Let C be the current in the conductor, and let p', q', r' be its components, then

$$X a\delta = C a\delta x\left(\frac{dy}{ds}\mu\gamma - \frac{dz}{ds}\mu\beta\right),$$

or

$$\left.\begin{aligned} X &= \mu\gamma q' - \mu\beta r'. \\ Y &= \mu\alpha r' - \mu\gamma p', \\ Z &= \mu\beta p' - \mu\alpha q'. \end{aligned}\right\} \quad \text{(J)}$$

Similarly,

These are the equations which determine the mechanical force acting on a conductor carrying a current. The force is perpendicular to the current and to the lines of force, and is measured by the area of the parallelogram formed by lines parallel to the current and lines of force, and proportional to their intensities.

Mechanical Force on a Magnet.

(77) In any part of the field not traversed by electric currents the distribution of magnetic intensity may be represented by the differential coefficients of a function which may be called the magnetic potential. When there are no currents in the field, this quantity has a single value for each point. When there are currents, the potential has a series of values at each point, but its differential coefficients have only one value, namely,

$$\frac{d\phi}{dx} = \alpha, \quad \frac{d\phi}{dy} = \beta, \quad \frac{d\phi}{dz} = \gamma.$$

Substituting these values of α, β, γ in the expression (equation 38) for the intrinsic energy of the field, and integrating by parts, it becomes

$$-\Sigma\left\{\phi\frac{1}{8\pi}\left(\frac{d\mu\alpha}{dx} + \frac{d\mu\beta}{dy} + \frac{d\mu\gamma}{dz}\right)\right\}dV.$$

The expression

$$\Sigma\left(\frac{d\mu\alpha}{dx} + \frac{d\mu\beta}{dy} + \frac{d\mu\gamma}{dz}\right)dV = \Sigma m dV \quad \text{. . . . . . . (39)}$$

indicates the number of lines of magnetic force which have their origin within the space V. Now a magnetic pole is known to us only as the origin or termination of lines of magnetic force, and a unit pole is one which has 4π lines belonging to it, since it produces unit of magnetic intensity at unit of distance over a sphere whose surface is 4π.

Hence if m is the amount of free positive magnetism in unit of volume, the above expression may be written $4\pi m$, and the expression for the energy of the field becomes

$$E = -\Sigma(\tfrac{1}{2}\phi m)dV. \quad \text{. . . . . (40)}$$

If there are two magnetic poles m_1 and m_2 producing potentials ϕ_1 and ϕ_2 in the field, then if m_2 is moved a distance dx, and is urged in that direction by a force X, then the work done is Xdx, and the decrease of energy in the field is

$$d\left(\tfrac{1}{2}(\phi_1+\phi_2)(m_1+m_2)\right),$$

and these must be equal by the principle of Conservation of Energy.

Since the distribution φ_1 is determined by m_1, and φ_2 by m_2, the quantities $\varphi_1 m_1$ and $\varphi_2 m_2$ will remain constant.

It can be shown also, as GREEN has proved (Essay, p. 10), that

$$m_1\varphi_2 = m_2\varphi_1,$$

so that we get

$$\mathrm{X}dx = d(m_2\varphi_1),$$

or

$$\left.\begin{aligned} \mathrm{X} &= m_2\frac{d\varphi_1}{dx} = m_2\alpha_1, \\ &\text{where } \alpha_1 \text{ represents the magnetic intensity due to } m_1. \\ &\text{Similarly,} \\ \mathrm{Y} &= m_2\beta_1, \\ \mathrm{Z} &= m_2\gamma_1. \end{aligned}\right\} \quad \text{(K)}$$

So that a magnetic pole is urged in the direction of the lines of magnetic force with a force equal to the product of the strength of the pole and the magnetic intensity.

