Robert Armstrong-Jones, C.B.E., M.D., D.Sc., said: It would be an impertinence on the part of any Chairman to introduce Sir Ambrose Fleming and I think we might commence this meeting by simply offering to him our cordial congratulations on his vigorous and virile health, both mental and physical. He is phenomenally well and able. Time has not weighed upon him. The past

has not daunted or worn him out. The present is at his " beck and call " and is within his power. We hope he will enjoy a prolonged future of peace and happiness, the respect of his friends and the continued love of those dear to him.

After the reading of the paper, Sir Robert Armstrong-Jones added that in no department of thought does the intelligent reader get more pleasure than in reading the biographies of eminent men who have helped to make history. Sir Ambrose Fleming's life and work are well known to all of us. His scientific researches into wireless telegraphy owe more to him than to any other individual. Nor has he limited his investigations to practical facts. He has taken in addition the wider view of " How and Why," which are philosophical conceptions, and in his life's work he has not only been guided, but he has been comforted and helped by the earnest Christian's regard for the Bible, the revealed Word of God. He has introduced no doctrinal formulas into his papers, but he has been inspired by a spirit and feeling of deep reverence and a reliance upon Truth and Faith. He has always been a seeker after the higher verities, and his contributions have not only given us glimpses of the Divine Mind—the Universal Mind—but also the recognition of a Being, infinitely above human nature, yet infinitely regardful of it. We feel that when a great exponent of scientific thought declares his belief and devotion in the value of the spiritual life as interpreted by himself, he must be listened to with respect, even if we are not convinced by his argument.

May I state from the Chair, and Sir Ambrose Fleming will agree, that there has been a complete revolution in mental outlook and in scientific thought during the last 100 years. This has been stimulated, if not created, by advances in the knowledge of biology and geology. Geologists are agreed, for instance, that the age of the world must be regarded as having lasted for millions of years, during which organic life has existed and during which a regular succession of living beings has evolved, not by any immediate or sudden catastrophic process but slowly and gradually. We have to contemplate immeasurable antiquity in the development of living things totally different from those existing now and this change is proceeding at the present time.

The writer of the Pentateuch (the five books of Moses) has not claimed to be a scientist and no one to-day believes that the world is flat or that it was created 4,004 years before Christ, as was at one time taught. Let those who doubt the theory of evolution propound another more acceptable to account for the life we live and the world we live in. The educated man seeks the guidance of Philosophy for this purpose and earnestly seeks in Philospohy for an explanation of the natural phenomena of the physical universe, but Philosophy is a difficult subject to understand and some of us have to approach it warily, for has the Philosopher not been compared to a blind man, seeking for a black hat in a dark room—the hat in question not being there ? Again, Philosophy has been described as a speculative luxury for idle people, because, they assert, it does not deal with the practical aspect of life, which is left to men of affairs, and not to those who are concerned solely with unpractical notions. But is this true ? It is a fact that Philosophy as a study does not command the support of the populace. Its doors are not besieged by the crowd, but those who study it profitably are greatly benefited and enjoy the mental culture implied. One reason for its unpopularity is probably the fact that its devotees must possess an understanding above the average and it is the cult of a select few, and we may not be of this category. It is true to say that Philosophy is concerned with the life we live and the world we live in. It has concerned itself with the conception of matter and energy, with fundamental scientific questions such as the Quantum Theory of the atom, of Relativity, of Evolution, and probably with the result of experiments in the domain of Sir Ambrose Fleming's own researches, which are so well known. Philosophy is concerned with the exercise of the Mind, and scientific inquiry seems to demonstrate that there is one Great Mind working in Nature, the source of all Power, working through limitless space ; not mechanically, but intelligently with perfect and unvarying uniformity by Evolution through the ages, according to what we call Natural Laws. The existence of one Great Mind, the Supreme Being, and our relation to Him, brings before us the subject of Religion, and this Society—whilst showing a sympathetic attitude to Religion—has always been in favour of scientific inquiry. Formerly there existed antagonism

between Religion and Science, because theological dogma tended to limit the range of scientific inquiry, with the result that some earnest students of science in search of Truth were driven into an atmosphere of disbelief, the theological doctrines not being conformable with their own intellectual intuitions.

We find, for example, a statement of the scientific views in relation to theology, held by Prof. MacBride, expounded in the January number of the *Hibbert Journal* for 1936.

It would nevertheless be right to add that in spite of doubt, disbelief and logical difficulties, thousands of earnest believers have voluntarily suffered torture and given their lives for their Faith, myriads have given their life-blood for their belief, whilst countless numbers have derived hope and courage from their religion, among them being kings and queens, courtiers, ambassadors, men of science and scholars—men and women of all ranks and of all ages. The Bible, whose inspiration is sometimes challenged, has elevated the character of innumerable men and women. Bible truths have cancelled their sorrows, lifted their doubts and guided their thoughts.

We have listened with interest and instruction to a great Presidential Address which is evidence of a wide erudition, great knowledge and a clearness of expression which we all admire and for which we are deeply grateful.

Captain B. Acworth, D.S.O., R.N., in referring to the remarks of the Chairman, expressed some astonishment that, at this time of day, he should refer to the theory of organic evolution as though it rested upon evidence instead of speculation. He referred to the fact that not a single example had ever been forthcoming of any change of species.

He referred to the recent discussion at the Royal Society of the present position of the theory of Natural Selection. At this meeting, he pointed out, the insufficiency of natural selection as a means to the evolution of species was abundantly demonstrated.

Professor J. B. S. Haldane now claims the theory of natural selection as the means, not of evolving new species, but of guaranteeing their fixity

Professor MacBride, he reminded the audience, treated natural selection as a myth no longer believed by well-informed scientists.

Referring, in conclusion, to remarks of the Chairman which seemed to indicate a view that in early Biblical times the inspired writers of the Bible had little knowledge of "science," he reminded the audience that the Psalmist, for example, so far from being a "Flat-earthist," had shown his extraordinary understanding of facts when he exclaimed: "He hung the round world upon nothing."

Captain Acworth concluded his remarks by deploring that the theory of evolution should continue to be treated as scientifically established truth, when it was in fact a theory now widely rejected by some of the most distinguished scientists of the day.

Written Communication.

Sir Ambrose Fleming wrote that he desired to thank the Meeting for the kind reception given to his Annual Address, and particularly to offer to the Chairman (Sir Robert Armstrong-Jones) a grateful acknowledgement of his all too kind personal compliments.

It is not usual to invite discussion on the subject-matter of our Annual Addresses; and in the one under consideration the author has endeavoured to avoid as far as possible the introduction of questions on which differences of opinion might exist between Members and Associates of the Victoria Institute. Sir Robert Armstrong-Jones is doubtless aware that in the Session of 1935, and also in previous sessions, we have had given to the Victoria Institute many papers by very competent authors demonstrating in various ways the insufficiency and assumptions of the very popular Evolutionary philosophy; and that, broadly and generally, the Members have shown their agreement with the arguments put forward in these papers. Hence it is not possible to accept the opinion that the case for Evolution is unquestionable and settled. The writer therefore desires to express his thanks to Captain Acworth for voicing this attitude and his entire agreement with the statements Captain Acworth has made in his brief remarks.