(78) If a single magnetic pole, that is one pole of a very long magnet, be placed in the field, the only solution of φ is

$$\varphi_1 = -\frac{m_1}{\mu}\frac{1}{r}, \quad (41)$$

where m_1 is the strength of the pole and r the distance from it.

The repulsion between two poles of strength m_1 and m_2 is

$$m_2\frac{d\varphi_1}{dr} = \frac{m_1 m_2}{\mu r^2}. \quad (42)$$

In air or any medium in which $\mu=1$ this is simply $\frac{m_1 m_2}{r^2}$, but in other media the force acting between two given magnetic poles is inversely proportional to the coefficient of magnetic induction for the medium. This may be explained by the magnetization of the medium induced by the action of the poles.

Mechanical Force on an Electrified Body.

(79) If there is no motion or change of strength of currents or magnets in the field, the electromotive force is entirely due to variation of electric potential, and we shall have (§ 65)

$$\mathrm{P} = -\frac{d\Psi}{dx}, \quad \mathrm{Q} = -\frac{d\Psi}{dy}, \quad \mathrm{R} = -\frac{d\Psi}{dz}.$$

Integrating by parts the expression (I) for the energy due to electric displacement, and remembering that P, Q, R vanish at an infinite distance, it becomes

$$\tfrac{1}{2}\Sigma\left\{\Psi\left(\frac{df}{dx}+\frac{dg}{dy}+\frac{dh}{dz}\right)\right\}d\mathrm{V},$$

or by the equation of Free Electricity (G), p. 485,

$$-\tfrac{1}{2}\Sigma(\Psi e)d\mathrm{V}.$$

By the same demonstration as was used in the case of the mechanical action on a magnet, it may be shown that the mechanical force on a small body containing a quantity e_2 of free electricity placed in a field whose potential arising from other electrified bodies is Ψ_1, has for components

$$\left.\begin{aligned} X&=e_2\frac{d\Psi_1}{dx}=-P_1e_2,\\ Y&=e_2\frac{d\Psi_1}{dy}=-Q_1e_2,\\ Z&=e_3\frac{d\Psi_1}{dz}=-R_1e_2. \end{aligned}\right\} \quad \text{(D)}$$

So that an electrified body is urged in the direction of the electromotive force with a force equal to the product of the quantity of free electricity and the electromotive force.

If the electrification of the field arises from the presence of a small electrified body containing e_1 of free electrity, the only solution of Ψ_1 is

$$\Psi_1=\frac{k}{4\pi}\frac{e_1}{r}, \quad (43)$$

where r is the distance from the electrified body.

The repulsion between two electrified bodies e_1, e_2 is therefore

$$e_2\frac{d\Psi_1}{dr}=\frac{k}{4\pi}\frac{e_1e_2}{r^2}. \quad (44)$$

Measurement of Electrical Phenomena by Electrostatic Effects.

(80) The quantities with which we have had to do have been hitherto expressed in terms of the Electromagnetic System of measurement, which is founded on the mechanical action between currents. The electrostatic system of measurement is founded on the mechanical action between electrified bodies, and is independent of, and incompatible with, the electromagnetic system; so that the units of the different kinds of quantity have different values according to the system we adopt, and to pass from the one system to the other, a reduction of all the quantities is required.

According to the electrostatic system, the repulsion between two small bodies charged with quantities η_1, η_2 of electricity is

$$\frac{\eta_1\eta_2}{r^2},$$

where r is the distance between them.

Let the relation of the two systems be such that one electromagnetic unit of electricity contains v electrostatic units; then $\eta_1=ve_1$ and $\eta_2=ve_2$, and this repulsion becomes

$$v^2\frac{e_1e_2}{r^2}=\frac{k}{4\pi}\frac{e_1e_2}{r^2} \text{ by equation (44)}, \quad (45)$$

whence k, the coefficient of "electric elasticity" in the medium in which the experiments are made, *i. e.* common air, is related to v, the number of electrostatic units in one electromagnetic unit, by the equation

$$k=4\pi v^2. \quad (46)$$

The quantity v may be determined by experiment in several ways. According to the experiments of MM. WEBER and KOHLRAUSCH,

$$v=310{,}740{,}000 \text{ metres per second.}$$

(81) It appears from this investigation, that if we assume that the medium which constitutes the electromagnetic field is, when dielectric, capable of receiving in every part of it an electric polarization, in which the opposite sides of every element into which we may conceive the medium divided are oppositely electrified, and if we also assume that this polarization or electric displacement is proportional to the electromotive force which produces or maintains it, then we can show that electrified bodies in a dielectric medium will act on one another with forces obeying the same laws as are established by experiment.

The energy, by the expenditure of which electrical attractions and repulsions are produced, we suppose to be stored up in the dielectric medium which surrounds the electrified bodies, and not on the surface of those bodies themselves, which on our theory are merely the bounding surfaces of the air or other dielectric in which the true springs of action are to be sought.

Note on the Attraction of Gravitation.

(82) After tracing to the action of the surrounding medium both the magnetic and the electric attractions and repulsions, and finding them to depend on the inverse square of the distance, we are naturally led to inquire whether the attraction of gravitation, which follows the same law of the distance, is not also traceable to the action of a surrounding medium.

Gravitation differs from magnetism and electricity in this; that the bodies concerned are all of the same kind, instead of being of opposite signs, like magnetic poles and electrified bodies, and that the force between these bodies is an attraction and not a repulsion, as is the case between like electric and magnetic bodies.

The lines of gravitating force near two dense bodies are exactly of the same form as the lines of magnetic force near two poles of the same name; but whereas the poles are repelled, the bodies are attracted. Let E be the intrinsic energy of the field surrounding two gravitating bodies M_1, M_2, and let E′ be the intrinsic energy of the field surrounding two magnetic poles m_1, m_2, equal in numerical value to M_1, M_2, and let X be the gravitating force acting during the displacement δx, and X′ the magnetic force,

$$X\delta x=\delta E, \qquad X'\delta x=\delta E';$$

now X and X′ are equal in numerical value, but of opposite signs; so that

$$\delta E=-\delta E',$$

or

$$\begin{aligned} E&=C-E' \\ &=C-\Sigma\frac{1}{8\pi}(\alpha^2+\beta^2+\gamma^2)dV, \end{aligned}$$

where α, β, γ are the components of magnetic intensity. If R be the resultant gravitating force, and R′ the resultant magnetic force at a corresponding part of the field,

$$R=-R', \text{ and } \alpha^2+\beta^2+\gamma^2=R^2=R'^2.$$

Hence

$$E=C-\Sigma\frac{1}{8\pi}R^2dV. \qquad (47)$$

The intrinsic energy of the field of gravitation must therefore be less wherever there is a resultant gravitating force.

As energy is essentially positive, it is impossible for any part of space to have negative intrinsic energy. Hence those parts of space in which there is no resultant force, such as the points of equilibrium in the space between the different bodies of a system, and within the substance of each body, must have an intrinsic energy per unit of volume greater than

$$\frac{1}{8\pi}R^2,$$

where R is the greatest possible value of the intensity of gravitating force in any part of the universe.

The assumption, therefore, that gravitation arises from the action of the surrounding medium in the way pointed out, leads to the conclusion that every part of this medium possesses, when undisturbed, an enormous intrinsic energy, and that the presence of dense bodies influences the medium so as to diminish this energy wherever there is a resultant attraction.

As I am unable to understand in what way a medium can possess such properties, I cannot go any further in this direction in searching for the cause of gravitation.

PART V.—THEORY OF CONDENSERS.

Capacity of a Condenser.

(83) The simplest form of condenser consists of a uniform layer of insulating matter bounded by two conducting surfaces, and its capacity is measured by the quantity of electricity on either surface when the difference of potentials is unity.

Let S be the area of either surface, a the thickness of the dielectric, and k its coefficient of electric elasticity; then on one side of the condenser the potential is Ψ_1, and on the other side Ψ_1+1, and within its substance

$$\frac{d\Psi}{dx}=\frac{1}{a}=kf. \qquad (48)$$

Since $\frac{d\Psi}{dx}$ and therefore f is zero outside the condenser, the quantity of electricity on its first surface $=-Sf$, and on the second $+Sf$. The capacity of the condenser is therefore $Sf=\frac{S}{ak}$ in electromagnetic measure.

Specific Capacity of Electric Induction (D).

(84) If the dielectric of the condenser be air, then its capacity in electrostatic measure is $\frac{S}{4\pi a}$ (neglecting corrections arising from the conditions to be fulfilled at the edges). If the dielectric have a capacity whose ratio to that of air is D, then the capacity of the condenser will be $\frac{DS}{4\pi a}$.

Hence
$$D=\frac{k_0}{k}, \quad \ldots \ldots \quad (49)$$
where k_0 is the value of k in air, which is taken for unity.

Electric Absorption.

(85) When the dielectric of which the condenser is formed is not a perfect insulator, the phenomena of conduction are combined with those of electric displacement. The condenser, when left charged, gradually loses its charge, and in some cases, after being discharged completely, it gradually acquires a new charge of the same sign as the original charge, and this finally disappears. These phenomena have been described by Professor FARADAY (Experimental Researches, Series XI.) and by Mr. F. JENKIN (Report of Committee of Board of Trade on Submarine Cables), and may be classed under the name of "Electric Absorption."

(86) We shall take the case of a condenser composed of any number of parallel layers of different materials. If a constant difference of potentials between its extreme surfaces is kept up for a sufficient time till a condition of permanent steady flow of electricity is established, then each bounding surface will have a charge of electricity depending on the nature of the substances on each side of it. If the extreme surfaces be now discharged, these internal charges will gradually be dissipated, and a certain charge may reappear on the extreme surfaces if they are insulated, or, if they are connected by a conductor, a certain quantity of electricity may be urged through the conductor during the reestablishment of equilibrium.

Let the thickness of the several layers of the condenser be a_1, a_2, &c.

Let the values of k for these layers be respectively k_1, k_2, k_3, and let
$$a_1k_2+a_2k_2+\&c.=ak, \quad \ldots \ldots \quad (50)$$
where k is the "electric elasticity" of air, and a is the thickness of an equivalent condenser of air.

Let the resistances of the layers be respectively r_1, r_2, &c., and let r_1+r_2+ &c. $=r$ be the resistance of the whole condenser, to a steady current through it per unit of surface.

Let the electric displacement in each layer be f_1, f_2, &c.

Let the electric current in each layer be p_1, p_2, &c.

Let the potential on the first surface be Ψ_1, and the electricity per unit of surface e_1.

Let the corresponding quantities at the boundary of the first and second surface be Ψ_2 and e_2, and so on. Then by equations (G) and (H),

$$\left.\begin{array}{ll} e_1=-f_1, & \dfrac{de_1}{dt}=-p_1, \\ e_2=f_1-f_2, & \dfrac{de_2}{dt}=p_1-p_2, \\ \&c. & \&c. \end{array}\right\} \quad \ldots \ldots \quad (51)$$

But by equations (E) and (F),

$$\left.\begin{array}{l} \Psi_1-\Psi_2=a_1k_1f_1=-r_1p_1, \\ \Psi_2-\Psi_3=a_2k_2f_2=-r_2p_2, \\ \quad \&c. \quad \&c. \quad \&c. \end{array}\right\} \quad \ldots \ldots \quad (52)$$

After the electromotive force has been kept up for a sufficient time the current becomes the same in each layer, and

$$p_1=p_2=\&c.=p=\frac{\Psi}{r},$$

where Ψ is the total difference of potentials between the extreme layers. We have then

$$\left.\begin{array}{ll} f_1=-\dfrac{\Psi}{r}\dfrac{r_1}{a_1k_1}, & f_2=-\dfrac{\Psi}{r}\dfrac{r_2}{a_2k_2}, \ \&c. \\ \text{and} \quad e_1=\dfrac{\Psi}{r}\dfrac{r_1}{a_1k_1}, & e_2=\dfrac{\Psi}{r}\left(\dfrac{r_2}{a_2k_2}-\dfrac{r_1}{ak_1}\right), \ \&c. \end{array}\right\} \quad \ldots \ldots \quad (53)$$

These are the quantities of electricity on the different surfaces.

(87) Now let the condenser be discharged by connecting the extreme surfaces through a perfect conductor so that their potentials are instantly rendered equal, then the electricity on the extreme surfaces will be altered, but that on the internal surfaces will not have time to escape. The total difference of potentials is now

$$\Psi'=a_1k_1e'_1+a_2k_2(e'_1+e_2)+a_3k_3(e'_1+e_2+e_3), \ \&c.=0, \quad \ldots \ldots \quad (54)$$

whence if e'_1 is what e_1 becomes at the instant of discharge,

$$e'_1=\frac{\Psi}{r}\frac{r_1}{a_1k_1}-\frac{\Psi}{ak}=e_1-\frac{\Psi}{ak}. \quad \ldots \ldots \quad (55)$$

The instantaneous discharge is therefore $\frac{\Psi}{ak}$, or the quantity which would be discharged by a condenser of air of the equivalent thickness a, and it is unaffected by the want of perfect insulation.

(88) Now let us suppose the connexion between the extreme surfaces broken, and the condenser left to itself, and let us consider the gradual dissipation of the internal charges. Let Ψ' be the difference of potential of the extreme surfaces at any time t; then

$$\Psi'=a_1k_1f_1+a_2k_2f_2+\&c.; \quad \ldots \ldots \quad (56)$$

but

$$a_1k_1f_1=-r_1\frac{df_1}{dt},$$

$$a_2k_2f_2=-r_2\frac{df_2}{dt}.$$

Hence $f_1=A_1 e^{-\frac{a_1 k_1}{r_1}t}$, $f_2=A_2 e^{-\frac{a_2 k_2}{r_2}t}$, &c.; and by referring to the values of e'_1, e_2, &c., we find

$$\left.\begin{aligned} A_1&=\frac{\Psi}{r}\frac{r_1}{a_1 k_1}-\frac{\Psi}{ak}, \\ A_2&=\frac{\Psi}{r}\frac{r_2}{a_2 k_2}-\frac{\Psi}{ak}, \\ &\text{\&c.}; \end{aligned}\right\} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (57)$$

so that we find for the difference of extreme potentials at any time,

$$\Psi'=\Psi\left\{\left(\frac{r_1}{r}-\frac{a_1 k_1}{ak}\right)e^{-\frac{a_1 k_1}{r_1}t}+\left(\frac{r_2}{r}-\frac{a_2 k_2}{ak}\right)e^{-\frac{a_2 k_2}{r_2}t}+\text{\&c.}\right\}. \quad . \quad . \quad . \quad . \quad (58)$$

(89) It appears from this result that if all the layers are made of the same substance, Ψ' will be zero always. If they are of different substances, the order in which they are placed is indifferent, and the effect will be the same whether each substance consists of one layer, or is divided into any number of thin layers and arranged in any order among thin layers of the other substances. Any substance, therefore, the parts of which are not mathematically homogeneous, though they may be apparently so, may exhibit phenomena of absorption. Also, since the order of magnitude of the coefficients is the same as that of the indices, the value of Ψ' can never change sign, but must start from zero, become positive, and finally disappear.

(90) Let us next consider the total amount of electricity which would pass from the first surface to the second, if the condenser, after being thoroughly saturated by the current and then discharged, has its extreme surfaces connected by a conductor of resistance R. Let p be the current in this conductor; then, during the discharge,

$$\Psi'=p_1 r_1+p_2 r_2+\text{\&c.}=p\mathrm{R}. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (59)$$

Integrating with respect to the time, and calling q_1, q_2, q the quantities of electricity which traverse the different conductors,

$$q_1 r_1+q_2 r_2+\text{\&c.}=q\mathrm{R}. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (60)$$

The quantities of electricity on the several surfaces will be

$$\begin{aligned} &e'_1-q-q_1, \\ &e_2+q_1-q_2, \\ &\text{\&c.}; \end{aligned}$$

and since at last all these quantities vanish, we find

$$\begin{aligned} q_1&=e'_1-q, \\ q_2&=e'_1+e_2-q; \end{aligned}$$

whence

$$q\mathrm{R}=\frac{\Psi}{r}\left(\frac{r_1^2}{a_1 k_1}+\frac{r_2^2}{a_2 k_2}+\text{\&c.}\right)-\frac{\Psi r}{ak},$$

or

$$q=\frac{\Psi}{akr\mathrm{R}}\left\{a_1 k_1 a_2 k_2\left(\frac{r_1}{a_1 k_1}-\frac{r_2}{a_2 k_2}\right)^2+a_2 k_2 a_3 k_3\left(\frac{r_2}{a_2 k_2}-\frac{r_3}{a_3 k_3}\right)^2+\text{\&c.}\right\}, \quad . \quad . \quad . \quad (61)$$

a quantity essentially positive; so that, when the primary electrification is in one direction, the secondary discharge is always in the same direction as the primary discharge*.

PART VI.—ELECTROMAGNETIC THEORY OF LIGHT.

(91) At the commencement of this paper we made use of the optical hypothesis of an elastic medium through which the vibrations of light are propagated, in order to show that we have warrantable grounds for seeking, in the same medium, the cause of other phenomena as well as those of light. We then examined electromagnetic phenomena, seeking for their explanation in the properties of the field which surrounds the electrified or magnetic bodies. In this way we arrived at certain equations expressing certain properties of the electromagnetic field. We now proceed to investigate whether these properties of that which constitutes the electromagnetic field, deduced from electromagnetic phenomena alone, are sufficient to explain the propagation of light through the same substance.

(92) Let us suppose that a plane wave whose direction cosines are l, m, n is propagated through the field with a velocity V. Then all the electromagnetic functions will be functions of

$$w = lx + my + nz - \mathrm{V}t.$$

The equations of Magnetic Force (B), p. 482, will become

$$\mu\alpha = m\frac{d\mathrm{H}}{dw} - n\frac{d\mathrm{G}}{dw},$$

$$\mu\beta = n\frac{d\mathrm{F}}{dw} - l\frac{d\mathrm{H}}{dw},$$

$$\mu\gamma = l\frac{d\mathrm{G}}{dw} - m\frac{d\mathrm{F}}{dw}.$$

If we multiply these equations respectively by l, m, n, and add, we find

$$l\mu\alpha + m\mu\beta + n\mu\gamma = 0, \quad \ldots \ldots \quad (62)$$

which shows that the direction of the magnetization must be in the plane of the wave.

(93) If we combine the equations of Magnetic Force (B) with those of Electric Currents (C), and put for brevity

$$\frac{d\mathrm{F}}{dx} + \frac{d\mathrm{G}}{dy} + \frac{d\mathrm{H}}{dz} = \mathrm{J}, \text{ and } \frac{d^2}{dx^2} + \frac{d^2}{dy^2} + \frac{d^2}{dz^2} = \nabla^2, \quad \ldots \ldots \quad (63)$$

$$\left.\begin{aligned} 4\pi\mu p' &= \frac{d\mathrm{J}}{dx} - \nabla^2\mathrm{F}, \\ 4\pi\mu q' &= \frac{d\mathrm{J}}{dy} - \nabla^2\mathrm{G}, \\ 4\pi\mu r' &= \frac{d\mathrm{J}}{dz} - \nabla^2\mathrm{H}. \end{aligned}\right\} \quad \ldots \ldots \quad (64)$$

* Since this paper was communicated to the Royal Society, I have seen a paper by M. GAUGAIN in the Annales de Chimie for 1864, in which he has deduced the phenomena of electric absorption and secondary discharge from the theory of compound condensers.

If the medium in the field is a perfect dielectric there is no true conduction, and the currents p', q', r' are only variations in the electric displacement, or, by the equations of Total Currents (A),

$$p'=\frac{df}{dt}, \qquad q'=\frac{dg}{dt}, \qquad r'=\frac{dh}{dt}. \quad \ldots \ldots \quad (65)$$

But these electric displacements are caused by electromotive forces, and by the equations of Electric Elasticity (E),

$$\mathrm{P}=kf, \qquad \mathrm{Q}=kg, \qquad \mathrm{R}=kh. \quad \ldots \ldots \quad (66)$$

These electromotive forces are due to the variations either of the electromagnetic or the electrostatic functions, as there is no motion of conductors in the field; so that the equations of electromotive force (D) are

$$\left.\begin{aligned} \mathrm{P}&=-\frac{d\mathrm{F}}{dt}-\frac{d\Psi}{dx}, \\ \mathrm{Q}&=-\frac{d\mathrm{G}}{dt}-\frac{d\Psi}{dy}, \\ \mathrm{R}&=-\frac{d\mathrm{H}}{dt}-\frac{d\Psi}{dz}. \end{aligned}\right\} \quad \ldots \ldots \quad (67)$$

(94) Combining these equations, we obtain the following:—

$$\left.\begin{aligned} k\left(\frac{d\mathrm{J}}{dx}-\nabla^2\mathrm{F}\right)+4\pi\mu\left(\frac{d^2\mathrm{F}}{dt^2}+\frac{d^2\Psi}{dxdt}\right)&=0, \\ k\left(\frac{d\mathrm{J}}{dy}-\nabla^2\mathrm{G}\right)+4\pi\mu\left(\frac{d^2\mathrm{G}}{dt^2}+\frac{d^2\Psi}{dydt}\right)&=0, \\ k\left(\frac{d\mathrm{J}}{dz}-\nabla^2\mathrm{H}\right)+4\pi\mu\left(\frac{d^2\mathrm{H}}{dt^2}+\frac{d^2\Psi}{dzdt}\right)&=0. \end{aligned}\right\} \quad \ldots \ldots \quad (68)$$

If we differentiate the third of these equations with respect to y, and the second with respect to z, and subtract, J and Ψ disappear, and by remembering the equations (B) of magnetic force, the results may be written

$$\left.\begin{aligned} k\nabla^2\mu\alpha&=4\pi\mu\frac{d^2}{dt^2}\mu\alpha, \\ k\nabla^2\mu\beta&=4\pi\mu\frac{d^2}{dt^2}\mu\beta, \\ k\nabla^2\mu\gamma&=4\pi\mu\frac{d^2}{d^2t}\mu\gamma. \end{aligned}\right\} \quad \ldots \ldots \quad (69)$$

(95) If we assume that α, β, γ are functions of $lx+my+nz-\mathrm{V}t=w$, the first equation becomes

$$k\mu\frac{d^2\alpha}{dw^2}=4\pi\mu^2\mathrm{V}^2\frac{d^2\alpha}{dw^2}, \quad \ldots \ldots \quad (70)$$

or

$$\mathrm{V}=\pm\sqrt{\frac{k}{4\pi\mu}}. \quad \ldots \ldots \quad (71)$$

The other equations give the same value for V, so that the wave is propagated in either direction with a velocity V.